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European Association for Research on Services
RESER

Bernd Bienzeisler, Katrin Peters, Alexander Schletz (eds.)

31ST CONFERENCE
THE DISRUPTIVE ROLE OF DATA, AI AND ECOSYSTEMS IN SERVICES

Heilbronn, Germany
14th – 15th October 2021
www.reser21.de

PROCEEDINGS

Imprint

The Disruptive Role of Data, AI and Ecosystems in Services
Conference Proceedings of the 31th RESER conference
Bernd Bienzeisler, Katrin Peters, Alexander Schletz (eds.)

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URN: urn:nbn:de:0011-n-6429286
Download: http://publica.fraunhofer.de/dokumente/N-642928.html

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THE DISRUPTIVE ROLE OF AI, DATA AND ECOSYSTEMS IN SERVICES

Proceedings of the 31th RESER Conference

Bernd Bienzeisler, Katrin Peters, Alexander Schletz (eds.)

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Preface

2021 hasn't been a normal year – neither for the service economy nor for service research. On the one hand the contact-intensive service industry suffered the most due to persistent Anti-Covid measurements. Unfortunately this includes scientific meetings, such as last year's RESER Conference, which could merely be held using an online format. On the other hand, the contact restrictions made crystal clear how important digital interactions to customers have become which includes digital service products, sales channels and business models.

This year's 31st RESER Conference, set up in Heilbronn, tried to capture these developments. First, this conference was conducted using a sophisticated hybrid format. Meaning taking part on-site, as well as virtual participation was possible. Second, the emphasis regarding the content was put on Digitalization, Data, and Artificial Intelligence. Following the headline »The disruptive Role of Data, AI, and Ecosystems in Services Next Gen« more than 120 scientists united from October 14^{th} – 15^{th} 2021, in order to present their newest research results.

We are pleased that we have managed to motivate numerous young scientists to engage and participate actively in this conference. Furthermore, it was a pleasure to set up the RESER Conference at our new research location in Heilbronn. Since 2019, we are about to establish a new research center for Cognitive Service Systems. The 31st RESER Conference was our first international event in Heilbronn. My thanks go out to every participant that contributed to the success of this meeting. Especially Katrin Peters and Alexander Schletz who ensured the perfect organization of the event.

In the end, the core of a scientific conference is formed by its diverse research results. Once again, this year, many excellent abstracts, extended abstracts, and full papers were submitted. All the accepted contributions are processed and edited in these Conference-Proceedings. It is, so to speak, the product of a conference on service research. Anyways, the question whether a differentiation between services and products is still useful, refers to a content-related discussion. No doubt that there also can be found answers and links to that question in the following contributions. Enjoy the reading!

Dr. Bernd Bienzeisler

Head of Research and Innovation Center for Cognitive Service Systems
Fraunhofer IAO, Heilbronn

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Scientific Committee

- Prof. dr. Liudmila Bagdoniené, Kaunas University of Technology, Lithuania
- Dr. Daisy Bertrand, CERGAM - Aix-Marseille Université, France
- Prof. Dr. William Beyers, University of Washington, United States
- Prof. Dr. Thilo Böhmann, University of Hamburg, Germany
- Prof. Dr. Christian Bourret, Université Gustave Eiffel, France
- Prof. Dr. Jan Bröchner, Chalmers University of Technology, Sweden
- Prof. Dr. John Bryson, The University of Birmingham, United Kingdom
- Prof. Dr. Pedro Costa, Lisbon University Institute, Portugal
- Dr. Wolfgang Dunkel, ISF München, Germany
- Prof. Dr. Torsten Eymann, Universität Bayreuth, Germany
- Prof. Dr. Ingrid Fasshauer, Université Paris-Est Marne-la-Vallée, France
- Prof. Dr. Lars Fuglsang, Roskilde University, Denmark
- Dr. David Gago-Saldana, San Pablo CEU University, Spain
- Dr. Zoltán Gál, Hungarian Academy of Sciences, Hungary
- Prof. Dr. Faïz Gallouj, Université de Lille, France
- Dr. Robert Glawar, Fraunhofer Austria, Austria
- Prof. Dr. Ida Gremyr, Chalmers University of Technology, Sweden
- Dr. Estibaliz Hernandez, Mondragon University, Spain
- Dr. Volker Hielscher, Institut für Sozialforschung und Sozialwirtschaft e.V., Germany
- Dr. Ursula Holtgreve, ZSI - Zentrum für soziale Innovation, Austria
- Dr. Rimante Hopenienė, Kaunas University of Technology, Lithuania
- Prof. Dr. Christian van Husen, Hochschule Furtwangen University, Germany
- Prof. Dr. Helmut Krcmar, Technical University of Munich, Campus Heilbronn, Germany
- Dr. Luna Leoni, Università degli Studi di Roma "Tor Vergata", Italy
- Prof. Dr. Nicola Marsden, Hochschule Heilbronn, Germany
- Prof. Dr. Céline Merlin-Brogniart, Univesité de Lille, France
- Prof. Dr. Ian Miles, University of Manchester, United Kingdom
- Prof. Dr. Marie Christine Monnoyer, Institute Catholique de Toulouse, France
- Prof. Dr. Oscar Montes Pineda, University of Alcala, Spain
- Prof. José Luis Navarro Espigares , Universidad de Granada, Spain
- Birgit Oelker, Stiftung Universität Hildesheim - Center for Digital Change, Germany
- Prof. Dr. Diane Robers, EBS Universität, Germany
- Prof. Dr. Luis Rubalcaba-Bermejo, University of Alcalá, Spain
- Prof. Dr. Tiziana Russo Spena, University of Naples Federico II, Italy
- Prof. Dr. Maria Svona, University of Sussex, United Kingdom
- Dr. Markus Scheuer, RESER President, Germany
- Welf Schröter, Forum Soziale Technikgestaltung, Germany
- Dr. Metka Stare, University of Ljubljana, Slovenia
- Prof. Dr. Patrik Ström, Stockholm School of Economics, Sweden
- Prof. Dr. Wiltrud Terlau, Hochschule Bonn-Rhein-Sieg, Germany
- Dr. Daniel Werth, Ferdinand-Steinbeis-Institut Heilbronn, Germany
- Claus Zanker, INPUT Consulting, Germany

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Conference Programme

Day 1, October 14th 2021

8.30 – 9.00
Registration, Coffee & Networking

9.00 – 9.30
Welcome & Introduction »The disruptive Role of Data, AI and Ecosystems in Services - An Introduction«
Dr. Bernd Bienzeisler, Fraunhofer IAO, KODIS

9.30 – 10.00
Key Note Scientific Perspective »The Data Driven Enterprises – How to close the gap between today`s and tomorrow´s business«
Prof. Dr. Volker Stich, Research Institute for Rationalization e. V. at the RWTH Aachen

10.00 – 10.30
Key Note Business Perspective »The Business Challenge to Unlock Data Potential«
Dr. Katharina Schäfer, SAP SE

10.30 – 11.00
Coffee & Networking

11.00 – 12.30
Scientific presentations in parallel sessions

Digital Transformation in Services I
Chair: Luna Leoni, University of Rome Tor Vergata

- The impact of digital transformation on knowledge management practices
  Luna Leoni, University of Rome Tor Vergata
- **Micro learning towards adaptive learning in french University**
  Catherine Lande, Marianne Abramowici, Université Gustave Eiffel
- **From smart service to social service**
  Mike Freitag, Fraunhofer Institute for Industrial Engineering IAO
- How to Overcome Organizational Inertia by Shaping Institutions and Value Propositions: an Analysis of the Impact of Service-Catalogs
  Markus Warg, Institut für Service Design, Hamburg

Innovation in Services I
Chair: Christian van Husen, Furtwangen University

- Virtual Reality Service Prototyping – concept for a new instrument for experience
  Christian van Husen, Furtwangen University
- The challenges of implementing smart service projects in small business structures, especially in craft sector
  Christophe Said, University of Siegen

Geographic, Social and Ethic Aspects of AI
Chair: Nicola Marsden, Heilbronn University

- A Framework to Improve Team Work in the Data-Based Service Economy
  Nicola Marsden, Heilbronn University
- Detecting Social and Ethical Implications of Artificial Intelligence: A Structured Workshop Method from a Social Sciences Perspective
  Susanne Sczogiel, Fraunhofer-Institut für Integrierte Schaltungen IIS
- Corporate Digital Responsibility in Construction 4.0 - Ethical Guidelines for Digitization and Artificial Intelligence (AI)
  Bianca Weber-Lewerenz, Bianca Weber-Lewerenz Engineering
- Smart Salesperson and Smart Service-Owner – New role profiles due to changed competence requirements in the context of digital work
  Lena Maria Fischer, TU Chemnitz

AI and New Service Development
Chair: Jens Neuhüttler, Fraunhofer Institute for Industrial Engineering IAO

- **Testing Perceived Quality of AI-based Smart Services**
  Jens Neuhüttler, Fraunhofer Institute for Industrial Engineering IAO
- Innovation in the digital firm from a service logic perspective
  Christer Nygren, Mälardalen University
- Perspectives on service provision connected to generational expectations
  Alina Iosif, The Bucharest Academy of Economic Studies
- Augmented Intelligence in professional services: Position, competences and client-relations
  Jon Sundbo, Roskilde University

12.30 – 13:30
Lunch

13.30 – 15.00
Scientific presentations in parallel sessions

Innovation in Services II
Chair: Céline Merlin-Brogniart, CLERSE/Lille University

- Services at the heart of new sustainable business models: from service logics to territorial arrangements
  Céline Merlin-Brogniart, CLERSE/Lille University
- Towards the role of smart services as well as AI in building and enhancing organizational resilience in small and medium-sized service companies – Part A: A conceptual framework
  Alexander Gorovoj, University of Stuttgart
- **Gender Innovations in Construction in Digital Era**
  Bianca Weber-Lewerenz, Bianca Weber-Lewerenz Engineering
- An Institutional Logics Perspective on Birmingham's Accounting Industry
  Emma Gardner, The University of Birmingham

From Industry 4.0 to Service 5.0 – Servitization of Specific Industries I
Chair: Claudio Geisert, Fraunhofer Institute for Production Systems and Design Technology

- **Context Sensitive Field Service Assistance Based on Digital Twins**
  Claudio Geisert, Fraunhofer Institute for Production Systems and Design Technology
- **Towards HVAC system for Industry 4.0: Methodology**
  Atte Partanen, Häme University of Applied Sciences
- AI driven analytics service for supporting municipal employees after heavy wind events
  Marvin Stölzle, Fraunhofer Institute for Industrial Engineering IAO

Digital Transformation in Services II
Chair: Erica Del Vacchio, University of Naples Federico II

- Blockchain and ecosystem perspective: a focus on agrifood business
  Erica Del Vacchio, University of Naples Federico II
- **Towards sustainable service value economy**
  Heikki Ruohomaa, Hame University of Applied Sciences
- Automatic Generation of Word Problems for Academic Education via Natural Language Processing (NLP)
  Stanley Keller, CAS Heilbronn
- The Impact of InsurTech on the Transformation of the Insurance Sector
  Ivan Sosa Gomez, Universidad Camilo José Cela

15.00 – 15.30
Coffee break

15.30 – 17.00
Scientific presentations in parallel sessions

From Industry 4.0 to Service 5.0 – Servitization of Specific Industries II
Chair: Jonathan Roesler, University of St.Gallen (HSG)

- An empirical study of organizational capabilities for digital servitization and their impact on financial and non-financial firm performance
  Jonathan Roesler, University of St.Gallen (HSG)
- **Servitization for workplace wellbeing: concept and research agenda**
  Kentaro Watanabe, National Institute of Advanced Industrial Science and Technology (AIST)
- Communicating »sustainability«: A study of corporate web presence and digital services by Norwegian seafood companies
  Cheryl Marie Cordeiro, Nofima
- New work practices in service organizations: ornamental or direction change
  Timo Brunner, HHL Leipzig Graduate School of Management

Digital Transformation in Services III
Chair: Veronika Belousova, HSE University

- Russian banks resilience and technological development amid the COVID-19 pandemic
  Veronika Belousova, HSE University
- **Digital transformation in Colombia´s public administration**
  Jorge Alirio Ortega Cerón, Comisión Nacional del Servicio Civil
- Digital Transformation and Co-Creation in Social Innovation
  Ada Scupola, Roskilde University
- Case of use in Digitalization, data and AI driven services : Smart Commertial Street Project of Zaragoza
  Fernando Tomás, IDOM

Innovation in Services III
Chair: Daisy Bertrand, Aix Marseille Université

- Exploring the Sharing Consumption Economy: Insights from the P2P Car Renting Platforms
  Daisy Bertrand, Aix Marseille Université
- Prototype for the Analysis and Visualization of Data for Municipal Parking Management as a Cloud Service
  Melanie Handrich, Fraunhofer Institute for Industrial Engineering
- Smart services – are German companies ready to take up the challenge?
  Michaela Friedrich, Fraunhofer Institute for Industrial Engineering
- The effect of costs, satisfaction and recommendation on service creativity and service portfolio thinking
  Markus Holzweber, Kufstein University of Applied Sciences

17.00 -17.15
Closing Session
Dr. Bernd Bienzeisler, Fraunhofer IAO, KODIS

Day 2, October 15th 2021

8.30 – 9.00
Coffee & Networking

9.00 – 10.30
Scientific presentations in parallel sessions

AI in Front Stage Service Interactions
Chair: Diane Robers, EBS University

- AI-supported service interactions between organizations and their consumers
  Pascal Hamm, EBS University
- Artificial Intelligence in the Customer Journey: A Systematic Overview of the Most Popular Use Cases Through the Creation of AI Archetypes
  Richard Sander, University of St.Gallen (HSG)
- Human-centered work and technology design with AI – insights into the project »humAIn work lab«
  Ines Roth, INPUT Consulting; Dominik Grafenhofer, Deutsche Telekom
- **Interaction-Sensitive Chatbot Process**
  Thorsten Zylowski, CAS Software AG; Stephanie Porschen-Hueck, ISF München e.V.

What's next? Innovative Service Research I
Chair: Lars Fuglsang, Roskilde University

- The integration of an environmental perspective into public administration budgetary planning
  José Aureliano Martín Segura, University of Granada
- A bridge between Social Innovation and Sustainability research: cases of active mobility public services
  Silvia Stuchi, Universtiy of Sao Paulo
- Service innovation capabilities: toward a comprehensive framework
  Rafael Crispim, University of Sao Paulo
- Accelerating local ecosystem for sustainable services: towards comprehensive and systemic impact evaluation
  Kirsi Hyytinen, VTT Ltd.

AI driven Service Ecosystems and Value Chains I
Chair: Philipp Riegebauer, BABLE GmbH

- Ethical and trustworthy application of Artificial Intelligence - Challenges and Strategies for City Administration and Services
  Philipp Riegebauer & Gretel Schaj, BABLE GmbH
- HVAC control scenario to demonstrate district heat reduction possibilities
  Genrikh Ekkerman, HAMK
- An architecture to forecast a dynamic price for supporting load management and optimizing the utilization of charging stations
  Florian Maier; Fraunhofer Institute for Industrial Engineering
- Aligning Ecosystems with Shared Logic
  Annika Bengts, Aalto University

10.30 – 11.00
Coffee & Networking

11.00 – 12.30
Scientific presentations in parallel sessions

Data based Service Products I
Chair: Nick Große, TU Dortmund

- Impact of climate change on banking organizations and emergence of new services
  Christian Bourret, Université Gustave Eiffel
- Service innovation in Platform Firms from the perspective of economic theories
  Leonel Corona-Treviño, Universidad Nacional Autónoma de México
- Blockchain-based life cycle record as an instrument for data management in smart maintenance
  Nick Große, TU Dortmund

What's next? Innovative Service Research II
Chair: Marie Christine Monnoyer, Institute Catholique de Toulouse

- Estimation and tests for structural breaks in service portfolios
  Markus Holzweber, Kufstein University of Applied Sciences
- IDEA - Towards an interactive intelligent supportive tool that facilitates collaborative creativity sessions
  Verena Lisa Kaschub, GSaME
- Towards a Shared Understanding in Transdisciplinary, Experiential Entrepreneurial Education
  Apurva Ganoo, Aalto University
- Visualization of uncertainty and probabilities – A generic design approach for user-centered information visualization using the example of warehouse logistics
  Rebecca Hippeli, Fraunhofer IIS

Digital Transformation in Services IV
Chair: Estibaliz Hernandez, MIK - Mondragon University

- Blockchain and Cultural heritage: a systematic literature review
  Erica Del Vacchio, University of Naples Federico II
- Can service firms build resilience and recover from crises faster than manufacturing firms?
  Iris Koleša & Andreja Jaklic & Metka Stare, University of Ljubljana
- The development of competencies on artificial intelligence (AI) for small and medium-sized enterprises (SMEs) of the skilled crafts: Empirical study and conception of a low-threshold qualification
  Judith Schliephake, Institut für Betriebsführung im DHI e.V.
- **Robot design: What's Ahead for Services?**
  Doris Schartinger, AIT Austrian Institute of Technology

12.30 – 13.30
Lunch

13.30 – 14.30
Science meets Practice
Digital Data driven Science and Factory Transformation – Presentation and discussion of the Creathon/Makeathon Results

14.30 – 15.00
Coffee & Nertworking

15.00 – 16.10
Scientific presentations in parallel sessions

AI driven Service Ecosystems and Value Chains II
Chair: Katharina Dieterich, Graduate School of Excellence advanced Manufacturing Engineering

- IP-traceability: Discussing suitable technologies for tracing data from creativity processes in interorganizational R&D projects
  Katharina Dieterich, Graduate School of Excellence advanced Manufacturing Engineering
- The influence of investors on the AI ecosystem
  Arbia Chatmi
- Impact of innovation ecosystems on green innovation and digital transition in small and medium-sized enterprises
  Joern Kjoelseth Moeller, Roskilde University

Digital Transformation in Services V
Chair: David Kremer, Fraunhofer Institute for Industrial Engineering

- Inclusion on delivery: Development of a digital assistance system for delivery drivers with handicap
  David Kremer, Fraunhofer Institute for Industrial Engineering
- **Defusing Psychosocial Risks: Development of a Detection System**
  Samuele Meier & Magali Dubosson & Emmanuel Fragnière, Haute école de gestion de Fribourg
- The potential of Telehealth in the Co-creation of value in University Hospital services
  Fernanda Gusmão, COPPEAD - Federal University of Rio de Janeiro

Data based Service Products II
Chair: Janika Kutz, Fraunhofer Institute for Industrial Engineering IAO

- ScooP: Concept for a nationwide multi-operator platform for e-scooters
  Janika Kutz, Fraunhofer Institute for Industrial Engineering IAO
- Evaluation of job performance as an instrument to measure gender equity in access to public employment in Colombia and Data Analytics
  Frídole Ballén Duque, Comisión Nacional del Servicio Civil
- Return on Investment - Digital Value Creation in German SMEs
  Claudia Lehmann, HHL Leipzig Graduate School of Management

16.10 – 16.30
Key Note Research Perspective: »Challenges for Cyber-Physical Service Systems Design - Business Models, Digital Platforms and Architecture Ecosystems, and User Interfaces«
Prof. Dr. Helmut Krcmar, Technical University of Munich

16.30 – 16.50
Key Note Business Perspective: »EnBW District Development – For a sustainable and climate friendly way of living«
Benjamin Wanke, EnBW

16.50 – 17.10
Keynote Applied Research Perspective »Managing Uncertainties by Digitalization and Servitization – An Applied Research Perspective«
Prof. Dr.-Ing. Oliver Riedel, Fraunhofer Insitute for Industrial Engineering IAO

17.10 – 17.20
Outlook and Introduction of upcoming Event
Dr. Bernd Bienzeisler, Fraunhofer IAO, KODIS
Dr. Markus Scheuer, RESER President

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Topic »Innovation in Services«

4.1
List of papers

- **Virtual Reality Service Prototyping – concept for a new instrument for experience**
  Daniela Fehrenbach, Louis Tei, Abdul Rahman Abdel Razek, Christian van Husen (Furtwangen University, Germany)

- **The challenges of implementing smart service projects in small business structures, especially in the craft sector**
  Giuseppe Strina, Christophe Said (University of Siegen, Germany)

- **Towards the role of smart services as well as AI in building and enhancing organizational resilience in small and medium-sized service companies – Part A: A conceptual framework**
  Alexander Gorovoj (Universität Stuttgart IAT, Germany), Christian Schiller, Michaela Friedrich (Fraunhofer IAO, Germany)

- **Gender Innovations in Construction in the Digital Era**
  Bianca Weber-Lewerenz (Bianca Weber-Lewerenz Engineering, Germany)

- **Exploring the Sharing Consumption Economy: Insights from the P2P Car Renting Platforms**
  Daisy Bertrand (Aix Marseille University, France)

- **Prototype for the Analysis and Visualization of Data for Municipal Parking Management as a Cloud Service**
  Melanie Handrich, Vincent Philipp Göbels, Marvin Stölzle, Veronika Prochazka, Kristian Schäfer (Fraunhofer IAO – KODIS, Germany)

- **Smart services – are German companies ready to take up the challenge?**
  Michaela Friedrich, Christian Schiller, Thomas Meiren (Fraunhofer IAO, Germany), Alexander Gorovoj (Universität Stuttgart IAT, Germany)

Virtual Reality Service Prototyping – concept for a new instrument for experience

Daniela Fehrenbach, Louis Tei, Abdul Rahman Abdel Razek, Christian van Husen (Furtwangen University)

Abstract

Service prototyping is a novel technique that enables a service to be experienced before it even exists, where service prototypes are used to support service development. This makes it possible to obtain detailed customer feedback in an early development phase and thus iteratively develop the service prototype until desired service level is reached. We methodically use our service prototyping approach based on the four design dimensions (environment, process, artefacts, and actors). The main challenge is to combine all four dimensions so to anticipate and create a more realistic service experience. However, we found the service prototype approach to be lacking in previous academic or practice studies. As part of our smart service innovation research group, we developed a Virtual Reality (VR)-based service prototype. By integrating immersive technologies, all development dimensions could be represented in the VR prototype. The industrial solutions lab of Furtwangen University was recreated as a service environment. Artefacts were implied by various experimental setups and devices. The actors´ dimension is experienced through the use of avatars that move through the lab and explain various things using "text-to-speech" and "voice acting". The interaction of the created environment, the implemented artefacts, and actors represents the process and can be extended by any objects or characters. The process is an interactive immersive lab tour, audio visualized by animations of the artefacts and actors, explaining the content of several experimental setups and devices. The prototype was created using different programs including Creo, Blender, Character Creator 3, iClone7 and Unity. This implementation opens up completely new possibilities in experimenting with different service solutions, in market research and service evaluation as well as in training. The current findings already allowed the experiencing of the prototype through a VR HMD. Due to the immersive properties of VR this experience seems almost real for users. The aim is to build an independent application platform so that it can be exported, edited and used for all end devices and stakeholders. Consequently, the service prototype will be subjected to a critical review to evaluate the findings and identify the potential for improvement.

Introduction

Current times allow smart services to grow rapidly, as the COVID-19 pandemic causes many organizations to move into the digital world. Intelligent and networked products, as well as their individuality and speed of change, bring many challenges with them. As a result, the complexity of developing such smart services is increasing rapidly. For these reasons, service prototyping is becoming increasingly important in service development. Service prototyping allows a service or parts of it to be tested at an early stage of development, providing valuable feedback that can be incorporated directly into the development process. This has the advantage of gaining stakeholder feedback at an early stage, which directly influences the success of the service and leads to increased sales. The Smart Service Competence Center (2021) categorizes smart services into the following three application areas: (1) smart solutions, (2) smart maintenance and (3) smart training. The division into these application areas is intended to make it easier to understand smart services. Smart Solutions are data-based solutions for customers that include a combination of tangible goods and services. The digital networking of sensor technology within the company plays a central role in this context. Completely new business models can be established on this basis. The aim is to provide the customer with the best possible solution customized to their individual needs. Smart maintenance is based on an intelligent form of maintenance. Comprehensive and predictive maintenance of the production components is of high importance. The smart training application area includes various training, explanation and exercise options, which are mainly available digitally and, in some cases, immersively. This communicates an intensive understanding for example of complex procedures. Smart training creates a service experience for the stakeholders.

This experience is an ongoing, dynamic, subjective and individual involvement of stakeholders that depends on their expressions and interpretations, as well as encompasses all possible encounters with different stakeholders in different service situations (Chandler & Lusch, 2015; Edvardsson, Enquist, & Johnston, 2005; Jaakkola, Helkkula, & Aarikka-Stenroos, 2015; Patrício, Fisk, Falcão e Cunha, & Constantine, 2011; Tseng, Qinhai, & Su, 1999). Abdel Razek (2020) defined a service prototyping experience as individual experiences, impressions, observations and reactions that stakeholders receive during a service prototyping process. Buchenau und Suri (2000) state that immersive technologies, especially eXtended Reality (XR) technologies, are widely used in the industrial service sector to enhance stakeholder experiences. Pallot und Pawar (2012) explain that immersive technologies provide a more accurate representation of stakeholders temporal and spatial experiences, while enabling better testing of the usability of scenarios in a cost-effective and flexible manner. Similarly, immersive technologies can be used to provide stakeholders with information about the future service offering (Kohler, Fueller, Stieger, & Matzler, 2011). Per Dupont et al. (2016), the use of immersive technologies enables the perception of being physically present while in an immersive environment that allows for interaction and communication, engaging one or more of the five senses. Abdel Razek (2020) defined a Virtual Reality (VR) based service prototyping, which is a virtual replication of a service idea or its parts and allows stakeholders to be immersed in an interactive virtual environment using VR-HMD. Trough virtual simulation development technique, it is possible to simulate an immersive service experience within a virtual environment to represent a service idea and support communication virtually (Mattes, 2021).

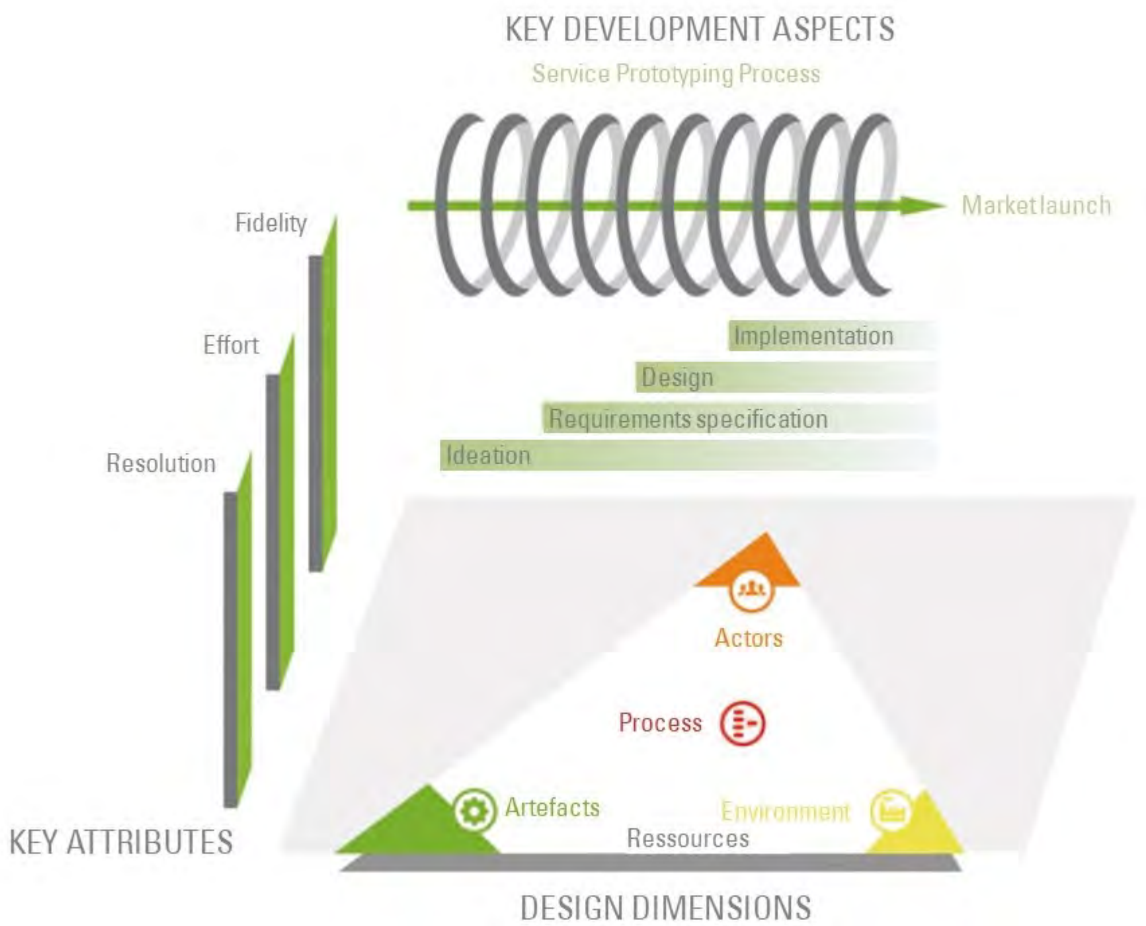
Service Prototyping

Service Prototyping is used to support service development and is assigned to the discipline of service engineering (Abdel Razek, Raban, Hengels, & van Husen, 2020, p. 16). Blomkvist und Holmlid (2011) explain that prototyping uses prototypes to explore, communicate and evaluate services. According to van Husen et al. (2016), service prototyping seeks to transform intangible service ideas into real-world experiences that enable service exploration, evaluation and communication. By representing a complete service or parts of it, it is possible to obtain detailed stakeholder feedback at an early stage of development. The Feedback allows the service prototype to be iteratively refined until the desired level of service is achieved. According to Exner et al. (2015), a prototype has the following characteristics:

- A prototype visualizes mental ideas.
- A prototype supports the comprehension of complexity.
- A prototype enables communications, thus removing cultural and linguistic barriers.
- A prototype always contains a specific question and is limited due to given constraints.
- A prototype tests functionalities and requirements.

These characteristics should be considered when developing a service prototype. Using various service prototyping techniques, complex services can be described and prototyped. For this purpose, Abdel Razek et al. (2020) defined a toolbox of selected tools, methods and procedures to improve the service prototype development process. The service prototyping model shown in the following figure serves as an approach for methodical development.

Figure 1 Service Prototyping Model (Abdel Razek, Raban, Hengels, van Husen, et al., 2020)



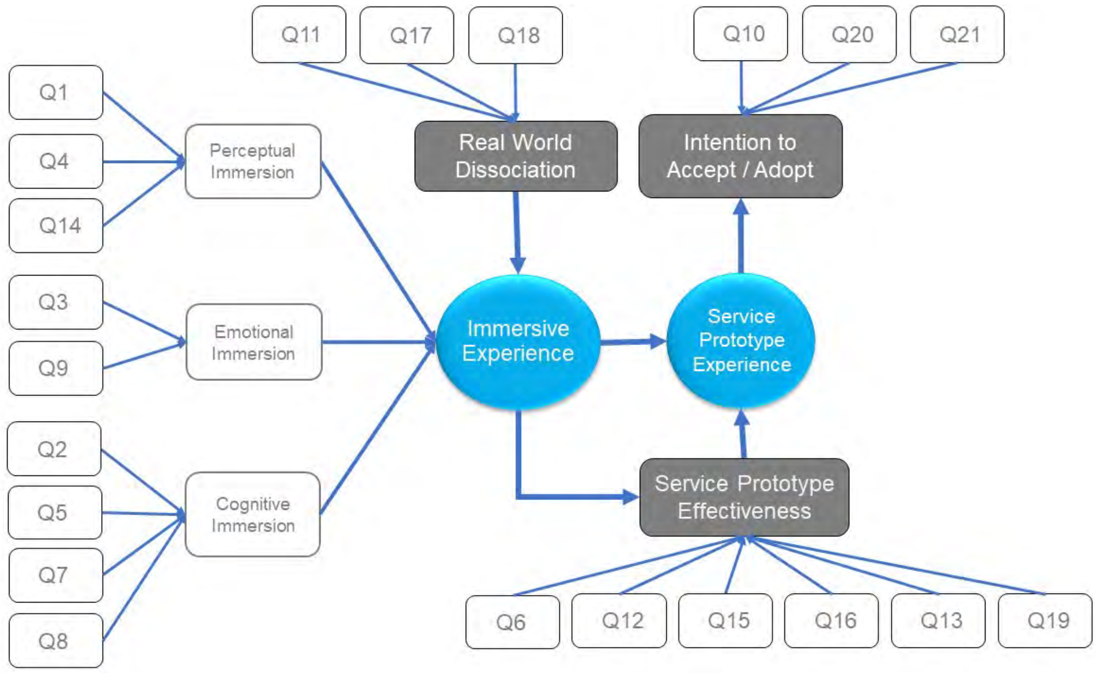
The service prototyping process implies the four development tasks, which are applied iteratively. The key attributes serve as evaluation criteria for the prototype. The level of detail describes the extent to which the prototype corresponds to the final service. Effort indicates how much time and resources were spent to create the prototype. Furthermore, the functionality and level of detail of the prototype is measured. For the development of a prototype, the design dimensions are essential. With the help of these dimensions, the prototype can be planned from scratch and the experience of a prototype can be designed. The design dimensions are divided into artefacts, actors, the environment and the process. Artefacts are all physical and digital objects that are represented in the prototype (Abdel Razek, Raban, Hengels, & van Husen, 2020). Actors are represented as acting persons involved in the service process (Abdel Razek, Raban, Hengels, & van Husen, 2020). For example, this can be a customer or a service consultant. The environment dimension visualizes the location where the service takes place (Abdel Razek, Raban, Hengels, & van Husen, 2020). The environment can therefore be at the customer´s site or in other premises. For this purpose, the locations can be digitally visualized and the service can be performed despite greater distance. The interaction of all artefacts, actors and the environment forms the process (Abdel Razek, Raban, Hengels, & van Husen, 2020). The biggest challenge lies in combining all design dimensions to anticipate and create a realistic service experience. However, previous approaches in science or practice didn't consistently allow for this. To perform an evaluation of a service prototype, Raban et al. (2020) developed categories that were ranked by importance as follows:

1. Reliability
2. Communication
3. Responsiveness
4. Economy
5. Competence
6. Safety

7. Knowledge
8. Appreciation
9. Associated product
10. Material appearance
11. Empathy
12. External resources

According to the study of Abdel Razek (2020) immersion affects the distance from the real world and the effectiveness of the service prototype. Effectiveness, in turn, affects the experience with the service prototype, which is critical to acceptance and adoption of the prototype. The VR service prototyping model proposed in the following figure is based on the immersive service prototyping model by Abdel Razek (2020). The proposed model for VR service prototyping includes the effect of real-world dissociation on the immersive experience of the user. This is due to the fact that the user is engaged in a VR environment by wearing a VR HMD and navigating through the prototype. Cybersickness is also a factor that affects the overall experience while using VR HMDs.

Figure 2 Proposed VR Service Prototyping Model and Survey based on Immersive Service Prototyping Model (Abdel Razek, 2020)



The used model, as shown in figure (2), was derived using the evaluation categories (Abdel Razek, Raban, Hengels, van Husen, et al., 2020), prototype properties (Exner et al., 2015), User eXperience (UX) (Pallot et al., 2017) properties and Service Prototyping Experience (SPX) constructs (Abdel Razek, 2020). For the usability test, the model was formed into a 21 hypothesis questions survey that was answered by the participants after using the VR prototype. Table lists the hypothesis in their respective dependencies.

Table 1 Theses formation for the usability test

SPX-Constructs	UX-Features	Evaluation categories	Questions	Hypothesis
Immersive Experience	Intuitiveness	Responsiveness	1	The user finds his way around the environment / intuitive environment
			14	The control runs reliably and intuitively
	Interactivity		4	The application is very interactive
	Attractiveness	Empathy	3	The environment is designed attractive and interesting
	Emotional Engagement		9	The avatar can establish an emotional connection with the user
	Interestedness	Knowledge	7	The artefacts are attractively designed
	Cognitive Engagement	Communication	2	The explanation buttons at the individual stations are noticed and used
			5	The avatar appears appealing and helpful to the users
			8	The signs of the stations are perceived and legible
Real World Dissociation	Perception of time		11	The visuals and audio content between actors and artefacts are harmonizing
	Attentiveness to their surrounding		17	The user was aware that this is nevertheless in the real environment
	Unresponsive to external events	External Resources	18	External reactions of the real environment were perceived during the prototype deployment
	User-Friendliness (less error)	Responsiveness	6	The on-demand functionality of the explanation keys is user-friendly
Service Prototyping Effectiveness		Empathy	12	The user copes with teleportation as a method of locomotion
			13	The user uses the touchpad keys to rotate 45° at a time
			19	The user did not suffer from cybersickness
	Usefulness (goal achievement)	Material Appearance	15	The teleportation circle as an additional orientation at the individual stations is helpful
	Pleasantness (less questions)		16	The user found the prototype useful
		Economy	10	The user finds the explanation process pleasant and informative
Intention to Adopt	Willingness to re-use the service	Competence	20	The user has a high willingness to re-use the prototype
	Willingness to recommend	Responsiveness	21	The user recommends the prototype

Virtual Reality Service Prototyping

According to Abdel Razek (2020), a prototype is not necessarily a physical object, but can also be digital, virtual 2D or 3D simulations, such as model created with a special software environment. The service innovation team at Furtwangen University has been researching service prototyping with extensive conditional and immersive forms since 2015. A VR based service prototype was developed as part of the smart service innovation research group. Due to the immersive visualization technology, it is possible to represent all design dimension of service prototyping (artefacts, actors, environment and processes) and thus map a complete service. The industrial solutions lab at Furtwangen University has been chosen as an environmental dimension and built up in detail. Various experimental setups and devices, such as an industrial robot, a collaborative robot, a 3D scanner, a 3D printer and other lab inventory and lab furniture are implemented as artefacts. Figure (3) shows the station on the industrial robot without the use of the lab avatar.

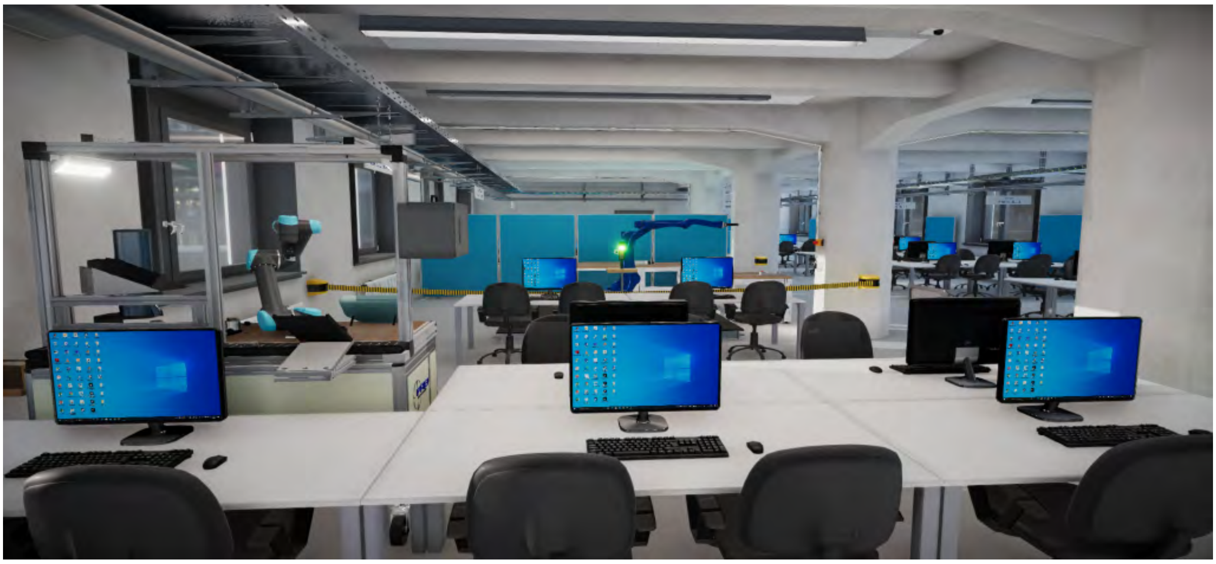
Figure 3 VR Prototype Artefact Industrial Robot

The actor dimension is experienced though the use of avatars, which can be called up at the various stations of the laboratory by interacting with artefacts (buttons). In this prototype, a lab manager is integrated as an avatar, which conveys basic information about the experimental station to the user through audio-visual animations created by *text-to-speech* and other means. The lab manager avatar is shown explaining a lab demonstration of industrial robot solution in figure (4).

Figure 4 VR Prototype Actor Lab Manager

The interaction of the created environment, the implemented artefacts and the actors represents the process and can be extended by any objects or characters. The process is an interactive, immersive lab tour, which is audio visually accompanied by animations of the artefacts and avatar explaining the content of various experimental setup and devices. In this VR prototype, the actor, the avatar of the lab manager, explains the different stations and provides information about what students can learn in the course of their studies. The VR finished tour would be used primarily at trade fair presentations and when the lab is inaccessible due to unforeseen events. This experience is intended to make the digestion of the information more tangible and interesting. A digital clone of a part of the lab is depicted 1:1 in VR as shown in figure (5).

Figure 5 VR Prototype



The prototype is created using various software. The artefacts are created with modelling programs such as Creo and Blender. The actors are created by tools like Character Creator 3 and animated with iClone7. The final implementation of the complete application takes place in Unity. The creation of such a VR prototype initially requires a lot of effort. Once it is created, it can be more easily adapted and modified so that it can be used for different purposes. This can be explained by the fact that economies of scale occur in the development process due to the databases and modularizations created. For example, this means, that environments, artefacts, actors or even processes can be reused several times and do not have to be generated anew. The implementation of various service prototyping project also results in learning curves that make the development of future prototypes more favourable. To ensure this, a compact practical guide should be created regarding the production rules in the development environment used, such as Unity. It specifies the setup for various end devices, describes how t handle CAD data and explains how to animate artefacts and actors. The level of detail of the service prototypes also benefits from a well-laid-out structure and clear production rules. Rough service prototype can thus be created quickly and photo realistically and visualized in great detail using iteration loops with little additional effort.

Compared to conventional approaches such as mapping the process through process modelling, the VR service prototype makes it easier to understand the process. This can be explained by the fact that the process is more tangible and easier to experience. In process modelling, the degree of abstraction is often difficult to imagine. One needs prior knowledge of process modelling and high imagination. These factors vary from person to person and can lead to misinterpretations or misunderstandings. Furthermore, due to the high complexity of such process modelling, errors can be overlooked. By contrast, the experience and the lower complexity by means of VR prototype allows errors to be detected more easily and quickly and consequently corrected. The VR prototype offers besides the storage and transfer possibility also an easy changeability of the dimensions.

Usability Test

Abdel Razek (2020) investigated the differences in experience, performance and acceptance of various forms of service prototypes by empirically testing and evaluation them. Abdel Razek et al. (2021) deepened the study to include other characteristics of the participants, such as age and gender, to account for differences in performance, experience and intention to adopt. This helped determine the most appropriate service prototyping form. According to the study, an immersive service prototyping can help service stakeholders leverage experience to improve feedback for exploing and evaluating service ideas. Communicating a service concept through an immersive experience leads to a more holistic view, which may not even exist at the time. This allows stakeholders to experience a service or parts of it before it exists to increase understanding of the service and its processes and improve the process through feedback. It is important to know when to implement which form of service prototyping, as immersive service prototyping processes require more organizational resources, but also provide a better representation of the future service.

In this case, the use of VR for an immersive and digital lab for industrial solution was necessary as digitalization is key of surviving and thriving in the future. To test the created VR service prototype, an initial usability test was conducted with five participants. Two had no experience with VR applications and two already had first experiences with VR applications, and one VR expert. The aim of the usability test was to assess and evaluate functionalities and the control of the immersive prototype. The task of the participants was to independently walk around the lab within the application, followed by a survey. The test was designed to last 30 minutes per participant including questioning and discussion. During the usability test their actions and reactions were noted down, which is of high importance for the evaluation and optimization. The HTC VIVE Pro was used for the first couple of usability test. After a high cybersickness could be detected, the hardware was changed for a fifth test person and the HTC VIVE Cosmos was used. In doing so, the cybersickness problem was resolved. Table (2) shows the participants' average rating per SPX construct, UX properties, and rating categories for each question.

Table 2 Usability Test Results

SPX-Constructs	**UX-Features**	**Evaluation categories**	**Questions**	**Evaluation average (-2 → +2)**
Immersive Experience	Intuitiveness	Responsiveness	1	1,6
			14	1,6
	Interactivity		4	1,6
	Attractiveness	Empathy	3	2
	Emotional Engagement		9	2
	Interestedness	Knowledge	7	2
	Cognitive Engagement	Communication	2	1,2
			5	1,6
			8	1,8
Real World Dissociation	Perception of time		11	1,8
	Attentiveness to their surrounding		17	0,6
	Unresponsive to external events	External Resources	18	-0,6
	User-Friendliness (less error)	Responsiveness	6	1,6
Service Prototyping Effectiveness		Empathy	12	1,8
			13	-0,4
			19	-0,4
	Usefulness (goal achievement)	Material Appearance	15	1,8
	Pleasantness (less questions)		16	1,8
		Economy	10	1,2
Intention to Adopt	Willingness to re-use the service	Competence	20	1,2
	Willingness to recommend	Responsiveness	21	1,6
Service Prototype Average Evaluation				**1,3**

Cybersickness had the biggest impact on interaction and control. However, this is highly dependent on which hardware is used. For future usability tests, the HTC VIVE Cosmos should therefore be used. The VR prototype was rated 1.3 on average by the test persons. This rating is very good for the prototype, but the rating could be significantly improved by making the smallest changes, such as replacing the hardware.

Conclusion & Future Work

There is clear potential through the integration of all dimensions. In the future, this prototype will be used to explore, evaluate and communicate intangible services between all stakeholders. This implementation opens up completely new possibilities in experimenting with different service solutions, in market research and evaluation, and in training. The prototype enables an end-to-end user experience. Due to the high level of realism and the use of immersive technology, this experience seems almost real to the user. Currently, it is not yet possible to make the application platform independent. This follows from the fact that the graphics performance of the application is very high and a connection to the PC is necessary, which does the computing work. The computing power of VR glasses without a connection to the PC is currently still far too low. The aim is still to make the application platform-independent so that it can be exported and used for all end devices.

Technological progress in hardware is necessary for this, as it is not intended to make any compromises in graphics quality. Consequently, the service prototype will be subjected to a critical review and a usability test in order to evaluate the result and identify potential for improvement. An extensive usability test is planned for the near future. A larger number of participants should provide more qualitative feedback. This prototype will be refined and further tests will be conducted to foresee the most optimal software and hardware configuration for each scenario. This will allow us to create options for using the VR Lab tour, one for users with HMD connected to PCs, or Users wearing untethered HMDs (not connected to a PC), or even mobile VR users.

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The challenges of implementing smart service projects in small business structures, especially in the craft sector

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Introduction

The increasing networking of business processes towards the "Internet of Things" will radically change a large part of today's value creation processes in just a few years. Large companies, in particular, are already addressing its impact on critical core processes, digital business models, and innovative smart services (Matt et al., 2015, 339-343). As these upheavals cannot be managed without extensive adjustments and investments in digital infrastructure, IT security, and skilled workers, there is a risk that SMEs, as well as craft enterprises, will lose competitiveness.

But the argument of high investment costs is only one side of the coin. The other side is that the small businesses must recognize that they must adjust to these changes in the market accordingly. It is often pointed out that the needs of customers are changing due to digitalization: better performance and price information, on the one hand, reduces switching costs, on the other hand, the comparability and demands on the services increase, resulting in the increased bargaining power of customers. Consequently, the customer's desire for higher service quality has been evident for a long time, especially in the craft sector, which is reflected in the distribution of sales: the share of craft and/or material-related work declines in favor of the share of services and consulting. The importance of the Internet as a platform for initiating and concluding business is now also increasing steadily in many craft trades. More and more customers orientate themselves online and obtain service and product offers electronically. Digitally supported services are therefore suitable for increasing customer satisfaction and thus for increasing customer loyalty and attracting new customers.

The **concept of digitally supported services** therefore now refers to any beneficial and digitally supported interaction with the customer along the customer contact circle, be it for inspiration through advertising (in the information phase), for product advice (in the offer and purchase phase), for support of transactions (in the execution phase) or the provision of additional digital services as a supplement to a physical product (in the usage phase). The changes associated with this digital change mean a fundamental transformation for the trade, so to say a mental shift: **from “classic craftsmen” to “modern service providers”**. This change can no longer be achieved with the traditional methods of management, organization, and the acquisition and processing of information that the craft has been taught in training up to now. Service orientation includes not only the introduction of new services but also a complete redesign of the entire company, from the entire external communication to the handling of the order processes to the specific work processes up to a revision of the existing business model.

The challenges of implementing smart service projects in SME, especially crafts, therefore exist in several respects: in addition to the always existing **restrictions of tight resources in SME** (money, time, personnel, etc.), these are **the mental shift** mentioned above, the **lack of affinity for digitalization** and the **lack of awareness of the scope of the necessary changes**.

Purpose of Research

This paper will examine the challenges that exist in the implementation of smart service projects in small business structures, especially in the skilled trades sector. The focus will be on the approaches that can help organizations integrate smart service projects into their processes to build up additional or new service innovations.

Methodology

Since services have a strong process character, a variant of the action research approach in the sense of a "research-by-design" was developed during the research project. The core element of a research-by-design approach is a continuously interactive environment in which participants in the design process are enabled to creatively exchange ideas, collaborate, and jointly develop new knowledge. At each stage, research is brought into the design process, beginning with a focus on what is available. The second phase is informed by what might be present and has an exploratory nature. The last phase is about what will be present (Roggema, 2016, 15). Thus, we see great similarities in the "research-by-design" approach with the systemic approach on which the model to be developed is based. The process design used is based on the "Solution Cycle", a learning and solution cycle according to Bergmann and Daub (2009), which consists of three main stages: Diagnosis (analytical stage), Realization ("Could" stage/therapy), and Reflection ("Will" stage). Experience has shown that in innovation and development processes it is advisable to first take a comprehensive look at the overall situation from different perspectives: Innovations are systemic developments that cannot be characterized by causal attribution processes (Bergmann, 2014).

In the "DIGIVATION coaching approach", in which we adapted the "Solution Cycle" as a framework for digital transformation projects in SME, the first of eight phases consist of illuminating multiple perceptions and views, interests, and positions of influence of various project participants especially with the focus on digital aspects (Fig. 1).

Figure 1: The DIGIVATION Coaching approach, based on the "Solution Cycle" as a Process Design (Bergmann, 2014, 23)

	Analysis		Design		Implementation		Reflection	
Steps in "Solution Cycle Digitalization"	Recognizing the situation from multiple perspectives	Describing the problem holistically together	Try new ways (expand solution space)	Planning interventions	Realize a turnaround	Perceive change	Multiply differences	Consolidate changes
Our methods and tools	Digicheck	Diagnosis digital Leadership	Business model innovator	Balance Scorecard	Marketing Mix	Identify early successes	Best Patterns	Feedback
Usefulness	Determine maturity level in relation to digitalization	Developing and defining a common new understanding of leadership	Identify and develop new digitally supported business opportunities	Define the criteria for later success at an early stage	Adaptation of product, price, communication and sales strategies	Quickly capture and evaluate results	Learning organization that recognizes patterns	Deeper understanding of processes and procedures

The goal of the research is to examine and overcome the above-mentioned challenges that exist in the implementation of smart service projects in small business structures and will be investigated with the help of qualitative analysis and represent a case study with an explorative character. While in quantitative research preformulated answer categories are used for data collection, in qualitative research an openness towards the interviewees, the research situation, and the methods are aimed at. Hypotheses are not formed in advance (Lamnek and Krell, 2016, 33 f). In contrast to quantitative research, it is characterized by relatively small samples as well as open questions (Ahlrichs, 2012, 105). The answers and statements of the interviewed people are understood as processual constituents of the construction and reproduction of people's social reality, but not as statistical representations of invariable cause-effect relationships. The relationship between the researcher and the research subject is both communicative and reflexive. Researchers must therefore have a reflexive attitude and the research instruments must have adaptability. Furthermore, the interpretation process of the researcher should be disclosed as much as possible to allow the analysis to be comprehensible. While quantitative procedures are limited to a standardized technique, qualitative data collection procedures should be kept flexible and adapt to the individual characteristics of the objects of investigation (Lamnek and Krell, 2016, 33 ff).

The advantage of working with qualitative methods is the uncovering and description of new worlds of knowledge and unknown aspects in already known areas. New connections can be filtered out, the validity of a theory can be tested on individual cases, and qualitative evaluations can be carried out (Oswald, 2013, 191 ff).

Expected results

Based on our research, our results cast a new light on the potentials of digitalization for SMEs, especially crafts, to implement smart service projects into their processes. We formulate first suggestions, which support the evolution of new smart digital service innovations for SMEs, in particular crafts, which leads to new USP. We will demonstrate our approach using two case studies.

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Towards the role of smart services as well as AI in building and enhancing organizational resilience in small and medium-sized service companies – Part A: A conceptual framework

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Problem

The COVID-19 pandemic has led to numerous changes in politics, social environment and economy. The fear of the virus as well as the actions to contain the pandemic have threatened the existence of numerous German service companies. So far, many of them have only been able to avert the threat of bankruptcy by government interventions, short-time work and support from nongovernmental organizations (Adam & Alarifi, 2021). However, some of the service companies might not survive the pandemic. Small and medium-sized companies turned out to be particularly vulnerable. Unlike internationally active large enterprises, they have little financial cushion and therefore indicate higher bankruptcy risks (Peichl et al., 2021). While the manufacturing sector was able to continue business operations under certain conditions, many retailers and other service providers had to cease operations completely. As a result, the service sector, which is by far the most employment-intensive and at the same time the most value-adding sector in Germany, was confronted with challenges that have threatened its very existence (Peichl et al., 2021; Welter & Wolter, 2021).

Guides and frameworks that already exist in the academic literature to help increase organizational resilience may be viewed by SMEs in the service sector as either too complex or too generic. The ongoing study aims to derive recommendations for action for the service industry using current insights from organizational resilience research. Thus, the flexibility and resilience against external factors threatening the existence of service companies shall be increased. To facilitate this, a conceptual framework is presented that serves as a foundation for further industry- and company-specific extensions considering the heterogeneous structure of the service industry.

Methodology

The ongoing study consists of two parts. In the first part of the study, presented here, a literature review serves to provide an overview of existing models in organizational resilience research. These are evaluated for their suitability for SMEs in the service industry. The second part focuses on key insights gained from interviews with industry experts. Based on the information obtained, the conceptual framework recommendations for action are derived for service companies on how they can increase their own corporate resilience.

Key Findings

It is observable that the social and scientific interest in resilience and how to build it is steadily increasing and has been boosted by the COVID-19 pandemic. To meet the increased interest, numerous scientific papers have been published on this topic. For example, the number of scientific publications on the topic of organizational resilience has almost quadrupled from over 14k in 2012 to over 52k in 2020 (Digital Science, 2018-). Several standards such as BS 65000:2014 (British Standards Institution, 2014) or ISO 22316:2017 (International Organization for Standardization, 2017) have also been developed on this subject. In addition, numerous models and frameworks have been published in the scientific community over time to either identify the processes that contribute to increasing organizational resilience (e.g. Duchek, 2020) or to highlight the influencing factors (e.g. Barasa et al., 2018). Furthermore, the need for approaches that take company size into account has become apparent. While Burnard and Bhamra (2011) pointed out some implications of their resilient response framework for small and medium-sized enterprises (SMEs), Gunasekaran et al. (2011)

considered the characteristics of SMEs in their concept. A study by Sullivan-Taylor and Branicki (2011) identified a lack of technical as well as organizational capabilities and resources being characteristic obstacles in SMEs while rapidity has been found to foster their organizational resilience. Adam and Alarifi (2021) have examined the role of SME's innovation practices and external support in their performance during the COVID-19 crisis. They concluded that innovation practices of SMEs have a direct impact on the likelihood of surviving the crisis, while external factors (such as government support programs) play a mediating role. An overview of further factors and characteristics that have been found to influence resilience of SMEs can be obtained in publications of Korber and McNaughton (2018) and Ates and Bititci (2011).

Despite the plethora of generic frameworks on organizational resilience, little has been published specifically on resilience of SMEs in the service sector. In addition, many of the frameworks published to date have a high degree of abstraction, showing only "what" needs to be done to increase resilience, but not "how" it could be done. This lack of practicality might be considered as insufficient by some SMEs. To address this shortcoming, we present a conceptual resilience framework for SMEs operating in the service sector. The proposed concept is mainly based on previous work by Punzo et al. (2020) on resilience of complex systems. Complex systems are characterized by a variety of attributes (for a comprehensive approach, see Bar-Yam, 2002; Ladyman et al., 2013; Lloyd, 2001). Among its major ones are: "a large number of interacting parts; interactive complexity; and self-organization." (Tan et al., 2005, p. 38). The transfer from complex systems research is driven by the assumption that the high number of interactions and the behavior of entities in a service delivery network correspond to the properties of complex systems (Barasa et al., 2018; Briscoe et al., 2012; Burton et al., 2018; Engelseth et al., 2021; Rouse & Basole, 2010; Sebhatu et al., 2016; Tan et al., 2005). In addition, increasing connectivity in technology augmented services, such as smart services or the use of artificial intelligence, are associated with increasing complexity (Briscoe et al., 2012).

For the purpose of better feasibility in practical use, the circular representation of the "resilience wheel" (Punzo et al., 2020, p. 3870) has been converted into a linear process visualized by a horizontally aligned sequence of arrows (see figure A in appendix). Also there have been made minor changes to the terminology. As we hypothesize that leveraging and offering smart services as well as using artificial intelligence in service delivery will increase resilience in SMEs, an additional, practice-related layer, "Actions & Methods", has been added to serve as a placeholder. This extension helps to account for heterogeneity in the service sector because it encourages to make case-specific adaptations. Initially, it includes a sample of conceivable activities and tools that can be adapted and extended to the area of application. One of these tools is a so-called "stress test" or simulation. Along with impact and risk analysis, these can be powerful instruments for creating awareness of potential hazards and developing solutions to address them.

Clients play a central role in the service delivery process. Therefore, they should also be highly relevant for activities to increase the resilience of service companies. As mentioned before, we assume that offering smart services and leveraging artificial intelligence can generate benefits for both providers and customers with a positive impact on the company's resilience. Thus, ongoing studies are intended to identify appropriate methods, tools and actions for each process phase that are suitable for a particular service branch or entity in the service delivery network.

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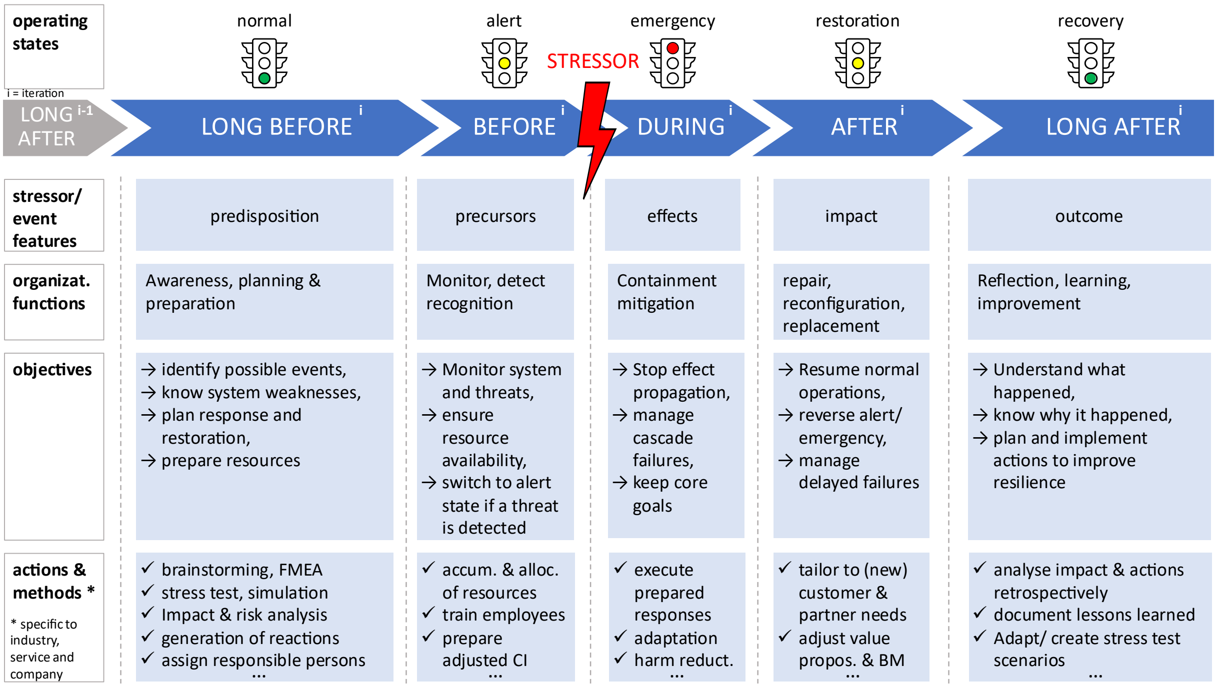
Appendix

Figure 1: Conceptual resilience framework for SMEs in the service delivery network.



Note. Adapted from “Engineering Resilient Complex Systems: The Necessary Shift Toward Complexity Science”, by G. Punzo, A. Tewari, E. Butans, M. Vasile, A. Purvis, M. Mayfield and L. Varga, 2020, *IEEE Systems Journal*, *14*(3), p. 3870 (https://doi.org/10.1109/JSYST.2019.2958829). CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/).

Gender Innovations in Construction in the Digital Era

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Abstract

It is true that women no longer have to be looked for with a magnifying glass in the executive floors of German businesses; however their share is still small. The digital age holds great potential for increased inclusion and closure of the „Gender Gaps", especially in the construction industry. Industry standards, including global ones, are being examined to achieve more inclusive corporate governance models. The construction industry, which is regarded as one of the most traditional and conservative, male-dominated industries, serves as the best example for a long overdue need for dynamic restructuring and action related to women leadership. There is a need to redefine, recalibrate and reshape this industry by increasing women's role in the social-, digital - and business transformation processes. This approach bridges the current divide and facilitates movement from discussion and advocacy towards application and practice.

Keywords: Women Leadership, Responsible Leadership, Digital Innovation, Digital Transformation, Digitization, AI, Construction Industry, Diversity Mandate, Ethics, Inclusion, Diversity, Block chain

Prolog

The Italian Presidency decided at the Digital Economy Ministers' Meeting in Trieste on the 5th of August 2021 to place digitization at the core of G20 discussions. Participation in education and training for all to eliminate digital gender gaps and challenge stereotypes are, thus, not just buzzwords anymore but lived engagement. The diversity of existing regulatory approaches and technologies within the G20 means that many questions are yet to be answered: how to make digitization an opportunity for all? Fostering diversity and inclusion in the digital era is essential to protect and enlarge global value chains, create a trustworthy Artificial Intelligence ecosystem, enhance the digital to achieve sustainable growth. A Memorandum has been created by two researchers from US and from Europe, who is the author of this article; both standing themselves for diversity, women leadership, strengthening the innovative action in digital era. Their recommendation has been fully embedded into the policy recommendations for G20 Summit 2021, in the frame of the external scientific support of *TF4 Task Force on Digital Transformation* (T20-B20 Joint Statement, 2021) (T20 Task Force 4, 2021) (Görlich, D., 2021).

When using the term "sustainability of digital innovations" in this article, it refers to securing its necessary basis: diversity, inclusion and equality.

Introduction

The analysis presented with this white paper is based on a methodology integrating the latest statistics from international organizations and scientific research around the globe and surveys of executives. The findings, interpretations and conclusions expressed in this work stress the urgent, long-overdue action. The provided diverse, inclusive approaches are in-line with gender equality strategies set up by international, high level social, economic and political institutions. The World Summit on the Information Society (WSIS) "Outcomes from Geneva and Tunis" and global partnership of governments and organizations dedicated to promoting gender balance in the technology sector raise awareness, such as EQUALS - a coalition with UNESCO and supported by the German Federal Ministry for Economic Cooperation and Development (BMZ). The World Economic Forum (WEF, 2020), UNESCO (EQUALS and UNESCO, 2019), United Nations (UN, 2020), European Union's Gender Equality strategy 2020-2025 and White Paper (European Commission, 2020), Construction Industry and Real Estate (Deloitte, 2021; Fortune, 2020, US Bureau of Labour Statistics 2020), International Labor Organization (2020) and consultancies e.g. Deloitte (Deloitte, 2019) - to name a few - set strong signals with their statistics and results of research. To accelerate this dialogue, covering the many rich facets, the paper examines aspects such as: Does the male-dominated AI competence make an impact in thinking patterns in AI, so-called gender bias? What data do programmers feed learning systems with and are prejudices reproduced in algorithms without being noticed? Do we need more female developers? One of the core tasks in the digital era for decision-makers in social, political, educational and corporate environments is to identify the benefits of AI and how to operationalize it in a responsible, morally reasonable way. Such process requires holistic, interdisciplinary business and professional conduct ethics as well as a balanced mix of gender so as to fully benefit from women's potential and avoid exclusion and bias in any sense. The construction industry has proven to be a good example for demonstrating existing gatekeepers, partial prejudices and a lack of both digital education and encouragement of constructive approaches to overcoming and strengthening gender innovation for a sustainable digital era. Strengthening of inclusion and diversity not only follows ethical responsibility, but also the principle of the common good.

Despite strong order books, construction companies face sustained cost pressures and the lack of a skilled workforce. New digital technologies and AI improve operational efficiencies, offer new business models, and ensure trainings for new qualifications answering new job profiles. The construction industry plays a vital national economic role; e.g. it added more than $900 billion to the US economy in the first quarter of 2020 - the highest levels since the 2008 recession (Deloitte, 2021). The branch could benefit significantly by implementing the strategic decision-making processes, planning and operational phases more efficiently by both standardizing digital technologies, methods of AI within more diverse environments. In short, diversity is essential to the cutting-edge portfolio in construction to shape digital transformation holistically, successfully and sustainably. Proof of hard facts such as the increase of economic efficiency (ROI) and overall excellence in corporate digital culture -evidenced in yearly corporate reports - rationalize gender discussions. Also the stronger communication, transparency, and larger networks speak for themselves as a stand-alone feature of women leadership potential's success.

As a Senior Civil Engineer (Fig.1) with a background of international experience in Europe and China, the author deals with all aspects of new technologies in the construction engineering in multidisciplinary, intercultural environments, arising with Industry 4.0. Since 2007, she runs her own engineering company, filled various management and leadership positions, coping with corporate and business ethics in multinational environments, and mentoring female apprentices and academics in STEM disciplines. In 2019, digitization and AI led her to scientific research and founding of the *Excellence Initiative for sustainable, human-led AI in construction* in 2020 (Weber-Lewerenz, 2020). She took a pioneering role examining ethical, social, and economic impacts of digitization and AI on human, societal and technological development (Giannakidis et al., 2021).

To be successful, digital transformation inherently requires and relies on diversity. AI is the result of human intelligence, enabled by its vast talents and also susceptible to its limitations. Therefore, it is imperative that all teams that work in technology and AI are as diverse as possible. Diversity of people does not mean just the obvious in terms of demographics such as race, ethnicity, gender, and age, but people with different skill sets, experiences, educational backgrounds, cultural and geographic perspectives, ways of thinking and working. Digital transformation bears high potential to aid both economical and efficient building project life cycle, and greatest possible social benefit, economic prosperity and protection of our natural resources of life. However, Digital Era requires strengthening strategical values for a more inclusive environment and the common good. *Gender mainstreaming* represents the answer as this concept of gender equality on all social and political levels takes interests of women and men fundamentally and systematically into account. Women increase public trust in AI by strong communication and consciousness. This is even more important in an industry like construction, having a very high share in the economy, but lagging behind digitization and AI, diversity and inclusion. Construction is considered a traditional conservative, male-dominated branch with a "let's do it as we always did" and "we need strong man on-site" attitude. The 'Good-Old-Boys'-Network and gatekeeping has a long tradition. Over the past years, the branch suffered a significant decrease of skilled work power. Digital transformation sets the stage for disruptive reforms and changes to get women involved, attract them for STEM, and offer new career paths. However, there are still prejudices and the lack of role models, although the construction industry cannot afford to forego the qualifications, expertise and social communicative digital high-potential of women. In order to fundamentally rethink technological progress enabling new business models and keep up with digitization in a sustainable manner, all parties involved are required to promoting the best skills, diversity and inclusion.

Intensified by digital change, inclusion, diversity, corporate governance, integrity, gender gaps, mandates and boards for financial and societal benefits increasingly come into focus. Ensuring corporate governance - as required by legislators and stock exchange regulators - led to more transparent yearly corporate reports. Another option to respond was to hire a Chief Ethics Officer. Often such departments cover corporate diversity, inclusion, the promotion of women in management and leadership positions. More and more companies realize the significant role of HR, digital ethics, and corporate digital responsibility to shape a successful digital transformation. Thus, digital change additionally speeds up the process of these previously separately working units increasingly growing together. Diversity and digital transformation are closely linked and it is seen that the widespread implementation is essential to exploit important potential for both the entrepreneurial and the common good. Corporate environments with agile, dynamic management style and female leadership should be a matter of course to generate high performance.

Fig.1: Women and Leadership. The author Bianca Weber-Lewerenz in her male-dominated working environment in construction. 2004. *Source: Bianca Weber-Lewerenz*

Profound insights, openness and recommendations of the interviewed experts enabled this research to reveal these new findings and set constructive approaches as a Call for Action into the ongoing debate. The wide variety of specialist knowledge and areas of responsibility illuminated the challenges and innumerable chances of diversity from different angles. The holistic, inclusive, interdisciplinary approach of the author not only empowers to educate, raise awareness and provide orientation in dealing with digital transformation, but adds value to this new field of scientific research. One of the major outcomes of some scientific studies is the finding that not only standards and binding rules of the ethical framework for using AI must be set on the political level and by law but regulations ensuring diversity and inclusion. Independent of gender, education and academic training are basis for the next generation of engineers` expanded skills in digitization and AI. In fact, to enlarge value chains, save long-term costs, and achieve sustainable development goals (SDGs) it has been suggested that value-based decision-making processes in diverse corporate environments should be institutionalized around the globe. This study is part of a larger research project (Weber-Lewerenz, 2020), goes beyond dominant financial focus and aims to create societal and economic benefits at its core. The construction branch may encourage other branches to recognize the potential of the ethical implementation of digital transformation within a strong corporate culture. This research is met with the utmost approval to widen the awareness, education and application. Construction has just started applying first digital methods, e.g. BIM, digital twin. 3D to 7D construction modeling and the first AI tools can simplify, augment and amplify human efforts. The understanding and knowledge of such technologies is still limited to a minority of people in research and development, leading to the conclusion that its opportunities, the technologies' risks and weak points need stronger education, communication and transparency. This offers high potential for women for new jobs, work niches, new work in fields of STEM and enlarging networks.

Everyone involved is challenged to shape this process and fill niches proactively with qualified human resources. An open discourse on new technical possibilities and the allocation of potential fields of application is needed. Coping with these challenges is a top priority in construction. Nevertheless, there is a lack of recognizing potentials of new technologies and their applications as well as a lack of diversity. Knowledge about digital technologies and methods must first be acquired comprehensively to be able to assume digital responsibility for something that many do not yet know or cannot assess. It is a prerequisite for the greatest possible social benefit, economic prosperity and protection of our natural resources. It should be of such design that companies secure its data management, as well as offer full access and use of new technologies to everyone. This is why female strengths like strong communication, transparency, problem solving, empathy, relationship building and enlarging social networks, keeping authentic, drive innovations and empower a whole new construction industry culture. Therefore, having responsible and ethical leadership is indispensable.

Connecting "Gender gap", “Responsible Leadership” and “Digital Era” led to this paper dedicated “Gender Innovations in Digital Era”. For this powerful edition the author, pioneer in her field of research and work, build the best match for setting essential impulses. This paper is a signal for the full commitment to sustainable, diverse and inclusive working environments to strengthen technical innovations - not limited to the digital era.

Background

Research around the world has shown that board diversity enhances corporate performance, and a failure to recognize its benefits would undermine competitiveness. Questions have been raised as to whether legislation or quotas can be the solution. Influencing factors and tendencies can be shown on the basis of the historical development process. In 2019, for every 100 men on the construction jobsite, there was only one woman (AGC Diversity & Inclusion Council, 2019). Many of the women go to work and want a more diverse, inclusive workforce and exceptional contributions to their businesses. Making change to their mission paid off. Empirical evidence has proven that facilitating a diverse and inclusive work landscape is at the core of cultivating successful innovation and profit. Growth of the industry and becoming more complex is in favor of leadership opportunities for women. According to the latest AllBright report from March 2021 (AllBright Foundation, 2021), the proportion of women on the executive boards of the 24 listed real estate companies is only ten percent (Tab.1). In 60 percent of the companies, the board members are made up entirely of men. The proportion of women on the DAX board members was 16.6 percent on March 1, 2021; on the same date, a total of 613 men and 86 women worked on the boards of the 160 listed companies (DAX, MDAX and SDAX).

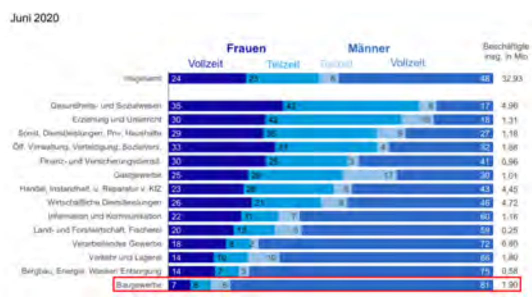
These men, in turn, are very similar in age, origin and education, which means one Thomas surrounds himself with another 12 Thomases, a so-called “Thomas Cycle”. The name Thomas derives from the fact that it is the name of 5% of the Chairmen of the board in Germany. The recruiting follows the same template, so-called “Thomas Template” and results in new boards mirroring existing board members. Germany stands out particularly in this report. On the one hand, after the USA and India, Germany is one of the most successful countries in the AI ranking; on the other hand, only 16 percent of all AI specialists in Germany are female (World Economic Forum, 2018).

Because stakeholders do not enforce the proportion of women and empowerment of female high potentials - though key for increasing digital economy efficiency - a new mindset and holistic change on all levels is needed. Participating in leadership roles and technical domains is therefore not reserved for men only or a question of good will. But it is, based on facts, a question of who is best qualified, who does the best job and fully uses their genders´ strengths. The 2020-2025 EU Gender Equality Strategy (EU Commission, 2020) power-drives the gender issues in AI and in digital transition.

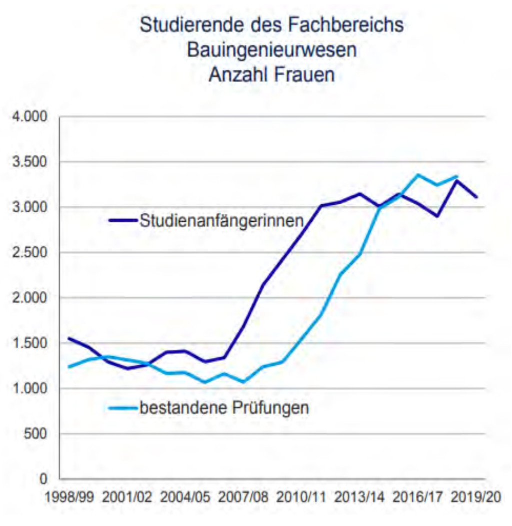
Tab. 1: Female mandates and boards in Germany ***Source: AllBright Report 05th of March 2021***

The disruptive change may allow access for women to bring in their high potential to mandates and boards. Axel Wallrabenstein sets impulses: “Diversity in management bodies is not only important, but essential for the success of companies and for our society.” His counterpart Rainer Esser follows, “Companies that want to forego 50 percent of their talent will face a massive problem in the medium term" (AllBright Foundation, 2021). Demographics are continuing to shift in a favorable direction. According to the NAWIC, in 2019 women made up 9.9% of the U.S. construction workforce (NAWIC, 2019). Statistics of the main association of German construction industry (HDB, 2021) show, that 30% of civil engineering students are female. 28% of the female civil engineers mainly work in construction companies; in public administration the proportion is 45%. On average in the main construction trade, however, the proportion of women is only an almost constant 10%. The salary level of women in managerial positions is 76% of their level male colleagues. In the average of all German industries, construction ranks last in terms of the proportion of women with 7% employed full time and 6% part time (Tab. 2). The construction industry is called upon as an industry to emphasize the attractiveness of the professions and increasingly to attract women in order to counteract demographic change and to fill positions with qualified managers. In the course of digitization and AI along with the opening of professional fields, new qualifications develop from it with an increasing number of newly created positions. In 2020, there were a total of 60.000 students in Civil Engineering, 18.000 of them female, which are 30 % (Tab. 3). In 2019, 2.770 were female student beginners, of a total of 9.500 students. Though 80% more compared with 20 years ago, it is 12% less than 4 years ago.

Tab. 2: Women in Construction in Germany Source: HDB Statistics Women in Construction 2021



Tab. 3: Female students in Civil Engineering in Germany ***Source: HDB Statistics Women in Construction 2021***



In 2020, only 2,1 % female apprentices started in construction trades. Two years ago it was only 1,8 %. Tasks and processes change according to innovation and technical progress. To date, no large company in Germany has 30% women on the executive board. Only 7% of women work in construction in a managerial position, every fourth women, however, as a highly qualified specialist. Women in construction are predominantly involved in construction planning, architecture and construction, surveying professions, calculation and cost management. The level of requirements is higher than in the commercial professions, female employees are mostly specialists and studied experts. Statistics reflect that between 2000 and 2020, on average, there was no significant change in female proportion in construction.

The number of female board or supervisory board members of the big player companies in construction, e.g. STRABAG, was zero until 2020, despite a 27% quote in the supervisory board. Though it is legally binding for companies to define their specific women quote to be achieved by 2022, HOCHTIEF and NEMETSCHEK chose 0% (Tödtmann, 2019). Statistics show that establishing diversity in the Corporate Governance Code beforehand has hardly any effect. The impetus must also come from the top management as the advocate for a positive environment for this - every day anew. Since 2018, BILFINGER has 1 female supervisory board member. Based on global comparison, no German DAX company has 30% female supervisory board members. The global player VINCI Construction's commitment to gender equality has been formalized in its Gender Equality action plan, which aims to see more female employees on teams, to the benefit of all team members. Their goal is for women to fill 25% of their management roles in 2022. In 2021, VINCI has 6 female board members (out of 16 in total) across the board.

Digital sovereignty means building on women's strengths and reducing strategic weaknesses, not excluding others or acting in a protectionist manner. Women want to shape a global world with global supply chains and shape the policy for the benefit of all. Inclusion and diversity are the guiding principles of such process, not waiting another 100 years to reach the 30% female quote based on current speed according to statistical forecast. Learning that traditionally male-dominated leadership circles are a self-reinforcing phenomenon that damages companies and society in the long term, it is time to set new sails and leave the comfort zone. Increasing female participation by a binding strategy of support and democracy in every sense is an option. The brutality of closing the gender gap and ensuring common good is evident in diverse areas: Guaranteeing the right of digital society carries over into customized academic positions in the digital era.

In Germany, as in other parts of the world, a significant number of skilled professionals leave for countries where companies need them to run innovative, diverse companies; they give full access to all working positions - without gatekeeping, but with inclusive spirit, providing most modern technical equipment and workplaces suitable to balance work and family. If Germany does not change attitudes and realize the historic chance offered by the digital era, it will lose track, the economy will lose qualified workforce, and the country will not participate in the global digital competition or move innovation progress forward. Historically, women have made substantial contributions to technical innovation as programmers and computer scientists.

The digital era can lead to "AI - Made in Germany" as seal of quality and role model for other countries. A study by Karlsruhe Institute of Technology (KIT) shows two important results: 1. AI and digital technologies have significant influence on the career choice of women and 2. Unfortunately, algorithms all too often have a "gender bias", a gender-related distortion effect, for example male thought patterns in the selection of job applicants. Thus, it is even more important to perform targeted training of machines, algorithms, and learning systems by multi-diverse teams. Only 16 percent of all AI specialists in Germany are female and are, thus, at the bottom in global comparison. Consequently, this technical discipline will get less and less attractive to women when the newly created positions should be filled with more women. This discrimination is one of the biggest problems for the future of AI applications. The legal situation is clear: Article 3 of the German Basic Law prohibits discrimination. The European Directive 2000/78 / EC on equal treatment in employment and occupation applies. This right must be enforced especially in applications of AI that evaluate people. We are still at the beginning of this debate. Understanding such interactions and dependencies among each other, AI is seen as an answer on a fair gender future; it is the approach for operationalizing the White Paper on AI of the European Commission. The motto in China "women carry half of the sky" also applies to the high proportion of women in the local tech scene.

Best Practices are evidence that disruptive changes to existing corporate diversity culture are a driver of more efficient corporate and project processes, and thus, for the increase of human and financial profits. Hierarchical structures are being replaced by network structures in many industries simply because networks are more efficient, connect around the globe, enjoy higher market valuation, are fault tolerant and self-regulating whereas hierarchy requires substantial managerial and administration overhead to secure individual nodes. Female networks, corporate culture and communication transparency, women leadership through economic crises, and female focus on speeding up diversity are a big PLUS for successful transformation and lay the foundation for trust.

Women Matter – New Approaches and Building a Legacy

This study examines the unique opportunities offered to women by the digital era. Using diversity for digital transformation and innovation with female role models inspires the younger female generation to take responsibility and be consistent. This paper draws attention to some fundamental strengths and essential personal and professional qualifications for women in STEM. Women matter to break down barriers, dissolve the glass ceiling, move forward global digital competition and increase its share in the value chain. The gender equality paradox in information and communication technology (ICT) has been a phenomenon for centuries. It is a proven fact that women can be the driver of digital transformation. Statistics and research data evaluations reflect the highly successful companies led by women and the economic, social and societal successes by strong diversity, inclusion and equality.

The construction industry stands out clearly from other industries with its unique and highly demanding manufacturing processes: On the one hand, protecting the climate and environment through the construction life cycle, from project idea to dismantling and recycling; on the other hand, completing building projects even faster, cheaper and at high quality. In doing so, the processes are supported by constantly evolving technologies. Construction industry is associated with multiple high risks in cost and budget, time planning and quality. These can be minimized with the help of digitization and AI and using women's digital skills. 3-7D digital models, visual object recognition, AI-based simulations of processes and concepts, measurements, AI-based predictive maintenance, data systems as a basis for business decisions and corporate strategies are amongst them. These new technologies create more economical and efficient handling of projects, transferring routine processes to machines, increasing protection of climate and of human and material resources and fulfilling sustainability goals. First experiences in practical application show how these new technologies relieve and support people, make communication more efficient and work processes even more secure. Women's strong social and communication skills enable education on these techniques and, thus, orientation and trust. Women are the drivers of digital excellence and highly skilled by their social competencies, empathy and strong networks (SecurityWomen.org, 2020).

It is still a long way to overcome barriers since women are still underrepresented in STEM and leadership positions. Stereotypes and prejudices still exist in large fields in the society. Instead of focusing on how to use the existing potentials best and decide the next steps of successful digital transformation, the current public debate is about the correct gender language. But it is actually time to use this historical chance, cope with the demographic change and reduce the outflow of female specialists abroad. There are still major differences between genders in terms of AI knowledge (Fig. 2 & Fig. 3) and the individual industries:

Figure 2. Gender Gaps and AI Skills Source: LinkedIn data featured in the Global Gender Gap, Report 2018. ***Source: World Economic Forum 2018***

Figure 3. Gender Gaps and AI Skills related to branches Source: LinkedIn data featured in the Global Gender Gap Report 2018. ***Source: World Economic Forum 2018***

Multiple approaches help to mitigate these limitations. Female potentials and strengths enable a build-up of trust in new technologies, recognize social aspects, improve corporate identity, address risks and moral and ethical questions in the application of AI. Representative experiences shared first-hand in expert interviews put significant light on real-world double standards about why the glass ceiling still exists, and many steps are still needed to dismantle it along with equal regulations to remove pay inequities. Whether one's interest is local or global, female scholars and female students are coached and mentored on career development. Women inspire each other for taking opportunities. The digital era offers, in myriad domains, these opportunities, from research and business to politics and policy. The agenda can be summarized as a triangle:

Programmatic

- Start inspiration and qualification at the earliest stages: higher self-confidence and self-perceived digital skills for girls, strengthen female abilities and strong performance by knowledge and skills
- Access funds without gender barriers
- Connect funding opportunities with recruitment especially in technology-related fields. Set up legal framework: mandates % regulated by law
- Embrace digital strategic alliances and prepare for a future of work accessible without gender gap
- Develop strategies and processes to continue performance and stay independent in times of crisis

Training & Development

- Promote Role Models and Mentoring Culture
- Close digital skills gaps (knowledge, qualifications)
- The European Commission estimates that by 2020, 90 % of all jobs will require digital skills. Digitization and AI create new working fields, thus, require new skills, new qualifications and competencies
- Digital skills facilitate entry into the labor market and are essential for women's safety
- Digital skills enhance women's community and political engagement. They bring benefits to corporate and societal welfare
- Digital skills empower women to help steer the future of technology and gender equality
- Digital skills accelerate progress towards international goals
- Promote hiring for gender-balanced staff: Critical goal to influence entire digital ecosystem.
- Develop a strong gender-equal reward system by 2022 that addresses unconscious bias and includes equal pay and equal opportunities
- Establish incentives, targets and quotas by embedding formal standards

Culture

- Reduce gender inequality in society to narrow the gender gap in digital skills (e.g. in less developed countries with low levels of gender equality, digital technologies provide clearest pathways to increase income and independence)
- Enabling employee workplace autonomy
- Create digital networks to build social and professional relationships
- Increase visibility through social media, digital networking

Women increase public trust in AI and the ethical implications by strong communication and consciousness. It is only by 2nd of March 2021, that Chancellor Merkel and her counterparts from Denmark, Finland and Estonia, four heads of government to the EU, address their appeal to the head of the EU Commission. They are worried about future viability and want to strengthen the EU's digital sovereignty with an offensive. "Digital value creation and digital innovations take place to a considerable extent outside of Europe" they write." Dependencies and weaknesses of European digital capacities, skills and technologies" are becoming more and more apparent. They see a need for action particularly in the area of artificial intelligence (Merkel et al., 2021). Since Biden moved into the White House, there has been a growing interest in technology-political cooperation with the United States in Berlin and Brussels. "Basic democratic values are under considerable pressure worldwide in the digital age", which sends a strong signal that there is a historical chance now of assuming leadership to build a legacy while reshaping digital transformation by strengthening values and ethics and fully using female potentials. Women around the globe, both in Construction and other branches, are witnessing the growing power of women associations leading to win-win scenarios, inspiring generations to come and move women leadership forward. They receive strong support from national and international networks and associations promoting diversity, solidarity and equality in fields of STEM, construction and digitization: The Association of German Female Engineers (dib), Member of the German Women's Council (Deutscher Frauenrat), German Competence Center for Technology - Diversity - Equality (Kompetenzzentrum Technik - Diversity - Chancengleichheit e.V.), International Network of Women Engineers and Scientists (INWES), U.S. National Association of Women in Construction (NAWIC) with affiliations in South Africa, New Zealand, United Kingdom, European Platform of Women Scientists (EPWS), WoMentor (European Federation of Mentoring for Girls and Women), Global Digital Women, SHE WORKS! – Network for women in companies or start-ups in Digitization, Finance and Marketing.

Making and Sustaining the Breakthrough

The digital era is marked by an exponential development and adoption of emerging technologies, as well as an accelerated pace of scientific discoveries. There are four main pillars of disruptive and transformative change our society needs to undergo to enhance There are four main pillars of disruptive and transformative change our society needs to undergo along technological advances and diversity: technological advances and diversity: educational, professional, cultural and governance. It is important to address all levels of education starting with preschool and going all the way to executive education. Furthermore, embedding the skills that are expected to be in highest demand in the digital era would need to be embedded into the classical curriculum. Ensuring that women of future generations have access to quality education early on is a crucial task. WEF highlights that some of the top skills in demand by 2025 will be creativity, analytical and innovative thinking, active learning, complex problem solving, as well as technology design, use, monitoring and control to only name a few (World Economic Forum, 2020).

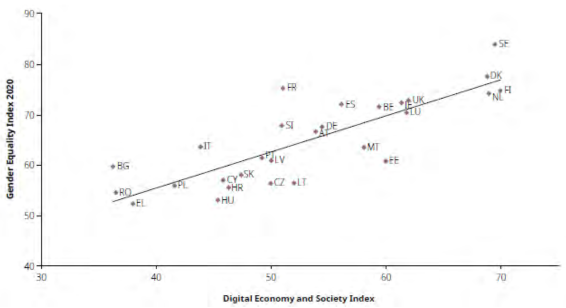
We have major challenges to overcome ranging from unintended childrearing consequences on gender roles, to creating an inclusive and diverse business culture, and reshaping societal cultural biases.

Some of the latest emerging technologies (such as Block chain, Artificial Intelligence, Next Generation Computing, 5G and 6G, 3D, IoT, AR, VR and XR etc.) can serve as catalysts or gateways to enhance inclusion and diversity when deployed mindfully. However they can also easily become the conduit for severe unintended consequences that worsen the gender gap. Developing state of the art proactive digital ethics programs that facilitate and accelerate the attainment of the United Nations Development Goals would be optimal for long term success. Although at first glance we should focus only on SDG #5 which stands for gender equality, it would be wise to have a complex approach and support all the other goals as they affect millions of women globally. By ensuring that women are involved in the decision making process for solutions that aim to reduce poverty, reduce world hunger, improve health and maintain wellness, offer access to quality education, offer clean water and sanitation, or offer equal employment opportunities, we ensure a more inclusive approach that does not leave any girl's and women's rights neglected.

Gateways for Empowering Women Leadership

The digital economy is shaped by several important domains such as digital infrastructure, digital services, digital jobs and digital content generated by various digital products or services. Strong women leaders could be highly conducive to addressing this gender justice urgency and positively influence, reshape and recalibrate the digital economy, while also ensuring that we set the stage for a more inclusive and diverse 5th industrial revolution (Balbo, S., & Marenssi, V. 2021). The role of women in shaping the digital economy depends closely on the awareness that diversity and gender equality increase profits, productivity and innovation. It lays the foundation for female leadership. The correlation between gender equality index and the digital economy and society index indicates that societies with greater equality - namely Scandinavian countries - also perform better in the digital economy, which is vital for sustainable economic growth (Tab. 4).

Tab. 4: Relationship between Gender Equality Index and the Digital Economy and Society Index Source: Gender Equality Index 2020-Digilisation and the future of work. European Institute for Gender Equality



Despite its many financial and operational benefits, finding and retaining diverse talent remains a struggle for organizations. The benefits are associated with greater diversity, and assist the best practices in the process of finding, hiring and retaining the most diverse talent. Talent intelligence e.g. instantly triples diverse talent. AI-driven talent intelligence instantly triples talent pool diversity while cutting recruiting cost by up to 60%. Diverse teams are 35% more profitable and 1.7 times more innovative. Interview pools must have at least 40% diversity to realize increases in talent diversity and blind hiring processes. Can AI application help to unlock diversity and increase profits and retention? With the impacts of COVID-19 and ensuing life changes disproportionately impacting women and making them more vulnerable to the economic effects, new approaches are researched. Those companies who experienced greater financial success and higher returns for shareholders, across multiple industries, have the highest representation of women leadership teams. The 2015 McKinsey & Company report found that the top quarter of companies for gender diversity were 15 percent more likely to earn above their industry standard compared to similar companies with less diversity. Conversely, those companies in the bottom quarter for gender diversity were statistically less likely to achieve financial success.

Companies that prioritize gender equality in their hiring practices and workforce also earn 41 percent higher revenue than those that don't. More recently, McKinsey & Company found that companies with diverse leadership teams were 21 % more likely than their counterparts to outperform profitability. They were also 27 % more likely to create and deliver value (McKinsey & Company, 2020). Best performers are the financials, healthcare, real estate sectors, while the laggards lie in the tech sectors. It often comes down to unconscious and sometimes conscious biases getting in the way of creating diverse work teams. We tend not to notice these injustices until they are pointed out to us. This may be especially true of men in hiring positions. Research has found that about half of all men believe women are equally represented in the workforce, even when only 10 percent of senior leaders in a company are women. Most processes happen based on how we are conditioned and what we grow used to. That is where intentionally diverse hiring practices come into play, like employing software that pre-empts unconscious biases and produces unbiased ranked lists of top candidates for every opening. Recruiting teams have to make their commitment to interview as many women as men. To be on the lookout for women in the current workforce who may be good candidates for promoting up. And most of all, to fill leadership teams with just as many women as men. Hillary Clinton stresses "Women are the largest untapped reservoir of talent in the world." Equality isn't going to happen overnight, but recognizing the need to strive toward that goal is the first step to reaching it. Companies that make that commitment are going a long way.

Business Transformation

We are witnessing an increased expectation for diversity, inclusion and advocacy for the environment, social impact and need for global governance. Empowering women with excellent negotiation and mediation skills, sharpening their financial acumen and offering them high performance coaching for board room positions can move the needle for future generations.

The pandemic crisis has highlighted the need, value and appreciation for empathic and humble leadership styles. Infusing a human-centered design thinking approach in the global business transformation process can ensure that the human transformation aspects are managed simultaneously with the digital transformation journey (Deloitte, 2021). Women are likely to excel at deploying the design thinking methodology as several studies have reported a natural tendency towards empathy and a more collaborative approach during their decision making process. There are a few surveys who have also indicated that women leadership drove organizational performance due to their participative decision making style, their efficient communication skills, and emphasis on people development.

Digital Innovation

International Women's Day 2021 honored female innovators and sent a strong signal across the globe that promoting women innovation is strengthening entrepreneurship ecosystems. However, this event also highlighted the gender abyss for innovation leadership roles and the need for a transformative change. Another indicator that correlates with the lack of women in STEM is the percentage of technology patents awarded to women. Despite tremendous strides from 1809 until the present day, we still have only a small percent of women compared to men. A great paper on this topic by Jorge Dominguez encourages optimism and quotes Marie Curie - the first woman to win a Nobel Prize and the only women to win two of them - by stating: "we must have perseverance and above all confidence in ourselves".

Digital Transformation and Gender Bias

Emerging technologies play a fundamental and catalytic role in digital transformation. We are witnessing an increased adoption of these technologies and an increasing number of global organizations that have recognized their long term potential aim to encourage women participation by creating social platforms and professional networks to empower women in AI, Blockchain, Nanotechnology, Next Generation Computing and other emerging technologies. AI and digital technologies help creating new and more inclusive governance models to overcome gender gaps. But, at the same time, AI may be "contaminated" by gender bias. Empowering women in AI tech offers ways to avoid bias: When deep learning systems are trained on data that contain gender biases, these biases are reproduced in the software. As one prominent female researcher in the AI field put it, such systems are 'bias in, bias out'. Bias comes in three main types: understanding who the user is and how they might use the software, bias in the data when feeding data to train algorithms delivering incorrect or biased suggestions to the user, bias in the product design making it unappealing for certain categories. Technology reflects the values of its developers, and that of the information they draw from. It is clear that having more diverse teams working in the development of such technologies might help in identifying biases and prevent them. The reach and impact of technology is so great that the limited representation of women on technology teams threatens to both perpetuate existing gender inequalities and impose new types of gender imbalances. Whether machine learning, advanced robotics, big data analytics or some other wing – this is where norms, including those related to gender, are negotiated and set. In addition, multiple research findings have evidenced that the trust of users and customers increases with the increase of women developing and testing the technology.

Women are underrepresented, so there is less data, data of lower quality, not free of bias. Thus, results are unpredictable and unexpected. There are serious concerns regarding the scalability of taking automatically biased decisions that can affect large sectors of the population, particularly minorities and more vulnerable communities. A growing body of evidence is indicating that algorithms are increasingly affecting decisions (Leavy, S. et al, 2020). Machine learning tools which can automatically take decisions represent high risk impacts by replicating unequal or unfair treatments (Leavy, S., 2018). Despite an increased adoption curve globally, other emerging technologies such as Internet of Things, 5G and 6G networks, virtual and extended reality, quantum-, cloud- and edge computing, 3D printing, nanotechnology, next generation sequencing are still lagging significantly in narrowing the gender gap for women leadership and gender parity is likely to take more than a decade. After AI, Blockchain and Cryptocurrencies, Women in Quantum Computing seem to be an upcoming trend as we are observing an increased interest. In 2020, *The Quantum Daily* published an article showcasing the top 12 women pioneering The World of Quantum Computing and a more recent 2021 Scientific American article highlighted, that the quantum computing revolution must include women.

Another promising emerging technology, that can leave its mark in this 4th industrial revolution, is 3D printing. A recent article showcased a few women leaders whose major contributions have elevated the 3D printing industry. Most notable were Neri Oxman, a designer and professor at MIT Media Lab, who won countless awards for her work in design, technology and 3D printing, as well as developing a new concept of architectural philosophy based on material ecology. Nora Toure is also worth mentioning in this paper; she is founder of "Women in 3D Printing", whose mission is to promote, support and encourage women to take a leadership role in manufacturing technologies.

The digital era has introduced virtual reality (VR), augmented reality (AR) and extended reality technology (XR). Over the past few years we have noticed deployments shifting from mostly entertainment to new industries. Construction, architecture and real estate are amongst those. Experts highlight several ways, AR and VR will revolutionize construction and women leaders play key role. Whether VR is used for virtual collaborations, training, project planning, or modeling and visualization it promises to redefine construction jobs of the future. The concept of digital twins is frequently used for industrial training and safety. However, it can also be extrapolated to digital twins for identity management, human resources and advisory board roles of the future. The same significant rise is noticeable in robo-advisors for wealth management. It is foreseeable, that gender parity could be achieved by deploying digital twins in other male-dominated industries, such as construction.

Women share common values, act as ambassadors of excellent academic education that moves forward societies, diversity, equality, digital innovation and lay grounds for digital transformation. The pure "women in leadership role" debate may be misleading and worsen the gender gap leading in the wrong direction. The debate is not about the repression of men or reversing the gender gap. The debate revolves around closing the gender gap - due to decades of imbalance and exclusion - and optimizing the value chain by using the resulting potential. An inclusive discussion requires detailed and step-by-step measures to be taken. Instead of broadly discussing mandate positions it is essential e.g. to define and allocate explicit appointments of the chairman of the supervisory board, or member of the supervisory board, or member of the board of directors, or chairman of the board of management. Especially in the construction branch, role models in such mandates and boards are still missing. However, digital innovation and transformation hold strong potential for a 360-degree change and significant rate of employment growth.

How do remarkable women lead and how did they make their way through? What is the Breakthrough Model for Work and Life? Where do they struggle most? What helps most to overcome and stay successful? A woman can only find her way into her leadership role if she trusts in her skills, is qualified, believes in herself and keeps persistent. Not too seldom women deliver a 200% performance when entering the field of competition with men. In order to get German companies engaged to give women access to leadership positions and promote qualified women, since 2015, all companies have to have at least 30% women on their supervisory boards. New Zealand implemented that equity issuers must now disclose in their annual report a breakdown of the gender composition of their boards of directors and officers, as well as an evaluation of their performance with respect to any formal diversity policy they may have. Initiatives in the U.S. like "2020

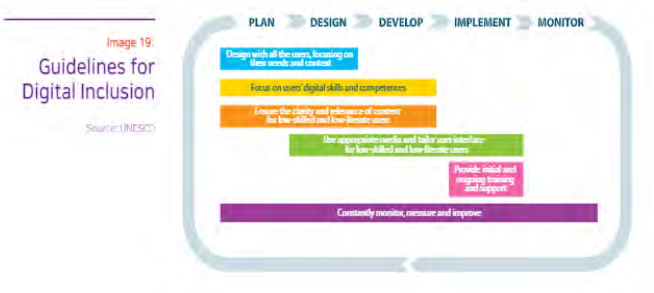
Women on Boards" and "The Alliance for Board Diversity" strengthen the shareholder value via the inclusion of women. Instead of a penalty for noncompliance with gender balance, the Spanish government pointed out that it will take compliance into consideration when assigning certain public contracts. The promotion of women ensures excellence. Diverse, inclusive working groups ensure a variety of perspectives and, thus, a quality boost for research and development. Interviewed experts in research and development confirm that the perspective and expertise of women is important for the decisions made in the committees. The opportunities for women in the digital era are massive, and now is the best time to take a closer look. Will automation and algorithms endanger male or female professions? Will the compatibility of family and work be improved by making it more flexible, or is it rather worsened due to constant availability? Which gender has greater needs when learning the digital skills that will soon be required in all professions? The digitized world of work is a matter of design, and the effects on people depend on the practical implementation, not on the technology alone. The effects of digitization on work and life are gender-dependent. This is not the only but a strong reason why women need to be more involved in research and design of ML e.g. (Tab. 5) in order to participate equally in decision-making processes and shape the digital transformation.

Tab. 5: Gender balance in ML research ***Source: EQUALS Report 2019***

Will digitization and AI make STEM professions (Science, Technology, Engineering and Mathematics) more attractive for women because of the more flexible working environments that offer multiple advantages for female employees? Agile structures and methods favor women's careers, since leadership is mainly understood as shared team leadership, conveying meaning and working on relationships. This development is predicted by many researchers, but it requires certain conditions: Women need a positive attitude and motivation towards digital technologies as well as digital skills.

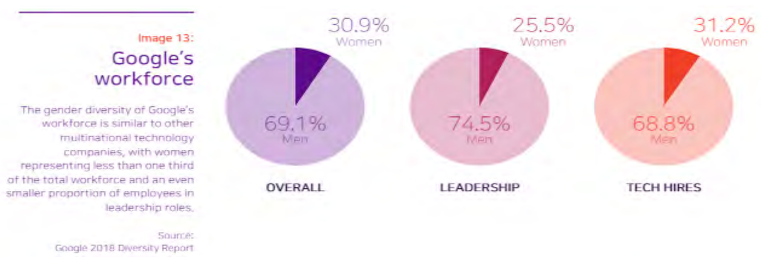
According to the Global Gender Gap Report of the WEF 2019, for example, only just under a quarter of those employed in the AI-sector are women, and in Germany only 16%. And women are even less represented in decision-making positions where decisions on strategies of digitization and specific applications are taken. Why is it important for women to have a say in shaping the digitalized world of work? Because the perception of technology and its consequences is gender-dependent, the approaches to problem solving and the dealing with the effects of digital technology on work and life are gender- dependent, accordingly. Gender 4.0 raises awareness on the female affinity for technology and digital competence. Women use digital technology more intensively than men - young women communicate more often and use digital media for learning. For the digitized world of work, not only digital skills in the narrow sense are required, but also social and team skills, the ability to innovate and learn as well as interdisciplinary cooperation – throughout the digital inclusion`s life cycle (Tab. 6). With their talents and skills, women have advantages over men.

Tab. 6: Guidelines for digital inclusion ***Source: UNESCO Report 2020***



However, many companies are specifically looking for women to shape their digital transformation, as they expect an improvement in corporate culture and higher corporate sustainability performance, in the social and ecological field (Zehnder, 2021). A study by Zehnder resulted in a 6% higher sustainability performance - and with strong preference by the capital market - by companies with strong female boards. The increase of pressure by society and orientation on environmental and societal criteria favor such long-term development. New business models and transformative digital processes give reason for optimism and hope for young women, soon to benefit from taking responsibility and leadership roles.

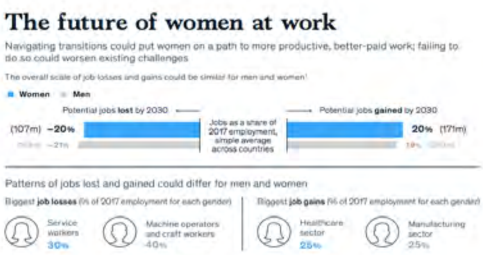
Tab. 7: Google`s diversity workforce 2018 ***Source: EQUALS Report 2019***



Google's gender diversity is similar to other multinational technology companies with women: less than one third of the total workforce and an even smaller proportion in leadership roles (Tab. 7). Carly Fiorina announced in 1999: "I hope that we are at the point that everyone has figured out there is not a glass ceiling." Years later, Clinton, Pelosi, Rice, and Obama recount endless examples of still-existing sexism. Are we ready to elect a female president? In 2021, we get closer in the US - Vice-President Kamala Harris. In Germany, for the past 15 years Angela Merkel has been chancellor. But the country needed a women quota. As of 2021, the quota model will gradually stipulate a minimum proportion of women in executive bodies. The proportion of women on the supervisory boards of companies represented in the DAX is 21%.

Role of Women in Human Transformation and Shaping The Future of Work

Tab. 8: The Future of Women at Work Page 9 *Source: McKinsey, 2019*



As stated prior, business transformation must include digital transformation that is synchronized and harmonized with a profound human transformation process. This transformation will cause a technological, social and cultural disruption that will redesign the way we live and work. There are several pathways to challenging the status quo and redesign The Future for Women's Work in order for women to be "valued and recognized for their contributions" (Frye, 2020). A new global governance model, big tech regulation, governmental mandates and impact investment incentives are all mentioned frequently by international experts that emphasize a top-down approach. However, equally important will be a bottom-up approach that will include access to high quality connectivity, educational and professional programs for digital skills and other future-ready skills, access to financial resources, custom designed innovation and accelerated programs that address the unique needs of women (Tab. 8, 9).

A recent comprehensive *Jobs of Tomorrow Report* published by the WEF reflects how 96 new jobs across seven professional clusters are emerging in the digital era. It is a moral imperative to ensure, that women will have equal access to learn and excel in these novel skill sets as they will generate 6.1M job opportunities globally. Another report highlights the need for a re-skilling and up-skilling revolution for all, with a specific emphasis on a targeted approach for women who have suffered great setbacks during this pandemic crisis. By 2022, 54% of all employees will require re-skilling to meet the digital era needs. The International Monetary Fund projects that 11% of jobs currently held by women are at risk for elimination due to digital technologies.

Tab. 9: The Future of Women at Work Page 18 *Source: McKinsey, 2019*

Exhibit E1

There are strong gender-based differences in employment within occupations and sectors in mature economies.

Occupation and sector gender mix, 2017
% of female workers out of total workers in sector and occupation category (weighted average across mature economies)[1]

<40 (male-dominated) 40–60 (gender-neutral) >60 (female-dominated)

	Elementary occupations	Clerical support workers	Agricultural and fishery workers	Service workers and shop and market sales workers	Machine operators and craft workers	Professionals, associate professionals, and technicians	Legislators, senior officials, and managers	**Simple average across countries**
	Wage increase →							
Accommodation and food services	59	66	21	60	30	50	45	59
Administrative and support and government	56	73	16	23	14	53	41	42
Agriculture, forestry, fishing, and hunting	51	86	30	50	12	42	21	32
Arts, entertainment, and recreation	47	63	28	51	17	45	39	49
Construction	7	80	0	21	2	20	12	12
Educational services	61	78	33	76	26	69	57	66
Finance and insurance	47	73	25	53	23	50	41	54
Healthcare and social assistance	72	87	4	84	27	76	66	78
Information	38	62	25	33	13	29	25	35
Manufacturing	33	56	34	42	25	25	20	30
Mining	11	63	8	16	4	19	16	14
Other services	62	82	22	51	17	50	49	54
Professional, scientific, and technical services	46	74	23	46	16	41	35	44
Real estate and rental and leasing	35	81	25	32	7	52	42	44
Retail and wholesale trade	38	62	51	54	20	49	31	50
Transportation and warehousing	24	48	33	45	10	27	22	25
Utilities	10	42	17	36	3	22	19	20
Simple average across countries	**45**	**72**	**24**	**60**	**15**	**52**	**31**	**47**
Median income[2] $ thousand, PPP	22.6	25.2	29.2	30.6	31.7	41.6	59.9	34.4

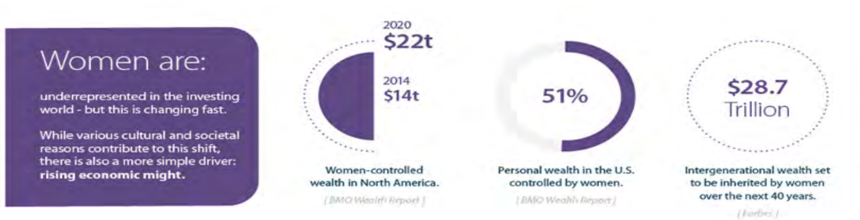
[1] Based on weighted average of Canada, France, Germany, Japan, the United Kingdom, and the United States.
[2] Determined by estimating the median income of each of the detailed occupations within each occupational category, and then calculating the median income across those detailed occupations.
Source: ILO 2017; CPS IPUMS; ONS 2017; Japan National Survey; EUROSTAT, 2016; Statistics Canada, 2016 Census; McKinsey Global Institute analysis

Despite increased advocacy for women in STEM we are still facing a major shortage with women holding only 36% of STEM university degrees, yet 56% of overall university degrees. International talent management and human resource experts recommend several strategies to address these challenges (IMF, 2021). One of the major recommended strategies relevant to our paper is to encourage inclusive and diverse leadership in companies, as it drives innovation and ensures resilience. Other important strategies revolve around redesigning work schedules, workspaces, work benefits, resolving pay gaps and creating an inclusive work culture by eliminating harmful stereotypes.

Role of Women in Impact Investing

The Digital Era Investments vision for women can be encapsulated by the motto: “Women as funders - Women as founders”. It is essential to address both in order to be successful and create a sustainable women investment ecosystem. Creating strong technology-powered women angel investor networks and women VC networks, in developed and emerging markets, is key and will require global collaboration among policymakers, legislators, entrepreneurs, academia and private industry.

Tab. 10: Unlocking the Power of Women in Investing ***Source: Visual Capitalist, 2019***



Over the past year we have noticed an increased interest in impact investing, however we now have to shift our focus towards translating advocacy to action and analytics driven monitoring of outcomes. Private impact investing will play a key role in funding all United Nations Sustainable Development Goals not only SDG #5 (Women Equality and Empowerment), however it is also an imperative for governments around the world. It is expected that women leaders will be well suited to lead, facilitate and promote these types of investments. A recent UBS report titled “Changing Face of Wealth” estimated, that, by 2023, 34% of women’s wealth will be led by women and - hopefully - be dedicated to support other women in business, while having a positive impact on our society and the environment (UBS, 2021) (Tab. 10). On the more optimistic spectrum, there are some experts foreseeing, that women will lead the way during the impact investing revolution of the digital era.

However, the current realistic assessment reveals severe under-representation of women in the venture capital and angel investment arenas. A *Harvard Business Review report* published February 2021 (Harvard Business Review, 2021) highlighted that women-led startups received only 2.3% of VC funding in 2020; the average size of a VC deal for all women teams was $6.8M versus $18.7 for all male teams and only 12% of decision makers in VC funds are women. Until these statistics change and the desired positive outcomes are achieved, we must continue building entrepreneurial ecosystems that promote development of women-led and women-powered investment networks.

Inclusive Ethical Leadership

So what is the role of women in creating a robust and sustainable culture of digital ethics (APA Psycnet, 2011)? Moral values, as defined by the ancient Greeks, are wisdom, courage, self-control and justice. They do not differentiate between the gender. However, we have witnessed numerous stereotypes over the years - unable to resolve. One prevailing misguiding message in Western Society has been to act more like men in order to succeed, with an emphasis on career advancement regardless of one’s own moral values or ethical conflicts. There are numerous meta-analysis publications highlighting gender differences in ethical decision-making. However, the authors believe, that, what is important for future generations, is to design a culture of ethical leadership in the digital era, free of gender differences (Amorelli et al., 2021). Mindfully deploying emerging technologies to assist in reducing some of the gender bias encountered historically could be one solution. For instance AI-powered human resource processes have already been deployed successfully in various industries and could become the norm. Likewise, we could conceive an AI-powered ethics advisory service and an AI-powered board governance model. However, a study concludes, women were less ready to compromise their ethics in pursuit of success at work (Kennedy et al., 2013).

Future Outlook

In this new era of globalization, hyper-connectivity and digitization it is crucial for key decision makers to collaborate and design a global governance model that suits the new remote work trends we have witnessed and that are likely to become dominant. In addition to interoperability, standardization, portability, harmonization of laws, regulations and policies, leaders at all levels are strongly recommended to consider gender equality as a major challenge, urgently addressed by key global decision makers.

Education is one of the core elements to build gender equality. However, how shall an optimal "future-proof" curriculum be defined and designed? Who is qualified to teach young children skills that will be beneficial for their future life and careers? Shall, and if yes, how shall their performance on this revised future-oriented curriculum be scored?

There are numerous indexes and metrics that measure gender diversity, however, most are retrospective. Future research could include real-time analytics enabling key decision makers to adjust and course-correct as needed. Further improvements would be to use digital twins and AI-powered hiring mechanisms to reduce or remove the potential for numerous biases. Should we succeed in redesigning our education system, it will also be incumbent upon us to design real time analytics that measure the impact of our novel curriculums and engage in a culture of continuous improvement in order to not repeat the mistakes from the past several hundred years. Should policy makers be successful in implementation mandates or financial incentives that change the paradigm in gender equality, we would also need to design customized performance indicators by industry to measure the impact of those changes.

Promoting and adopting an exponential style of thinking, as well as cultivating an abundance mindset - as suggested by Stephen Covey - would also be highly beneficial for our society, as they are powerful concepts that can transcend the digital or gender divide (Stephen R. Covey, 1989). Exponential thinking leverages the massive technological advances and large scale adoption we are currently witnessing, and encourages us to divert from a linear and short-term thinking style in order to be future-ready. It promotes the shifting from thinking about all the reasons why something is not possible to identifying what is possible. The abundance mindset paradigm has proven to be a highly successful business model and has profound implications from an inclusion and diversity perspective. By infusing these concepts into the DNA of our education and professional development architecture, we can hope that future generations will successfully bridge the gender divide.

The digital era has brought upon a digital revolution in the way we live and work. Protecting human rights in this digital era and optimizing them to match the requirements of the 5th Industrial Revolution is a moral imperative (United Women, 2020). We wish to generate a call to action for all stakeholders to play an active role in adopting a Global Declaration of Digital Human Rights (World Economic Forum, 2020) for future generations that will live in smart cities powered by 6G, Internet of Things, Quantum Internet and the Metaverse.

The author believes in a world where integrity, respect, empathy, humility, fairness and justice will prevail. Although this paper does not aim to cover all of the important topics related to women in the digital era, it offers new insights that can help leaders, makers and activists, female candidates and young generations to understand ways to move the dialogue forward. The paper addresses fields of action by providing a constructive agenda.

Think Piece 1: Small circles always draw big ones. What is the earliest moment to sow the seeds of values and morals, gender equality, respect and empathy? At the earliest stage of childhood, when children soak in what is discussed with their parents, draw strength and inspiration from the open dialogue and from parental role models, be able to say what they think, learn open discussion and mindfulness. On such a basis much good can flourish and society can develop itself further with values preserved. The digital era offers a historical chance for women empowering successful transformation, a legacy.

Think Piece 2: Diversity is a key factor. Shaping the world's digital future presents a digital transformation vision that works both for women and men, free of stereotypes and gender pay-discrepancies.

Think Piece 3: Female competencies, strengths and visions are still unused and open to a large extent. Fundamental change by inclusive, innovative corporate commitment is the basis to master successful business strategies and for adaption to digitization and AI. Role models and adjustments on academic and professional education and qualification portfolios prepare the new female generation for new technological challenges and get inspired to new career paths.

Think Piece 4: On 2nd of March 2021, Germany Trade and Invest announced that building efficiency in Germany gets a 6 Billion Euro funding boost in 2021. Sending a strong signal for the climate and the economy, Federal Minister Altmaier has outlined vast new federal funding measures for the building sector that are expected to double the related CO^2 savings by 2030. The construction industry not only offers a large niche for women, but is in severe need of female key competencies to further develop innovative technologies, bridge massive digital gaps, reach SDGs, and elevate the branch and its global digital competitiveness to the next chapter in history. So if not a quota, what else? Quite simply, just this: equality of opportunity.

This study demonstrates that women in construction - a typically male-dominated industry and one that does not satisfy gender equality and diversity - are strongly needed for a successful digital transformation. Overall, there are insufficient organizational mechanisms, hardly any corporate commitments to let women access the same career opportunities as men. Nonetheless, the study shows that women - despite facing barriers - can resist and combat the gender-bias because of their high qualifications and proper personal and organizational support.

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Exploring the Sharing Consumption Economy: Insights from the P2P Car Renting Platforms

Daisy Bertrand (Aix Marseille University)

Problem/Goal

The car is not only a means of locomotion but embodies many personal investments and desires. However, the car rental market has been booming in the last few years: in 2018, 7.7 million renters made more than 20 million short-term car rentals. This short-term car leasing appears to be an essential mobility service because it corresponds to a new consumer trend that is more focused on use than possession of a vehicle. This growth can also be explained by a sustained increase in tourist activities in recent years, and changes in people's behavior towards the car, rising fixed and maintenance costs of vehicles and increasing difficulties in parking in large cities (capacity, cost).

In this fast-changing market, competition is significant: the intra-sectoral competitive pressures of the historical players are accentuated by the breakthrough of non-specialists who are diversifying and, more recently, by the arrival of new entrants like P2P short-term car rental platforms who are exploiting the advantages of digitalization to offer new mobility-related services.

This research compares the service experience of consumers when they rent a car from a professional company or through a P2P sharing platform and to highlight the strengths and weaknesses of each type of provider.

Theoretical background

Unlike the historical short-term car rental players, P2P sharing platforms do not own any vehicles but they act as an intermediary between an individual car supplier and an individual customer. Their basic activity is to manage a classified ads website to connect people who want to make their vehicle available to people who are looking to rent a vehicle for a short period of time, and to manage communication, marketing, administration, payments, and customer service. However, the core of the car rental service (reservations, customer contacts, car disposal and return) is exclusively delivered by non-professional providers who also carry out most of the customer contact.

The terms 'service experience' and 'customer service experience' has been used in many studies. If they share many features, they focus on different actors: 'customer service experience' focus only on the customer while 'service experience' include all the relationships between organizations, processes, service employees and customers. If there is no agreement on a single definition of the customer service experience and no consensus on how to measure it, most authors agree on distinguishing the immediate experience of the service's delivery from the pre-purchase and post-purchase phases.

In the case of car rental service marketed on sharing platforms, these distinctions are particularly relevant as the service proposed to the customer is fragmented between two different actors: Platforms provide only online services in link with the pre-purchase and the post-purchase phase while hosts provide mainly on-site services, specific to the second phase. The customer interacts thus between a virtual and a physical channel and that has an impact on his overall satisfaction.

This service situation has now become quite common: the dissociation of the different phases of service delivery is increasing with the generalization of the Internet. This dissociation generates a new context of consumptions because, unlike traditional services, the customer of a multi-channel service is alone at the time of purchase and after-sales, and is therefore sensitive to service attributes different from those which traditionally impact the assessment of the quality of service and customer satisfaction.

Methodology

A netnographical method was used to study consumers' point of view. More than 700 comments left on the net over a period of 7 months by consumers who rented a vehicle from major car rental companies, and consumers from P2P sharing platforms acting in France were collected. They were subjected to a content analysis from an inductive perspective to bring out dimensions of analysis as advised by Spiggle (1994).

Results

The content analysis has allowed 6 dimensions and 26 sub-dimensions to emerge: the core of the offer - the vehicle and the reception (staff or owner), but also the financial aspects of the rental, the Website, the concept, and the elements of guarantee. In this presentation, only four major findings will be discussed.

A. The website is the strongest point of P2P sharing platforms. Consumers say it is well designed, pleasant, ergonomic, and attractive and feel that the platforms master both the technical aspects of the Internet and the marketing. This is important as their website is the only showcase of the proposed service and the only access to this service. However, consumers regret that the P2P platforms' Websites do not provide sufficiently complete information, particularly on prices and on the actual condition of the vehicles offered. The low price, for example, is a strong argument on websites to attract customers, but they do not always clearly mention the additional costs, making this price much less attractive and making it difficult for the consumer to compare the different offers

B. In traditional services, provider   charge of the full customer service, from the information request to the delivery of the service and the final payment. In this way, they can offer smooth, easy, and fast service processes.

On the contrary, in the P2P sharing offer, services are split between the platform and the individual vehicle provider. According to the consumers' comments, Platforms have for the most part succeeded in setting up smooth online processes, but the final completion of the core service is still based on non-professional actors leading to great heterogeneity of services and not always smooth relations between the platform, the supplier and the consumer, especially in case of problems.

C. As mentioned earlier, in the P2P sharing offer, the core of the car rental service (vehicle and contact) is delivered by individual suppliers. While consumers' comments highlight the quality of the vehicles, their comfort, and their equipment, they also denounce their condition, their lack of cleanliness or conformity with the offer. Concerning the people in contact, consumers appreciate their responsiveness, their accessibility but point out the quality of service that does not meet their expectations due to cancellations, non-available vehicles, etc.

The services provided by peer-to-peer platforms are not formatted in the same way as those of an integrated company or those of franchisees applying a network policy. Moreover, platforms cannot guarantee the quality of the service as they have no direct influence on the providers. However, customers expect the rental to be as promised on the website and expect the provider to behave in a professional manner.

To manage this quality, platforms are implementing tools such as user reviews, evaluations, labels, and referencing to reassure consumers and indirectly influence the individual provider.

D. Many of the comments are about the platform's customer service and focus on the shortcomings of that service in resolving the problems customers encountered during the rental. These comments indicate that not all platforms have a customer service that is really dedicated to making up for service accidents and that they are not fulfilling their role as a trusted third parties. The creation of customer services aimed at genuinely helping customers in difficulty and verifying vehicles appears to be a differentiation strategy between platforms and a sign of the maturation of the commercial sector.

Conclusion

P2P car rental is a sharing activity that is emblematic of the substitution of service for ownership. However, if they propose a very large and diversified offer of vehicles, spread over the whole territory, the platforms encounter serious quality problems of the service provided by the non-professional suppliers and real problems of management of this quality.

A certain mimicry seems to be at work between the traditional offer and the P2P sharing offer, which leads to exacerbate competition: both seem to have improved their offer, precisely where the platforms located their initial advantage (prices and website). Moreover, both seem to have opted for a model that allows an unbalanced customer relationship. The challenge for these new players in the future will be to manage the quality of services to keep the trust of consumers and not tarnish their brand image.

Prototype for the Analysis and Visualization of Data for Municipal Parking Management as a Cloud Service

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Problem/Goal

Data is an important resource for future mobility and municipal parking management. Many cities already have broad datasets, however, these are usually insufficiently integrated in analyses. Municipalities are trying to figure out how to utilize their data for parking management and traffic control. But Public administrations often lack the necessary human and infrastructural resources to implement their own data evaluations, forecasts and models.

The organizational structures in municipal administrations often make it difficult to collect and view city-system-mapping data across disciplines. Therefore, on the one hand, municipalities need knowledge about existing data sources within municipal administrations to link information in a meaningful way. On the other hand, there is a need for collaboration tools that promote interagency collaboration in data analysis and that do not require advanced infrastructure, such as data centers with information technology (IT) experts.

For high-performance systems, the simple scaling of resources and to reduce maintenance effort, cloud based offers of hyperscalers such as Amazon Web Services, Microsoft Azure, Google Cloud Project, or SAP Queries and other cloud service providers have become increasingly popular in recent years, also in the public. The solutions of these providers consist of individually bookable modules that fulfill various functions from data collection and storage to analysis and forecasting. In many cases, the first challenge is selecting the right combination from the large number of modules with very similar functions. Furthermore, the analysis tools are often rather generic in order to appeal to a broad mass. Occasionally, there are very special, industry-specific tools that do not respond much to the specific needs of municipal stakeholders. Although custom applications can be developed in addition to the supplied analyses and machine learning (ML) models, many municipalities lack the necessary artificial intelligence (AI) experts to do so. In addition, the solutions offered partly lack the necessary transparency about the methodical traceability of data evaluation and compliance with data protection regulations.

For this reason, Fraunhofer IAO is developing a prototype of a cloud service that provides municipal actors with relevant information on the control and management of parking space based on their supplied data. The service offers functionalities to visualize municipal (mobility) data in an appealing way, enrich the data with publicly available data and offers analysis options, which also allow for integrated investigations and data grading.

The aim is to show municipal actors the added value and potential of their data and to enable them to carry out their own evaluations.

Methodology

In the context of service development, an agile and user-centered approach is chosen. The cloud service is to be developed according to the Scrum method. To meet these requirements, the interdisciplinary development team of Fraunhofer IAO has designed a two-stage procedure: In a first step, personas of departments in the municipal administrations for which the use of such a cloud service will be designed are created based on expert interviews. User needs are identified, and functional and system requirements are derived from them, which are recorded in a product backlog.

The second step consists of the prototype development and testing. According to the agile scrum method, the defined functions of the service are categorized, subdivided into sub-modules and assigned a priority level. In subsequent sprints, developers independently assume responsibility for processing individual elements of the backlog, or sub-modules, in the areas of programming, testing and further development. The innovation process is accompanied by experts from municipal administrations, politics, parking operators, technology providers and data specialists, who give feedback on the modules and can act as test users.

Results

Overall, data analysis skills are generally assessed as low to moderate within the municipal departments. Therefore, it is planned to design the cloud service in such a way that it does not require any programming knowledge and can also be used by beginners. In total three main components were identified, which the prototype shall provide. These are described as building blocks below:

Building block I – data upload and integration of external data sources:

Users shall be able to upload their own municipal data via an upload function, which will be stored in a cloud. By means of checkboxes, users shall be able to manually classify the data before uploading it. In addition, it shall be possible to import external, freely available data sources via interfaces to open data portals (e.g. OpenStreetMap®). Furthermore, users shall receive information on data storage and processing. It shall be possible to delete individual personal data on request without having to remove entire databases.

Building block II – data and user management:

Before using the cloud service for the first time, municipal stakeholders shall have to register, which creates a user profile. The personal area shall provide an overview of already uploaded data as well as own and shared analysis results. Inter-agency communication and collaboration is to be promoted through user management, which can be used to create groups, assign authorizations for individual persons and departments, write notes and assign tasks.

Building block III – data analysis and visualization:

The unique selling point of the prototype developed is to be found primarily in the tailored analysis functions that can be used to answer specific questions in the context of parking management (e.g. Where in the urban area is a particularly high parking pressure at a specific time?). Classical statistical methods (descriptive and explorative methods) as well as AI and ML methods will be used to analyze the data sources. A special focus will be placed on the descriptive visualization of data and analysis results. For example, municipal data often have a spatial reference, which makes the presentation in maps particularly suitable. In addition, users shall be provided with assistance that facilitates the interpretation of the results by highlighting heavily weighted samples in supplied data and offering comprehensible in-depth explanations to applied methods. Furthermore, the interpretation shall enable recommendations to be made to political decision-makers (e.g. Where in the urban area could applications for the designation of new residential parking zones be successful?). The export of the analysis results will be ensured by a reporting function.

Due to the modular design with microservices, further functionalities and analyses can be added. All these microservices are strongly oriented towards municipal needs and can thus be applied in a targeted manner without further adjustments by data scientists, or similar. In the beginning, the use cases are defined from a test in one city, and new needs and requirements are continuously derived in an intended, close collaboration with municipal users.

Following the prototype development, the service must be tested in a city and different departments in a subsequent step. Here the focus lies on the effects on collaboration between departments and the impact of the service on them, while the quality of the analyses is continuously improved in the background.

The importance of a user-centric approach is already becoming apparent. Thanks to many years of cooperation with municipalities in the field of data-supported parking management, as well as the expert interviews in the beginning, the Fraunhofer IAO team is highly familiar with the needs of municipal actors and includes them in the prototype development. This ensures that the prototype meets the requirements of municipal actors and increases their acceptance for the use of the cloud service.

Smart services – are German companies ready to take up the challenge?

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Problem/Goal

Smart services are a hot topic in German business right now. This is because they offer companies a promising opportunity to expand their existing portfolio of services and, with the help of digital technology, carve out new areas of business. Large enterprises are already busy investing in human resources and infrastructure with a view to rolling out the first of a new generation of smart services. By contrast, many small and medium-sized enterprises (SMEs) are still struggling to recognize the potential of this emerging sector and devise their own strategies and concepts. In a quantitative company survey conducted in 2021, Fraunhofer IAO investigated the extent to which smart services are already being used in German companies and the challenges and opportunities arising from this use.

Recently, the term »smart services« has been used across all industries in Germany. It can be found in many service-providing areas and there are numerous examples of its application. Although the term »smart service« is now widely used, there is no clear definition. In the narrow sense, this means digital services that create additional added value for customers by collecting, processing, and analyzing (user or machine) data and use digital platforms to do so (see also acatech 2015). The use of the adjective »smart« is intended to express the fact that these services are highly customizable - i.e., they consider the needs, situation, and context of their respective users. An example of such classic smart services would be the control of home technology via app.

In a broader sense, the term »smart services« is used synonymously for modern services that are digitally supported. The supporting digital elements can be manifold - these include the processing of data on a large scale mentioned earlier and the use of platforms (e.g. cloud platforms). But the use of new digital technologies in connection with services is also often referred to as smart service. Examples include the integration of service robots in elderly care or the use of artificial intelligence in customer communication (e.g. chatbots).

An essential basic requirement for the provision of smart services is the storage, analysis, evaluation, and combination of data (Grohmann et al., 2017). Due to the significant increase in storage and computing capacities in recent years and decades, this basic requirement is increasingly being met. This is now also reflected in the corporate world. The proportion of companies that do not yet provide any data-based services at all has already declined significantly over the course of the last few years (Leiting & Rix, 2019).

Methodology

A survey of German manufacturing companies and service providers was conducted in spring of 2021. All in all, 150 companies were involved, 33 percent from manufacturing industry and 67 percent from the services sector. Of that total, 58 percent were SMEs and 42 percent large enterprises. Using this data, it was possible to compare the proliferation of smart services within the industrial and service sectors and within companies of different sizes.

Another interesting aspect is whether there are differences between successful and less successful companies. To identify the successful companies among those responding, a question was asked about the development of key corporate indicators (number of employees, sales, and profit). Here, it was ascertained how the companies had developed over the last three years in comparison to their own industry. A cluster analysis was used to identify a group of companies with largely positive key performance indicators and a group of companies with rather negative key performance indicators. In this way, the companies could be divided into successful and less successful companies.

Results

The results show that a specific application of a smart service is already in use at one in five companies. Less than five percent of companies reported no engagement with this topic whatsoever. In general, companies are looking to smart services to generate new markets, boost revenue, increase their competitiveness and, above all, help them tailor their services more closely to customers' needs. To date, however, this has largely failed to materialize on account of various factors, the most important of which are a lack of human resources, a lack of suitable strategies and concepts, an apprehension about the amount of effort required overall for the introduction of smart services, and unresolved questions regarding data protection and data security.

Small and medium-sized companies lag far behind large enterprises in their experience with smart services. 20 percent of the small and medium-sized companies surveyed said they were about to introduce smart services or already had an application in use. The figure for large companies is already 54 percent. Similarly, 8 percent of small and medium-sized companies - but only 2 percent of large companies - say they do not intend to engage with smart services. Looking at the business sectors, there are only slight differences between the secondary and tertiary sectors. The results tend to show that companies from the secondary sector already offer smart services more frequently.

Successful companies are more likely to report that they already have at least one smart services application in use (26 percent versus 17 percent of less successful companies). However, the study does not indicate whether successful companies are more likely to have the resources and risk tolerance to invest in new applications or, conversely, whether companies that are willing to invest in emerging issues such as smart services are ultimately more successful as a result.

It is also of interest to what extent essential competencies for the development of smart services are available in the companies. The competencies surveyed were based on key development steps from idea generation to conception and market launch. The companies surveyed see their own greatest competencies in relation to the development of smart services in the idea development phase (mean value of 3.7 points on a scale of 5). The companies also consider themselves to be relatively well positioned in the "Creating concepts" (mean value of 3.5) and "Developing strategy" (mean value of 3.4) phases.

The successful companies consistently achieve slightly higher mean values compared with the less successful companies. They rate their competencies for developing smart services somewhat better. The same applies to companies from the tertiary sector. Perhaps this better assessment by the service companies is due to the fact that they can transfer their experience from the development of classic services to smart services. About company size, there are no clear differences in the assessment of competencies for developing smart services.

A further question is whether companies need support with digitization. A look at the results shows that many topics receive comparably high scores. At 55 percent each, the digitization of processes, the optimization of services through digitization and the development of new digital services are at the top of the list. These are closely followed by the development of new digital business models and the acquisition of new customers with digital services (53 percent each), as well as increasing the digitization skills of employees (52 percent).

Overall, the companies surveyed have a very high need for support. The large number of topics mentioned in parallel - an average of 3.6 topics per company surveyed - also makes it clear that the companies have diverse expectations of digitization but cannot master the associated challenges on their own. It is interesting to note here that the successful companies identify almost as much need for support as the less successful companies.

Overall, smart services and digitization in general is a topic that has arrived in companies and its potential is recognized. Nevertheless, there are still unanswered questions, obstacles, and a lack of competencies in the companies to respond appropriately. It is up to the companies to develop strategies for the digitization of services and to build up the corresponding competencies. At the same time, science should provide support here by developing new instruments for transferring R&D results into practice that are more precisely tailored to the needs of companies and that support small and medium-sized enterprises.

Acknowledgement

The study was conducted as part of the Competence Center »Smart Services« funded by the German federal state of Baden-Württemberg.

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5
Topic »Digital Transformation in Services«

5.1
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How to Overcome Organizational Inertia by Shaping Institutions and Value Propositions: an Analysis of the Impact of Service-Catalogs

Markus Warg (Institut für Service Design, Hamburg), Stephan Hans (SDA SE, Hamburg, Germany)

The paper analyzes how companies can shape and establish institutions to take advantage of the opportunities of digital ecosystems for the transformation and development of their organizations. As part of broader polycentric networks, companies are connected with other actors through value propositions, shared institutional agreements and mutual value creation. In detail, we study how the shaping of institutions with the help of service catalogs can be used in a purposeful way to remove barriers to changing the value creation paths and by this to overcome organizational inertia.

Introduction, Problem Identification and Motivation

Digital technologies enable the creation of new value propositions aligned with customer behavior and expectations. That value propositions are increasingly based on the provision of services engaging customers to become active participants in a process of value creation (Barrett, Davidson, Prabhu, & Vargo, 2015). Digital technologies empower companies to transform from selling physical products to selling services as an integral part of their value proposition or to complement them in order to meet customers' needs by offering innovative solutions. At the same time, digital services enable data to be collected in the course of value creating interactions (Wulf, Mettler, & Brenner, 2017). A prime example for altering the value creation path and for the creation of new value propositions through the use of digital technologies is Netflix, whose business model was originally based on the rental of movies stored on physical media. Over the years, Netflix moved away from this value proposition and became the first major provider of video streaming services. More recently, Netflix has used data collected from the use of its streaming service (interaction) to better understand what content viewers like and how it is consumed to help produce its own content (Hastings & Meyer, 2020). The example demonstrates the potential of digital technologies and digital transformation to generate disruptive innovations and to new value creation paths that can significantly change existing value propositions (Vial, 2019).

Digital transformation encounters organizations as a process in which digital technologies cause disruptions that trigger strategic responses to change value creation pathways (Vial, 2019). Referring to (Demirkan, Spohrer, & Welser, 2016) digital transformation can be described as the profound and accelerating transformation of business activities, processes, and competencies to fully leverage the changes and opportunities brought by digital technologies and their impact across society in a strategic and prioritized way. The core building blocks of this process are the use of digital technologies, disruptions in consumer behavior and expectations, strategic responses affecting the value creation paths and changes in organizational barriers and structure and the outcome as impacts (Vial, 2019). Digital service platforms and service ecosystems offer an organizing logic for the actors to exchange service and facilitate access to capabilities thus play a central role in the implementation of these building blocks (Teece, Pisano, & Shuen, 1997). Service platform and ecosystem strategies are characterized by how the alignment of actors and activities is organized to materialize a focal value proposition (Adner, 2017; Lusch & Nambisan, 2015).

One of the biggest obstacles to digital transformation, especially in terms of exploiting the opportunities offered by digital service platforms and ecosystems, is organizational inertia. Inertia prevents transformation where existing resources and capabilities act as barriers. Organizational inertia, for example, is often a characteristic of incumbent companies that are deeply embedded in existing relationships with customers and suppliers. In particular when companies as actors experience successful times, organizational “lock-in” effects occur with regard to the technologies, processes and the social norms and rules in use (institutions). Arthur and others have already outlined a phenomenon of organizational inertia by describing that increasing returns lead to a "lock-in" effect of incumbent technologies and rules and discourage the adoption of potentially better alternatives (Arthur, 1989; Foxon, 2002). This motivated our core research question: "How can organizations overcome inertia as barriers to new value creation paths by shaping institutions?"

Research Design

Our research focuses on the key question of how companies can shape institutions and institutional arrangements to overcome inertia and foster organizational development. Overcoming inertia will depend on the organization's ability to evolve. Organizational development is understood as improving the ability to adapt, integrate and apply resources and capabilities (Warg & Zolnowski, 2018). As organizations are embedded in broader social networks, this issue is closely related to how organizations can remove existing barriers and boundaries, which are also the result of their current practices, processes and structures, in order to take advantage of the opportunities offered by digital ecosystems. Our research focuses on the relevance and the impact of institutions on the process of service exchange with other actors in actor-to-actor networks as well as on the resulting ability of the organization to better integrate, apply and use resources.

On the basis of this analysis, we examine the requirements that a solution must fulfill in order to foster organizational development and new value propositions through the shaping and establishing of institutions.

Referring to our research objectives we believe that a combination of the Design Science Research Methodology (DSRM) and the Case Study Methodology is valuable for our research result.

We apply the Design Science Research Methodology (DSRM) for two reasons. On the one hand, it serves as a widely accepted framework to address the design product and the design process (Baskerville, Baiyere, Gregor, Hevner, & Rossi, 2018; Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008; Walls, Widmeyer, & El Sawy, 1992). On the other hand, as a methodology that views design as an "act of creating an explicitly applicable solution to a problem" (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008).

We complement the DSRM with an embedded single case study. By analyzing different use cases within a single case study and using more than one perspective, we aim to gain a better understanding of the relevance of the solution created (Bass, Beecham, & Noll, 2018; Yin, 2018). Referring to DSRM (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008) our research proceeding is divided into six activities which are presented in the following briefly in general as well as for our key question.

Activity 1: Problem Identification and Motivation

How can organizations overcome inertia as barriers to new value creation paths by shaping institutions and institutional arrangements?

Activity 2: Define Objectives of a Solution

Our goal is to define the core elements of a generic solution pattern to overcome the challenges of organizational inertia within service ecosystems through institutional design. For this purpose, the modes of action for the co-creation of value propositions in service ecosystems are analyzed on the basis of the relevant theoretical foundations and concepts. We draw on Social Sciences (IAD framework, Coleman´s boat), Service-Dominant Logic and Service Science. On this theoretical basis, a generic solution pattern is created to represent the requirements and objectives of a solution. The implementation of a generic solution pattern should enable us researchers to check the extent to which the solution achieves the goal to overcome organizational inertia within service (eco) systems with the help of shaping institutions.

Activity 3: Design and Development

Following the understanding of design (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008) as an act of creating an explicitly applicable solution for our research question (problem) of "how companies can use the possibilities of service ecosystems by shaping institutions?". Therefore a service catalog as applicable solution for the establishment, change and shaping of institutions is designed.

Activity 4: Demonstration

The demonstration of the solution is based on an embedded single case study. For this purpose, different embedded use cases within the Service Dominant Architecture case study are analyzed to demonstrate the relevance of the service catalog from more than one perspective. Analyzing implemented artifacts – as embedded subunits will be used to demonstrate the suitability of the solution for shaping institutions.

Activity 5 Evaluation

The evaluation of the embedded single case study examines to what extent the service catalog is suitable for achieving the objectives of solution.

Activity 6: Communication

Our results will be communicated to the relevant scientific and practitioner communities e.g. on conferences, in projects or user groups.

Theoretical Foundations for Deriving Objectives of Solution

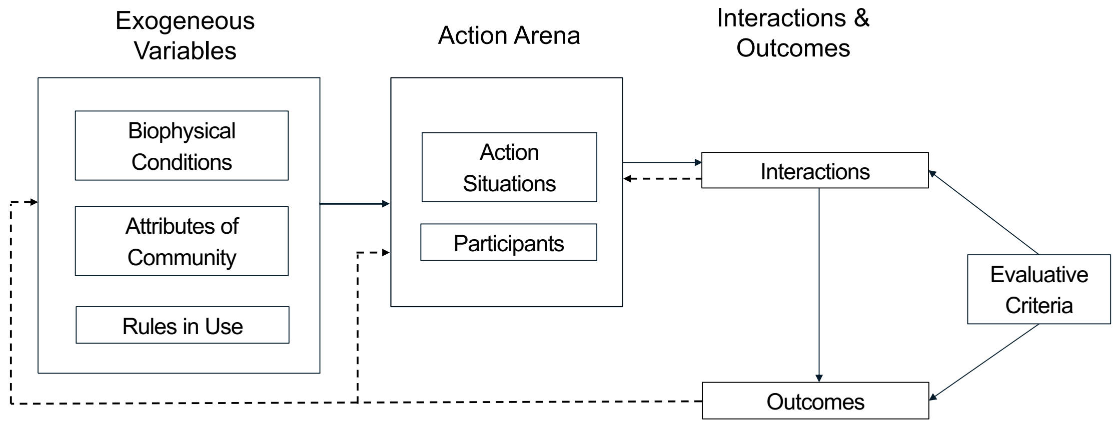
The way companies view the nature and process of digital transformation and the establishment of innovation has changed significantly in the last years. Whereas innovation itself and its attributes used to be the desired outcome, innovation is now input and one part of a value proposition that actors experience as value in use. Innovation development has also freed itself from organizational boundaries and increasingly relies on collaborative action as value cocreation within actor networks (Chesbrough & Rosenbloom, 2002; Lusch & Nambisan, 2015; Prahalad & Ramaswamy, 2004).

In order to identify the essential mechanisms of acting and value cocreation in actor networks as a prerequisite for digital transformation and overcoming organizational inertia, we will draw on theoretical foundations and concepts of: IAD framework, Coleman´s Boat, Service-Dominant Logic and Service Science.

IAD framework and Colemans Boat

With her research and studies, Ostrom developed a broader theory of institutional arrangements related to the effective governance and management of common-pool resources (Ostrom, 1990). One recognition was that society and its rules (institutions) are designed to optimally transform resources into goods, not how to preserve or increase commons. As a consequence the design of the institutions themselves is seen as the craft of long-term process design which requires the involvement of actors (Ostrom & Helfrich, 2012). With her research and the resulting design principles, Ostrom has shown that it is possible to treat resources by using appropriately designed institutions in a way that they become more when they are shared (Ostrom & Helfrich, 2012). An important concept for analyzing and understanding institutions is the Institutional Analysis and Development (IAD) framework. The framework is structurally detailing the action situation relevant to actors as participants in specific situations. For further detailing, we structure the framework into the following three areas: "exogeneous variables", "action arena" and "interactions & outcomes".

Figure 1 Ostrom`s Institutional Analysis and Development (IAD) framework (Kiser & Ostrom, 1982; Ostrom, 2005; Ostrom, Gardner, Walker, Walker, & Walker, 1994)

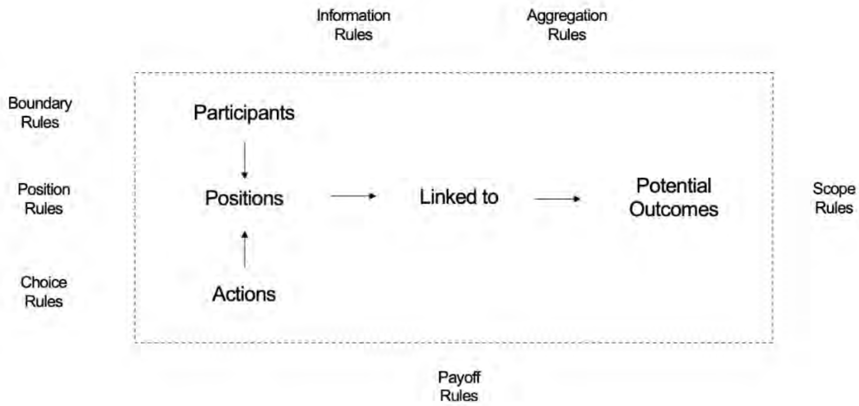


Starting on the left in the framework are the exogeneous variables that affect the participants, positions and actions of an action arena and by this its structure. The exogeneous variables include three clusters of variables (Kiser & Ostrom, 1982): 1. The attributes of states of the world that are acted upon in these arenas, e.g. the physical possibilities of actions, the producibility of outcomes and the linkage of outcomes to actions depend on the physical world and its transformations (Ostrom, Gardner, Walker, Walker, & Walker, 1994). 2. The attributes of a community as all aspects of the social and cultural context within the action situation is located (McGinnis, 2013). 3. The third set of variables that specify the values of the working components of an action arena relates to the rules specifying positions, set of actions or outcomes (McGinnis, 2013; Ostrom, Gardner, Walker, Walker, & Walker, 1994).

From this point, the action arena is viewed as a set of variables dependent upon other factors. In the action situation individuals act on their own or as agents of organizations, observe information, select actions, engage in patterns of interaction, and realize outcomes from their interaction (McGinnis, 2013). The action arena can be utilized to describe, analyze, predict, and explain behavior within institutional arrangements. The action arena is linked to the third area of the framework the "interactions & outcomes". Outcomes are generated by a given action situation and available information about action-outcome linkages. Participants choose actions on the basis of their preferences, their information, strategic considerations, the expected outcome and the relationship between the action and the outcome (McGinnis, 2013; Rudd, 2004).

The relationships among the various parts of the action situation are represented within the following figure. Rules effect the working components of an action situation which is embedded in rules. Therefore it is helpful to link and explain rules corresponding to the action situation they constitute (Li, Van Den Brink, & Woltjer, 2016; McGinnis, 2013; Ostrom, 2005).

Figure 2 Rules as exogenous variables directly affecting the elements of an action situation (Ostrom, 2005)



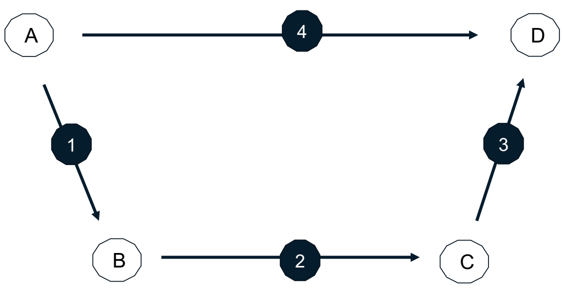
Rules specify the values of the working components within an action situation. The IAD framework describes the following rules (Aligica, 2006; McGinnis, 2013; Ostrom, 2005; Ostrom, Gardner, Walker, Walker, & Walker, 1994): position rules that specify a set of authorized actions, boundary rules specify how participants enter or leave the positions, choice rules specify which set of actions are possible in the respective position,

aggregation rules specify the transformation (function) from actions to outcomes, information rules specify the information available in the respective position, payoff rules specify how benefits and costs are assigned to outcomes and scope rules specify the set of outcomes.

These rules become institutions through the constitution of regularized patterns of engagement and interaction by changing the costs and benefits associated with alternative actions and by making available options that would not be feasible to any one individual acting alone.

By providing a systematic way to think about the macro-micro relations the central motivation of Coleman´s boat and the associated microfoundation movement is to "unpack collective concepts to understand how individual-level factors impact macro level and how the action of individuals leads to emergent, collective, and macro level outcomes and performance, and how relations between macro variables are mediated by micro actions and interactions" (Felin, Foss, & Ployhart, 2015).

Figure 3 Coleman´s boat (Coleman, 1990)



The nodes (A) and (D) refer to the macro facts that might be cited as causes of social, economic or organizational phenomenon. On the macro level (D)´s are the macro facts to be explained. It is relevant to note that (A) and (D) represent not the whole macro level but only a part of it. Coleman´s scale of macro is flexible and can scale from two persons to organizations and nations (Coleman, 1990; Frosch & Warg, 2020; Ylikoski, 2016).

Arrow 1 between (A) and (B) reveals that the condition of (B) at the micro level changes when the condition of phenomenon (A) at the macro level changes. Arrow 1 shows that phenomenon (A) is a condition according to which the actor directs his actions. (A) can be the exclusive cause or only a reason for the actor's engagement and change in the state of (B). Arrow 2 illustrates how actors' actions bridge state changes of resources (B) and outcomes of new combinations of resources as engagement properties (C).

Arrow 3 then demonstrates how a new macro phenomenon is aggregated out of the sum of engagement properties and that the relation of (C) and (D) is one of logical implication (Frosch & Warg, 2020; Ylikoski, 2016). As pointed out Coleman´s boat is the visualized result of macro-micro explanations where changes in macro level initiate observable actions on micro level. Individual actors adapt the new context with action (arrow 2, micro-micro level) and the transformation and aggregation of these outcomes describes how macro level changes (arrow 3, micro-macro level) arise.

Service-Dominant Logic and Service Science

In the last decades, Service-Dominant Logic (Vargo & Lusch, 2018; Vargo & Lusch, 2004) and Service Science (Spohrer et al., 2019; Spohrer & Maglio, 2008) have been establishing from different perspectives the foundations for a uniform understanding of service, service exchange, value cocreation and the systemic functioning of service platforms and ecosystems. This worldview transcends the output-based division (dichotomie) into goods and 'services' of the goods-dominant logic of the past: service – as the application of competences (goods, services, skills, knowledge etc.) for the benefit of another – is considered to be the fundamental basis of economic exchange (Maglio, Vargo, Caswell, & Spohrer, 2009; Vargo & Lusch, 2018).

The Service-Dominant Logic (S-D Logic) grounding of service ecosystems identifies the core elements of mutual service provision in actor-to-actor networks (Vargo & Lusch, 2016) and is partially conceptualized in terms of institutions and institutional arrangements for coordinating value co-creation (Vargo, Akaka, & Vaughan, 2017). (Vargo & Lusch, 2018). According to S-D Logic, service is always provided in interaction between different actors and results in a unique value. Following this, service is defined as the application of resources (in particular knowledge, skills and competences) to make changes that have value for another. S-D Logic "[…] is focused on the interaction of the producer and the consumer and other supply and value network partners as they co-create value through collaborative processes" (Lusch & Vargo, 2008). The interactive relationship during value co-creation results in added value that improves one's own state or condition. For the process of value co-creation the integration of resources is a central concept (Edvardsson, Skålén, & Tronvoll, 2012; Peters, 2016; Vargo & Lusch, 2004). In this process actors are natural or legal entities capable of acting on potential resources and by this carrier of operant and/or operand resources (Löbler, 2013). Operant resources, such as competences, are those that act upon other resources to create benefit; while operand resources are those resources which must be acted on to be beneficial, such as natural resources, goods and money (Constantin & Lusch, 1994; Vargo, Lusch, & Akaka, 2010). Organizational development and innovation pertains to service systems in action, such that actors integrate and act on available resources to create value for themselves and others in new and better ways (Caridà, Edvardsson, & Colurcio, 2019). For this S-D Logic serves as a meta-theoretical framework for explaining the process of value creation through service exchange among multiple resource-integrating actors forming institutionally coordinated service ecosystems (Vargo & Lusch, 2016, 2018).

Figure 4 The narrative and process of S-D Logic (Vargo & Lusch, 2016)

The idea of resource networks contributes to the understanding of value creation. Its consideration sometimes lacks a critical characteristic of systems and structures, which are dynamic and potentially self-adjusting and thus simultaneously functioning and reconfiguring themselves. "That is, each instance of resource integration, service provision, and value creation, changes the nature of the system to some degree and thus the context for the next iteration and determination of value creation. Networks are not just networks (aggregations of relationships); they are dynamic systems" (Giddens, 1984; Vargo & Lusch, 2011). In this context of dynamic systems the aspects of how structures arise as well as the effective value co-creation functioning at the different micro-meso-macro levels of service networks and service ecosystems (Vargo & Lusch, 2018), still represent key areas of service research.

Based on S-D Logic, Service Science grounds the nature, scientific understanding, management principles and engineering discipline needed to understand and improve service and dynamic emerging structures (Maglio & Spohrer, 2008; Spohrer, Vargo, & Maglio, 2008). With the service system as complex socio-technical system a new unit of analysis is introduced by Service Science (Spohrer, Maglio, Bailey, & Gruhl, 2007). Referring to the interactive character of service that involves at least two entities - one applying competence and another integrating the applied competences - these interacting entities are called service systems. More precisely, service systems are defined as dynamic value co-creation configurations of resources, including people, organizations, shared data (language, laws, measures, methods), and technology, all connected internally and externally to other service systems by value propositions (Spohrer, Vargo, & Maglio, 2008). Therefore from Service Science perspective service (eco) systems can be described as a structure of interconnected service system entities. Moving toward a general theory of service (Spohrer, Fodell, & Murphy, 2012; Vargo, Akaka, & Vaughan, 2017), the following distinctive characteristics of service (eco) systems are defined (Caridà, Edvardsson, & Colurcio, 2019; Spohrer, Maglio, Bailey, & Gruhl, 2007; Vargo & Lusch, 2018):

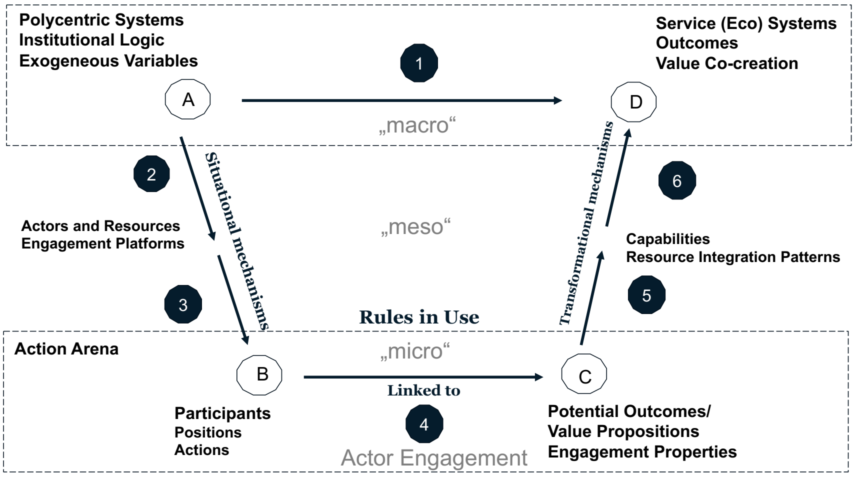
- service (eco) system as complex socio-technical system,
- service (eco) systems are relatively self-contained and have fuzzy boundaries,
- actors are relatively self-adjusting, as they show adaptive behaviour,
- actors are resource integrators,
- actors are coordinated and connected by shared institutional logics,
- service exchange in service (eco) systems results in mutual value creation.

In the context of actor coordination and service exchange S-D Logic has clarified the understanding and role of institutions as routinized, coordinating mechanisms, and becoming essential to understanding value co-creation: "As actors within a service ecosystem are cognitively distant from each other, shared institutional arrangements are necessary in order to coordinate their otherwise unrelated behaviour (Axiom 5)"(Vargo & Lusch, 2018). Institutions are the human-made rules, norms and beliefs that provide stability and meaning to social life by constraining and enabling collective action (Scott, 2014). They can be understood as the implicit and explicit 'rules of the game' (Milgrom, North, & Weingast*, 1990), which coordinate resource integration and service exchange among actors (Edvardsson, Kleinaltenkamp, Tronvoll, McHugh, & Windahl, 2014; Vargo & Lusch, 2016).

Generic Pattern and Objectives of a Solution

The following figure summarizes the core elements of the theoretical foundations as generic solution pattern.

Figure 5 Generic Pattern of Actor engagement; source Warg, Hans 2021 modified of: Coleman 1990, Ostrom 2009, Storbacka et. al. 2016



Storbacka et al. (2016) anchor and reveal the causes of the more abstract macro (ecosystem and institutional logic) concept of value co-creation with micro (actor engagement) and meso (sets of actors and their resources, e.g. organization) level mechanisms. At the macro level, the phenomenon of (B) value cocreation, outcomes and service (eco) systems based on (A) polycentric systems, institutions and exogenous variables then is evident.

Arrows 2 and 3 show how, as a result of changes at the macro level, situational mechanisms lead actors and other resources to engage on platforms. This leads to the change of positions and action possibilities in the action arena on the micro level (B). Linked to value propositions as potential outcomes actor engagement and engagement properties are fueled (C).

Actor engagement interconnected by value propositions triggers transformational mechanisms using platforms and leads to the emergence of various resource intgration pattern at the meso level (Arrows 5, 6). Transformational mechanisms in combination with new resource configurations as a result of the integration of resources lead to resource density, new capabilities and value cocreation on the engagement platform at the meso level. Fostered by resource integration pattern actor-to-actor networks arise and transform themselves by value cocreation and service exchange to service (eco) systems. Service (eco)systems arise at the macro-level (Storbacka, Brodie, Böhmann, Maglio, & Nenonen, 2016) if the resource integrating actors are connected by shared institutional agreements and mutual value creation (Spohrer, Maglio, Bailey, & Gruhl, 2007; Vargo & Lusch, 2018).

According to the domain theories of Social Sciences (IAD framework, Coleman´s boat), Service-Dominant Logic and Service Science we derive five objectives for overcoming organizational inertia with the help of institutions:

Table 1 Five Objectives to overcome Organizational Inertia with the help of Institutions

Objectives to overcome organizational inertia	Description	Source
actor engagement	fostering actor engagement and new situational mechanisms	(Ostrom, 2005, 2010), (Storbacka, Brodie, Böhmann, Maglio, & Nenonen, 2016), (Spohrer & Maglio, 2008), (Coleman, 1990; Vargo, 2011)
rules in use	changing the rules in use of the action arena	(Giddens, 1984; Kiser & Ostrom, 1982; Ostrom, 2005; Vargo & Lusch, 2016)
actor-to-actor networks	empowering actor-to-actor networks by offering resource integration pattern	(Koskela-Huotari & Vargo, 2016; Spohrer & Maglio, 2008; Spohrer, Piciocchi, & Bassano, 2012; Vargo, Akaka, & Vaughan, 2017; Warg, 2020)
resource density	enabling resource-integration; resource-density and resource-orchestration	(Lusch & Nambisan, 2015; Spohrer et al., 2019; Zolnowski & Warg, 2018)
service exchange	pave the way for resource application and service exchange	(Moeller, 2008; Vargo, Koskela-Huotari, & Vink, 2020; Vargo & Lusch, 2004)

Solution Design and Development

According to the five objectives derived out of the generic pattern for actor engagement and the objectives of solution, we demonstrate and evaluate a solution design based on different embedded use cases within the Service Dominant Architecture case study.

Within the embedded single case study of the Service Dominant Architecture (SDA) as design pattern used to develop engagement platforms and service ecosystems (Warg & Engel, 2016; Warg, Weiß, Engel, & Zolnowski, 2016; Weiß, 2019) we analyze and demonstrate the relevance of a service catalog as set of institutions to establish rules and social practices for actor coordination and resource integration. And in this way, the appropriateness of a service catalog for overcoming organizational inertia. For this purpose, we first describe the generic (solution) design pattern of Service Dominant Architecture that is already in use at a number of companies as the target architecture for their platform- and ecosystem-development. We then demonstrate the relevance of the SDA service catalog for overcoming organizational inertia. Finally we evaluate the extent to which the "five objectives to overcome the organizational inertia with the help of institutions" were achieved.

Generic Solution Pattern: Service Dominant Architecture

SDA was derived from the knowledge base of the domain theories Service Science, S-D Logic and Institutional Economics with the aim of putting the findings, logics and processes into practice by enabling actors in the process of value cocreation. Used in practice SDA enables entities to purposeful build up capabilities and to engage in the process of service exchange and value co-creation (Warg & Engel, 2016; Warg, Weiß, & Engel, 2015). SDA can be viewed from a conceptual and an applied perspective:

(1) firstly, SDA as design pattern (Alexander, 1977; Gamma, 1995; Gamma, Helm, Johnson, & Vlissides, 1995) or virtual order in the understanding of a structure (Alexander, 1977; Gamma, 1995; Gamma, Helm, Johnson, & Vlissides, 1995; Giddens, 1984) of five systems (Cardoso et al., 2015; Luhmann, 1984; Spohrer, Vargo, & Maglio, 2008).

(2) secondly, SDA as tangible structure instantiated by at least one entity (Giddens, 1984). The instantiated structure consists of five systems including the SDA service catalog as system of shared institutional

arrangements (Spohrer, Vargo, & Maglio, 2008). SDA applied within an actor-to-actor network facilitates the process and coordination of service exchange and mutual value creation (Vargo & Lusch, 2016).

In the following the systems of SDA are introduced (Warg, Weiß, Engel, & Zolnowski, 2016; Warg, Weiß, & Engel, 2015):

1. *System of Operant Resources*: The system of operant resources is the heart of the SDA design pattern. It represents the workbench, where the various resources and capabilities are brought together and processed. For this, this system applies certain logics or processes. In line with S-D Logic, the focus is on intangible capabilities, previously defined as operant resources (like competence, knowledge, skills, software code), which are used and brought together to (co-) create value propositions. These value propositions are dependent on the achievable level of resource density. A high resource density positively impacts the emergence and creation of innovative and relevant value propositions.

2. *System of Interaction*: The system facilitates value in use and value in context by enabling the application of capabilities bundled in value propositions. Interaction enables resource integration and service exchange between actors.

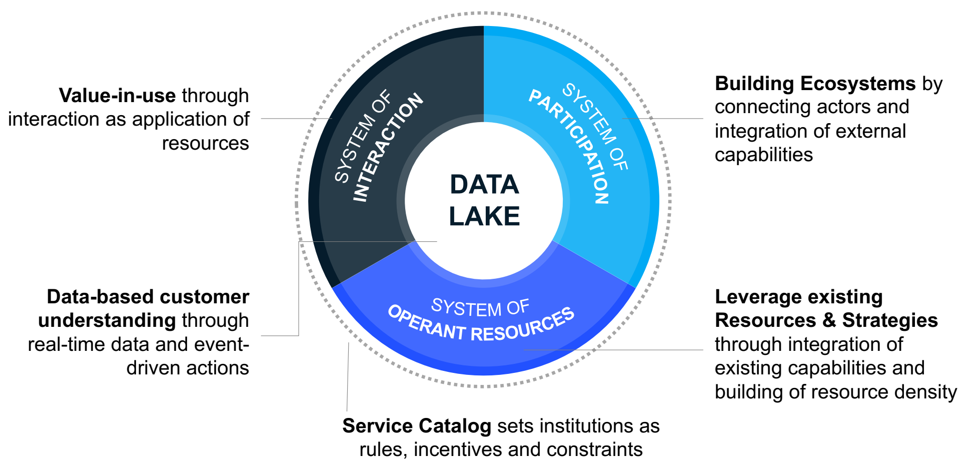
3. *System of Participation*: The concept of co-creation includes other (external) actors as co-producers of the value proposition. In this process the system of participation enables actor-to-actor orientation and the participation of other actors by coordinating actors and facilitating the process of resource integration.

4. System of Operational Data Stores (*Data Lake)*: From an actors (e.g. organization) point of view, data received and generated by interacting with other actors (e.g. customer) should be systematically recorded and evaluated in real time. In this way, data and knowledge about the preferences and the context of other actors like customers can be build up continously.

5. System of Institutional Arrangements (Service Catalog): As rules, institutions enable the coordination of actors and the access to and use of resources. In conjunction with SDA design pattern, institutions enable the coordinated creation of solution designs by connecting actors, and enabling the integration and application of resources.

The (design) patterns as architectural framework of SDA are summarized in the following figure.

Figure 6 Design Pattern as Architectural Framework of Service Dominant Architecture (SDA) (source: IfSD.hamburg)

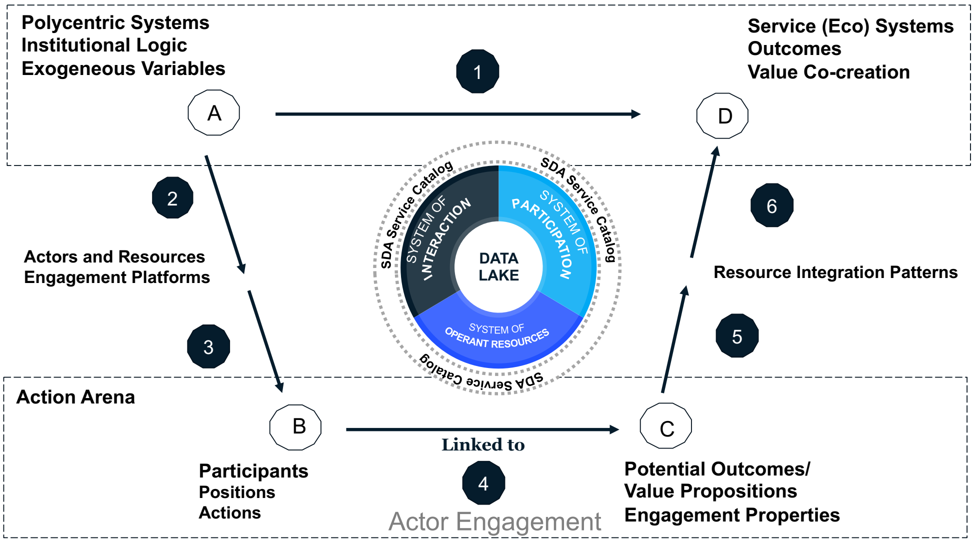


SDA enables the value co-creation process first on the level of "virtual order" as design pattern and then as material instantiation of an entity by engaging in service exchange. By engaginging in service exchange the design patterns are "animated" with operand and operant resources and become Service Systems (Spohrer, Maglio, Bailey, & Gruhl, 2007) by creating mutual value.

SDA Service Catalog

The purposeful building of capabilities is facilitated by enabling the integration and orchestration of resources and setting the institutions for participation and coordination. For this, the SDA Service Catalog enables to capture (integration, participation), exchange (interaction), and orchestrate actors and resources in a meaningful way.

Figure 7 DA Service Catalog (Warg, Hans (2021))



The institutions of the SDA Service Catalog are accessed via the SDA portal; it bundles individual institutions as well as sets of institutions up to already established service catalogs. As rules, institutions enable the coordination of actors and the access to and use of resources. In conjunction with the SDA Service Systems, institutions enable the integration and application of resources.

Demonstration

The working of the SDA Service Catalog is illustrated below on the basis of exemplary institutions and two embedded use cases within the SDA case study.

Table 2 Examples of Institutions within SDA Service Catalog (Warg, Hans (2021))

Examples of (single or sets of) institutions within SDA service catalog	Description	Relevance for actor engagement	Source
spotify backstage	software developer portal software and tool catalog (micro-) service overview service ownership documentation authorizations	standardization of (micro-) service creation and documentation makes it easy to create, maintain, find and use (micro-) services	(Lines, 2020) (Backstage, 2021)
Health Level 7 (HL 7); Fast Healthcare Interoperability Resources (FHIR)	standards to achieve healthcare systems interoperability health information exchange standards	health information exchange interoperability	(Bender & Sartipi, 2013)
ICD code	international classification of deseases and related health problems more than 1.6 million clinical terms interpreted multilangual design facilitates global use	health (deseases) information exchange interoperability	(Treede et al., 2019)

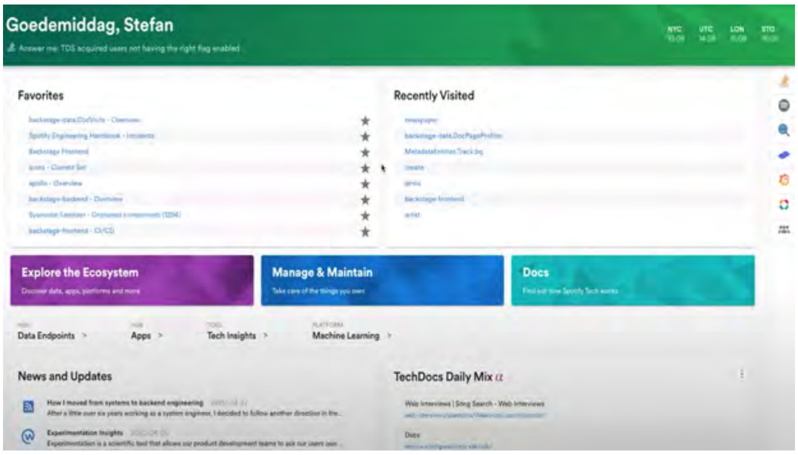
Embedded use case: software development (spotify backstage)

Software developer teams have to handle large numbers of tools, technical interfaces, and code. Especially in mature companies with a large number of development teams and business units, it becomes difficult to keep track of all these things. Documentation, data models, and architectures have to be findable, reusable and conform to the corporate strategy. Every existing piece of software must be maintained and meet organizational standards e.g. for security and quality. Although solutions like tools exist to help address these challenges, they are often redundant, scattered across different locations, and difficult for developers to find. For example, software code is stored in tools like GitHub, code quality is measured in tools like SonarCloud, documentation is stored in tools like Confluence, and security events are tracked in tools like DefectDojo.

As a result, teams spend more time searching for the right information and coordinating which tools to use, rather than building and testing code.

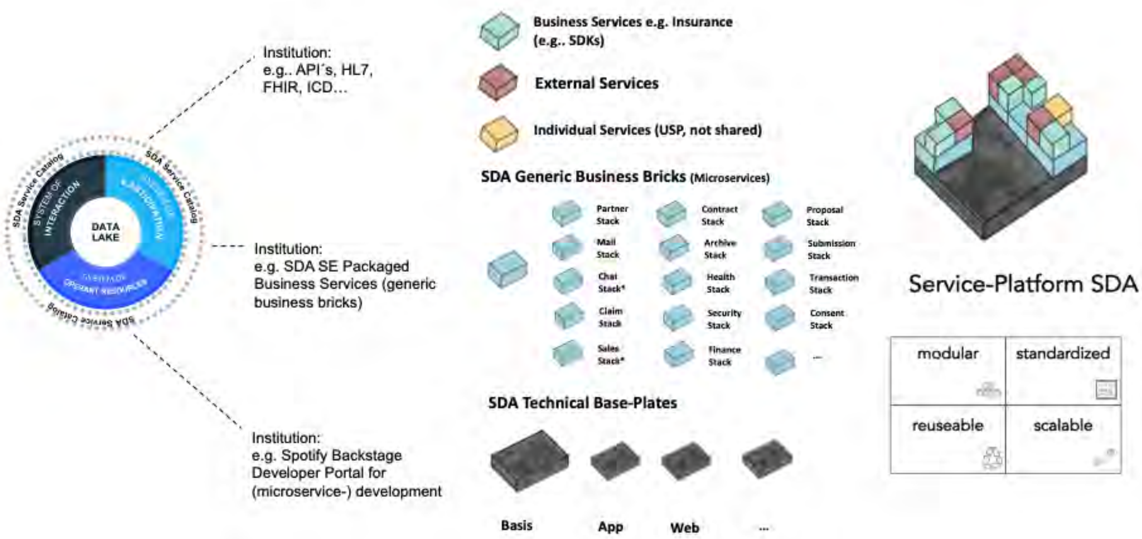
Backstage as a catalog of services accessed through a portal integrates all independent developer tools and the relevant information into a single user interface. Like an app store for all developer tools, backstage creates a standard for code development across all phases. All informations and tools (docs, services, API's) are easy and quick to find: e.g. API documentation and plug-ins, unified display and management of deployments, fast documentation. Personalized landing pages support the developer in software development, maintenance as well as error and license monitoring.

Figure 8 Personalized Developer Portal on basis of Backstage



The advantages of backstage in combination with the provision as open source lead to a rapid increase of the user community. Besides individual developers, companies like netflix or zalando already use backstage and thus contribute to further institutionalize the Backstage.

Figure 9 Institutions for Software Development



In the context of SDA, the Backstage institutions are part of the SDA service catalog and the basis for software (microservice-) development. These are expanded by so-called packaged business capabilities (Natis, 2021) as generic business functions. This refers to cross-industry functions such as partner management, contract management or consent management. Finally, there are industry-specific institutions such as HL 7 (Health Language) for exchanging healthcare data between different stakeholders.

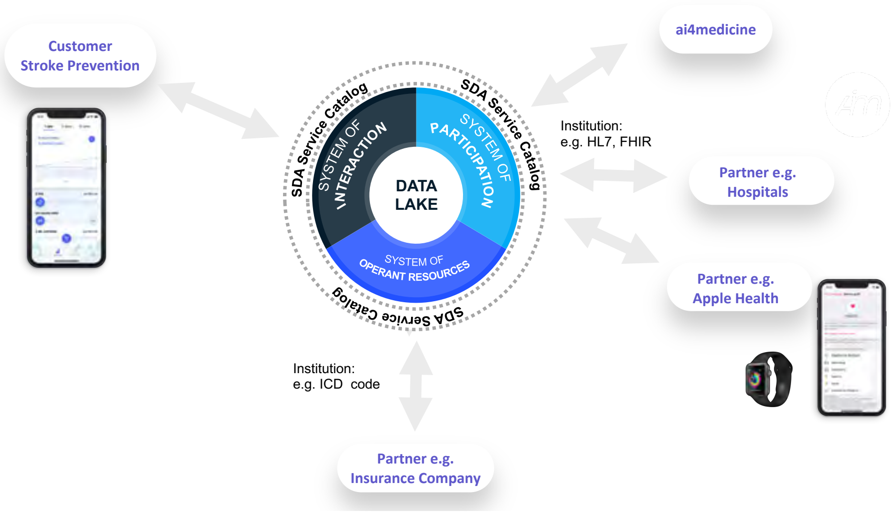
Embedded use case: stroke prevention (ai4medicine)

As described by (Zolnowski & Frey, 2020) ai4medicine is a personal health advice service for stroke prevention in Germany. The underlying prediction model was developed with machine learning algorithms based on clinical data (Berlin Charite) from patients with an increased risk of stroke. Stroke prevention offers both a high patient benefit and opportunities to improve customer relations for partner companies, all the way to reducing benefit expenses for health insurance companies.

The business model of ai4medicine is based on the use of the app with which customers are comprehensively supported in reducing their stroke risk. Based on a risk assessment, customers receive recommendations for behavioral changes that lead to a minimization of the risk of stroke. With this offer, targeted behavioral changes are made to the customer that reduce the risk of stroke. To enable the offering, ai4medicine has to combine clinical and epidemiological data on stroke and domain knowledge to develop and train artificial intelligence models. These models build the basis of the value proposition and enable evidence-based, AI-powered stroke prevention strategies. The application requires customers to use their devices and install the mobile app.

In addition, partners such as insurance companies can provide historical health data of the customer to further improve data quality and individual stroke prevention. Partner companies can integrate ai4medicine with their existing mobile apps. In addition, existing interoperable health data from waereables, for example, will be connected and integrated. This eliminates the need for the user to manually enter the data.

Figure 10 Institutions for Health Data exchange



Health Information exchange standards like Health Level 7 (HL 7), Fast Healthcare Interoperability Resources (FHIR) or the International Classification of Deseases (ICD) are established institutions to achieve healthcare systems interoperability. These institutions align actors by enabling actor coordination and resource integration (Adner, 2017).

Evaluation

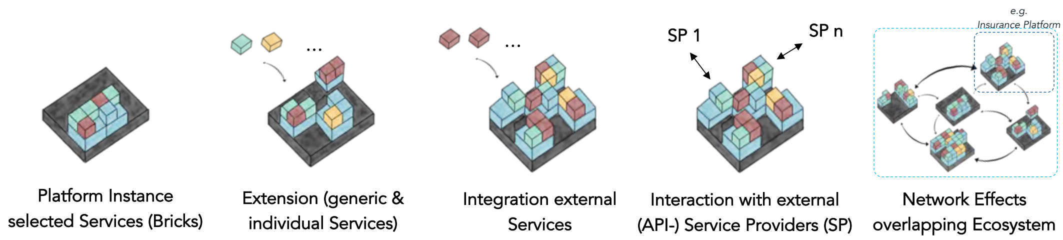
The two use cases show how institutions combined with modern digital technologies empower organizations to change processes and behaviors. In addressing this, all five objectives for overcoming organizational inertia are impacted.

Table 3 Evaluation of the Impact of Institutions on overcoming Organizational Inertia

Objectives to overcome organizational inertia	Institution within SDA Service Catalog	Impact
actor engagement	Combination of SDA design pattern implemented as service platform (engagement platform) and Institutions as rules for actor coordination and resource integration	fostering actor engagement and new situational mechanisms
rules in use	SDA generic business bricks; Spotify Backstage developer portal, industry-specific institutions like HL7, FHIR, ICD codes, API plug ins	changing the rules in use of the action arena; reuseability
actor-to-actor networks	SDA service systems as engagement platform Resource integration pattern (system of participation)	empowering actor-to-actor networks by offering resource integration pattern
resource density	SDA service systems as resource integration pattern; institutions to foster interoperability	enabling resource-integration; resource-density and resource-orchestration
service exchange	modular, standardized, reuseable (micro-) services and generic business bricks (packaged business services)	pave the way for resource application and service exchange

The interplay of modern technologies, reuseable packaged (technological and business) capabilities, and institutional agreements improves organizational development understood as the ability to integrate, adapt and apply resources and capabilities (Warg & Zolnowski, 2018). Actor engagement and service exchange facilitate resource density and network effects and enable to overcome the "lock-in"effects of incumbent technologies and business practices.

Figure 11 Service Exchange and Network Effects



Findings and outlook

The research question of this paper is "how can organizations overcome inertia as barriers to new value creation paths by shaping institutions?".

Based on the domain theories of Service Science, Service-Dominant Logic, Social Sciences and the IAD framework the paper elaborates that overcoming organizational inertia requires the orchestration of state-of-the-art technologies, business capabilities and the coordination of actors to change processes and socio-technical practices.

On behalf of the single case study of Service Dominant Architecture with the embedded use cases of Spotify Backstage and ai4medicine, the relevance of service catalogs for actor engagement, shaping institutions as rules in use and service exchange is demonstrated.

Within service (eco) systems service catalogs have strong impact to overcome the "lock-in" effects of incumbent technologies and business practices by finding, adopting and institutionalyzing better technologies, business capabilities and processes as socio-technological practices.

Figures

- Figure 1 Ostrom`s Institutional Analysis and Development (IAD) framework (Kiser & Ostrom, 1982; Ostrom, 2005; Ostrom, Gardner, Walker, Walker, & Walker, 1994)
- Figure 2 Rules as exogenous variables directly affecting the elements of an action situation (Ostrom, 2005)
- Figure 3 Coleman´s boat (Coleman, 1990)
- Figure 4 The narrative and process of S-D Logic (Vargo & Lusch, 2016)
- Figure 5 Generic Pattern of Actor engagement; source Warg, Hans 2021 modified of: Coleman 1990,Ostrom 2009, Storbacka et. al. 2016
- Figure 6 Architectural Pattern as Conceptual Framework of Service Dominant Architecture (SDA) (source: IfSD.hamburg)
- Figure 7 SDA Service Catalog (Warg, Hans (2021))
- Figure 8 Personalized Developer Portal on basis of Backstage
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- Table 1 Five Objectives to overcome Organizational Inertia with the help of Institutions
- Table 2 Examples of Institutions within SDA Service Catalog (Warg, Hans (2021))
- Table 3 Evaluation of the Impact of Institutions on overcoming Organizational Inertia

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Blockchain and ecosystem perspective: a focus on agrifood business

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Problem/Goal

Recently, the issue of sustainability of the agri-food ecosystem has attracted a lot of interest among scholars and practitioners. Agrifood ecosystems are complex systems, as they include biological, economic, social, health, and political variables at different levels, including farms, local, regional, national and global (Bryceson & Ross, 2020). Furthermore, agri-food supply chains are complex as they are labor intensive at all stages of the chain (Maloni & Brown, 2006). The agri-food chains are made up of more and more networks of actors (Mutonyi et al., 2018).

Managing such complexity can no longer disregard the development and implementation of technologies on security and data integrity (Tian, 2016). The phenomenon of blockchain technology fits into this perspective. Indeed, several studies (e.g., Kramer et al., 2021) agree that blockchain technology (BT) is capable to trace the Agrifood lifecycle from origin through every point of contact on its journey to the consumer reinforcing credibility, efficiency, resilience and safety. (Tripoli & Schmidhuber, 2018). Some studies investigate the role of blockchain technology as an enabler of the sustainable agrifood chain (Kamilaris et al., 2019; Duan et al., 2020; Mukherjee et al., 2021). Indeed, it is a shared opinion that blockchain technology is able to support the development of sustainable practices and support coordination and collaboration within the supply chain (Mukherjee et al., 2021). In this way, it is possible to monitor the activities that are distributed among actors, solve any inefficiencies of the agrifood supply chain (eg delays, food waste, etc.) and lead to the sustainability of the agricultural sector (Kshetri 2018; Nandi et al. 2020). Specifically, the BC has the potential to simplify and integrate agricultural supply chains, enhance food safety, reduce risk in trade finance and promote inclusive trade; it increases the access to agricultural financial services, generates smarter market information and provides greater legal certainty to land-tenure systems (Tiscini et al., 2020, p.1622).

These studies widely debated on potential adoption drivers and barriers, and application and implementation stages within the food supply chain. As the ongoing transformation in the agrifood industry is mostly focused on food safety (Vivaldini, 2021), there are no studies in management adopting a wider perspective of the entire ecosystems and analysing its real impact on the market.

In the service and business literature, it has been demonstrated that new technologies become a tool to improve resource integration and engage multiple actors for value co-creation (Sklyar et al., 2019).

However, how the blockchain impacts the existing agrifood ecosystems is not addressed yet (Kjellberg et al., 2015). Further, the implementation of that technology is still in an embryonic stage. There is still little empirical literature on the potential of blockchain technology for promoting sustainable agri-food chains. Our study addresses this gap, and we try to understand better how actors use and develop BcT and how its deployment affects ecosystems in order to co-create integrated value for all the stakeholders from a sustainability perspective

Methodology

This work adopts a case theory method (Gummesson, 2017) to understand how blockchain technology affects actors' activities, relations, processes and rules and the more extensive agrifood ecosystem. The focus is on the agri-food business, seen as complex ecosystems consisting of different actors' relationships and rules of games (Mutonyi et al., 2018). The qualitative methodology was chosen because it helps the researcher to understand what the individual does in practice and the sociocultural contexts in which he lives (Gummesson, 2017). The data collection phase was performed through the administration of in-depth interviews involving

30 companies (both technology suppliers and agri-food companies). The collection of primary data was accompanied by complementary data, including company reports and internal documents. Subsequently, the researchers analyzed the collected data in question, categories of themes were identified, and the relationships between them were defined. In the last step of the analysis process, the researchers discussed the results with the managers. In detail, this first phase of qualitative analysis allows us to identify the variables to be included in a more in-depth analysis of the agrifood ecosystem using a fuzzy-set qualitative comparative analysis.

Results

Our study will show that the applications of blockchain technology allow value co-creation by impacting many of the established activities, relationships, and processes in the agrifood ecosystem. Our preliminary results reveal that many challenges of the agri-food ecosystem are addressed through blockchain and its features (decentralization, transparency and immutability).

The results show that blockchain contributes to increasing collaboration, reduce the complexity of business processes involving both technical economics and environmental standards, and improving trust due to the possibility of overcoming bad market practices (Italian sounding and counterfeiting). The results show that blockchain contributes to increasing collaboration, reducing the complexity of business processes involving both technical economics and environmental standards, and improving trust due to the possibility of overcoming bad market practices (Italian sounding and counterfeiting).

In detail, our research reveals that BCT affects agrifood service ecosystem in term of activities (traceability, notification, data visibility, automation); process (trust, safety, information sharing, collaboration, coordination sharing) and institutions (new language based on QRcode, Token and new rules of the game and norms). The integrated value co-creation process for all the stakeholders is prompted by new interactions based on decentralized decision-making processes, transparency, and immutability. New processes emerge, actors' relationships are prompted by trust, safety, information sharing, and collaborations and new language and rules are established.

Our preliminary findings reveal that blockchain enables new processes to occur due to the availability of validated, transparent, certified information and relationships; equal relationships are encouraged as everyone can verify and share key information and establish trust; the institutional arrangement is favored based on new institutions (digital payment, currency, token, smart contract, ecc.). Indeed, the blockchain can be considered a multi-layered resource as it can act on other resources by impacting processes, relationships, and institutions.

Towards sustainable service value economy

Heikki Ruohomaa, Vesa Salminen (Häme University of Applied Sciences, HAMK Smart Research Centre)

Introduction

Purpose of Research

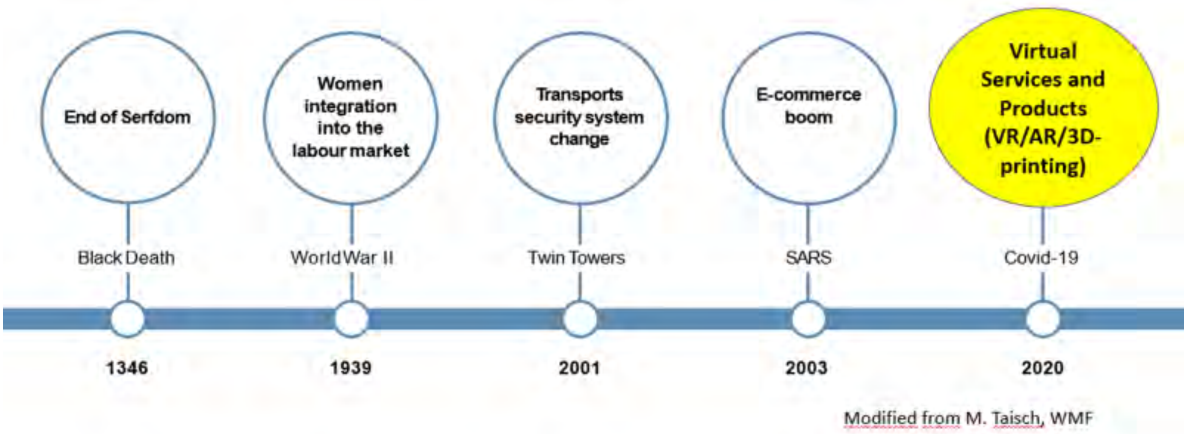
Two radical changes are transforming the society. One is a human created, rapidly worsening systemic, ecological and social crisis. The other is a continuously evolving, deeply systemic, human created digital technology revolution. This has influenced on a need for transformation of the economy systems from the linear model to circular one. COVID- pandemic has influenced so that business is evolving towards virtual direction on virtual products and services and on virtual business (figure 1).

On the human history big crises have been triggering big fundamental change. The crises themselves have not made a difference, but the crises have largely forced them to make the changes that society has or that technology makes possible.

The COVID-epidemic is a crisis that today is forcing the world to reform irrevocably [1]. The rapid development of ICT-based technologies, new ICT-based technologies and a globalizing market are enabling change.

The mainstreaming times of new technologies are well known and the rate of change (s-curve). As a result of development, the physical world mixes with the virtual world. As virtuality evolves, so do traditional value chains and business models that take advantage of virtuality and even replace value chains of traditional physical world.

Figure 1: COVID-pandemic influence towards virtual services and products [1, modified]



Methodology

Moving towards virtual value chains will reduce key physical operations such as manufacturing, storage, transportation, recycling, etc. The reduction in these physical ones will result in a huge reduction in CO2 emissions.

The opportunities offered by digitalization and the emergence and usefulness of new technologies are widely accepted. However, the exploitation of digitalization has focused on streamlining and modernizing traditional physical value chains. However, less thinking and attention has been left to replacing traditional value chains with virtual value chains. Merging virtual and real worlds, create new virtual products and services in addition to virtual value chains, and form global virtual innovation ecosystems. Understanding the virtual future requires detachment from traditional thinking and abandoning traditional value chain thinking.

The traditional thinking and operating model try to make value chains more efficient by utilizing digitalization. By using digitalization, increasing use of data and new technology, the material flow- based value chains are shifting towards the way of thinking that data is at the center. New ICT-based technologies and the growing amount of data enable the development of new type of value chains functioning virtually and in accordance with sustainable development.

Through the integration of the virtual world and the physical world, it is possible to move from circular economy towards the next stage of development, virtual economy. It is important to create an innovation ecosystem for value chain development that supports the integration of the physical and virtual worlds in the search for solutions.

The objective of this article has been to show how the technology development and increase of the amount of data influence on the value chain functionality and how to innovate new virtual services. COVID- pandemic has accelerated the change.

In this research has been used qualitative research methodology during five different R&D- projects by analyzing their execution and through expert interviews. During implementation phase material centric value chain were changing towards data centric value chain. Technology trends on influence of the increase of data amount and impact of climate change were followed during execution phase.

As a result, in this article has been introduced a framework of data centric service value chain, which will complement the traditional material centric value chain thinking. That is an

important approach for the development of transforming service business towards virtual service value economy.

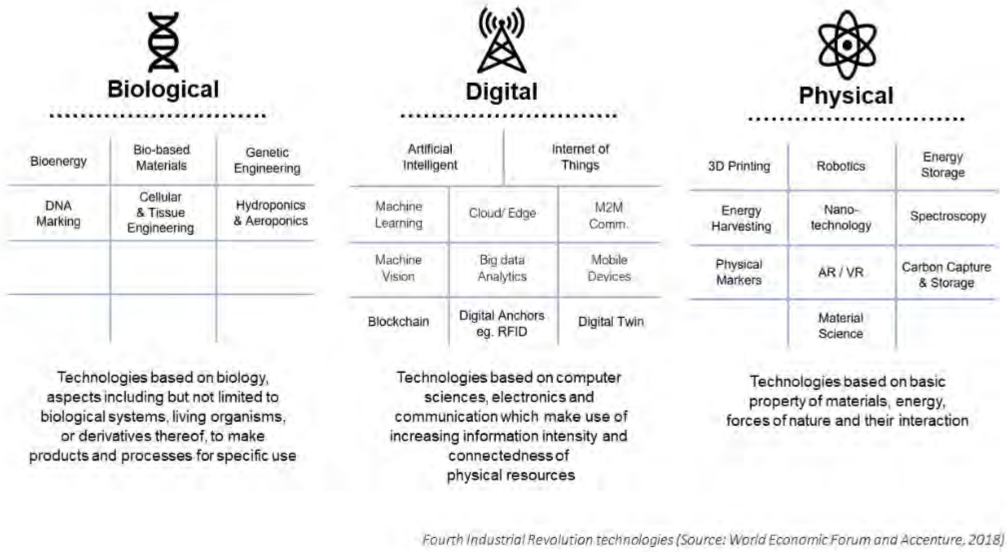
Theoretical Framework

Fourth Industrial Revolution

The fourth industrial revolution, new technologies and increasing amount of data will change society and structures of business. This move towards the ICT based technologies will happen unexpected fast including exponential growth of data. Thus, it is essential to understand the change and have strategic view to see the new opportunities and the key elements of development.

The expression "Industry 4.0" contains the promise of a 4th industrial revolution. In future, as Industry 4.0 open up, computers are connected and communicate with one another, in the end, to make decisions without human involvement. Everything will be connected virtually, if possible, and virtual world and physical world will be connected. This will transform whole economies and societies and our behavior. This means also new approach to understanding future value chain thinking.

Figure 2: Fourth Industrial Revolution Technologies [2]



Increasing amount of data

It is estimated data creation will increase to a huge 175 zettabytes (ZB) by 2025. This is ten times the amount of data generated in 2017 [3]. The 90% of the data, in the world has been created in the last two years alone, daily basis 2.5 quintillion bytes of data is collected. It is predicted that the 60 % of the world's data is collected via applications relying on artificial intelligence, and machine-to-machine technologies, automation and the increase of data collection from smart devices.

It can be seen that "the average rate per capita of data-driven interactions per day is expected to increase 20-fold in the next 10 years as our homes, workplaces, appliances, vehicles, wearables and also implants become data enabled". [3]

The conclusion of the increase is that data is progressively a critical influencer for all aspects of our lives. Smart devices and IoT are already promoting the amount of "life critical" data.

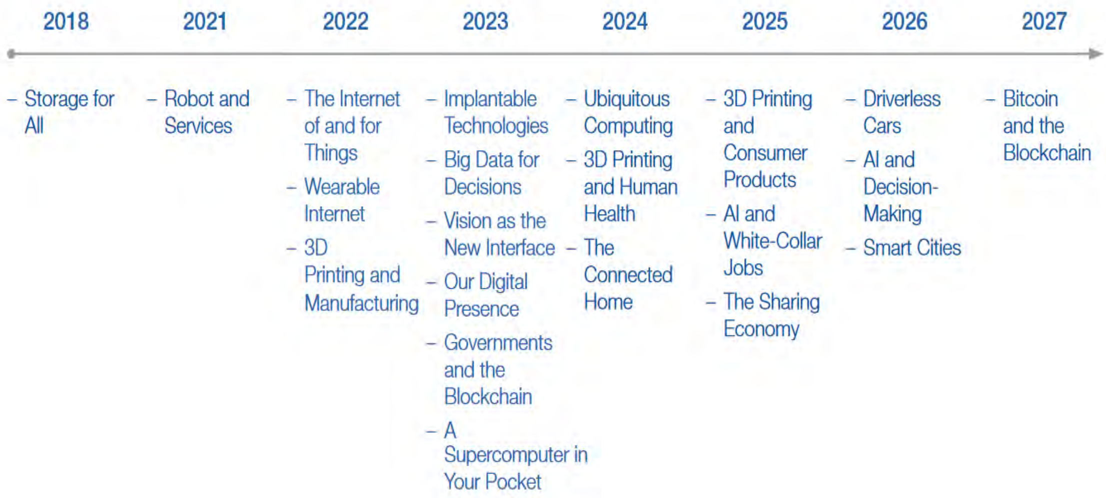
Therefore, it is essential to ensure that businesses and business environments are aware of where and how data growth is happening and are ready to manage data effectively and ensure that benefits have achieved

In addition to the societal impact, poorly managed increasing amount of data could result losing revenue in existing business by having operational inefficiencies and bad customer experience. By 2025 over 20% of the data collected globally could be useful for analytics. [3]

New ICT-based technologies (tipping points)

World Economic Forum research, results show that a remarkable number of new technologies were expected to take place in the coming years.

Figure 3: Average year each tipping point (shift) would occur at some point in time World Economic Forum, Technology Tipping points and Societal Impact [2]



Virtual Economy

The urgency of the climate crisis is driving some of Europe's leading manufacturers to pursue new strategic approaches intended to mitigate the environmental impacts of their products and processes. One such innovation is to adopt a *circular business model*, whereby a focal company collaborates with its ecosystem partners to create, capture, and deliver sustainable value [4]. The goal: to improve resource efficiency — by extending the life spans of products and parts, for example — to achieve environmental benefits while still meeting profit targets [5].

A manufacturer that adopts a circular business model must integrate itself more deeply in the operations of its customers, cocreate value with partners, emphasize value-in-use rather than value-in-transaction, and launch new, innovative services.

A virtual economy is an emergent economy existing in a virtual world, usually exchanging virtual goods. However, some people do interact with virtual economies for "real" economic benefit. Virtual property is a label that can refer to any resource that is controlled by the powers-that-be, including virtual objects, avatars, or user accounts [6].The following characteristics may be found in virtual resources in mimicry of tangible property. Note however that it is possible for virtual resources to lack one or more of these characteristics, and they should be interpreted with reasonable flexibility [7].

Virtual resources persist across user sessions. In some cases, the resource exists for public view even when its owner is not logged into the virtual world. Resources may affect or be affected by other people and other objects. The value of a resource varies according to a person's ability to use it for creating or experiencing some effect. Virtual resources may be created, traded, bought, and sold. Real-world assets (typically money) may be at stake. Users may enhance the value of virtual resources by customizing and improving upon the resource. The existence of these conditions create an economic system with properties similar to those seen in contemporary economies. Therefore, economic theory can often be used to study these virtual worlds. A different set of virtual economic activities creates unambiguously positive value by helping customers overcome natural scarcities that linger in the digital world. [8]

The term 'virtual economy' (VE) refers to the process of exchanging virtual items and services with virtual currency within a virtual world [9]. Many companies struggle to succeed in the virtual economy platform. In order to facilitate and drive success in virtual business strategies, it is necessary to have a framework for classifying elements of virtual economies.

Nazir and Lui [9] have outlined a classification framework for VE based on the characteristics of products and services, the transaction and marketplace, as well as the currency and exchange systems. Such a classification is necessary because the market environment, and the products and services offered in VE can be very different from those in traditional markets and e-business.
Now, in the age of digital, the challenge is not just about selling something in a different channel. The goal and the challenges are two-fold: a) how to envision and launch digitally enabled products and b) for existing products as well as new digitally enabled products (virtual or real), what is the best way of enhancing the customer experience [10].

Companies have learned that routine tasks involving transactions and coordination can be done purely virtually, while work requiring true team collaboration (collective learning, innovation, building a shared culture) is still best-done face to face. We envision that the post-pandemic future of teamwork will be a purposeful hybrid combination of virtual coordination and in-person collaboration.[11]

Ecosystem based change in virtual world

Thus, it is important to understand the ecosystem-based change in the complex and fast-changing era of the 4th industrial revolution transition by new ICT-based technologies and huge increasing amount of data.

The problems foreseen in the transition of the 4th industrial revolution are complex and unprecedented. The complexity, the speed the change and the new technologies, mean that an ecosystem-based approach is considered to function as a framework for development [12]. There are many ecosystems present and they are interacting and changing all the time. This mean that real time data is the oil of innovation ecosystem and is critical factor to build up continually new online services.

Research Objectives and Questions

The objective of this article has been to show how the technology development and increase of the amount of data influence on the value chain functionality and how to innovate new virtual services.

Research questions and topics addressed in this article:

- Do the merging of the physical world and the virtual world create a new virtual value chain model as paradigm shift?
- Are virtual products and services replacing physical products and services?
- What is the innovation ecosystem through which new innovations can be generated to develop a virtual value chain?
- Is the circular economy and resource efficiency thinking too much about the linear direction of material efficiency and the traditional value chain?
- What are the multiplier effects of the COVID pandemic as technology continues to evolve to deploy the virtual value chain?

In this research has been used qualitative research methodology on following five different R&D- projects during their execution and concentrating on expert interviews, trend analysis and data analysis of material centric value chain changing towards data centric value chain. It has been as well followed and analyzed for longer term the development of technology trends, influence of the increase of data amount and impact of climate change.

Development of value chain thinking

Traditional value chain thinking

Michael E. Porter, of Harvard Business School, introduced the concept of a value chain in his book, *Competitive Advantage: Creating and Sustaining Superior Performance* [13]. He wrote: "Competitive advantage cannot be understood by looking at a firm as a whole. It stems from the many discrete activities a firm performs in designing, producing, marketing, delivering, and supporting its product." In other words, it's important to maximize value at each specific point in a firm's processes.

In his concept of a value chain, Porter splits a business's activities into two categories, "primary" and "support". Specific activities in each category will vary according to the industry. Primary activities consist of **Inbound logistics, Outbound logistics, Marketing/Sales** and **Service (figure 4).** All are essential for adding value and creating competitive advantage.

The role of support activities is to help make the primary activities more efficient. These support activities are **Procurement**, **Technological development, Human resources (HR), Management** and **Infrastructure** (figure 4). These are generally denoted as overhead costs on a company's income statement

Figure 4: Value Chain Model [11]

Through a digital breakthrough, streamlining of traditional value chains (Porter) has opened up new opportunities with new technology providing unprecedented opportunities.

By analyzing the stages of a value chain, managers have been able to redesign their internal and external processes to improve efficiency and effectiveness.

By building the Value Chain companies integrate the information they capture during stages of the value chain—from inbound logistics and production through sales and marketing—they construct an information underlay of the business. This integrated information provides managers with the ability to “see” their value chains from beginning to end.

Future value chain thinking

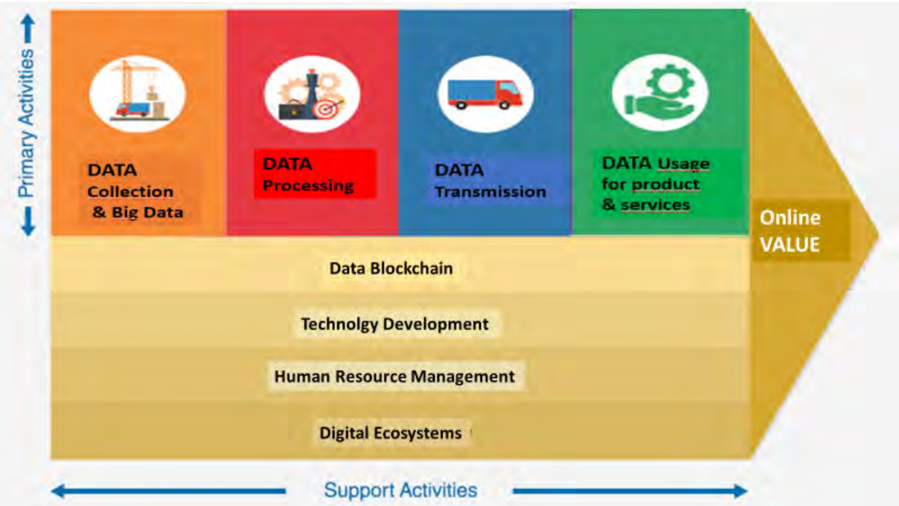
Our thinking has been largely based on streamlining the material flow of value chains or build services which are related to physical products. New technology and virtual services challenge material-centric value chains because it only represents the perspective of the physical world. The integration of the physical world and the virtual world leads to a new approach to traditional value chain thinking.

In a traditional physical value chain, the value of a material changes at different stages of the chain and is determined by the value that the physical product brings to the customer. In a virtual world, this may not be the case.

In virtual value chains, material, production, logistics, etc. is no longer present in its traditional sense. An analogy of the virtual and physical worlds, however, can be found; Materials are replaced by data, logistics by data transfer, big data represents storage and data analytics production for example. It is also conceivable that the services of the new value chain are real-time without delivery time.

It can rightly be argued that value is created in the virtual world through data and customer understanding based on data ownership, data availability, and customer understanding.

Figure 5: The value chain of digital time [11, modified]



In order to integrate the physical world and the virtual world in a sustainable way, the elements and specificities of building "digital value chains" should be taken into account in order to enable new value chains.

Such primary activities include:

- Data collection & Big data
- Data aggregation and processing • Data transfer
- Data usage on services and products (3D-printing)

Such secondary issues include:

- Infrastructure (telecommunication) and Digital Ecosystems
- Human Resource Management
- Technology development by Innovation Ecosystem
- Blockchains on Data Platform

The new value chain model requires that e.g. issues related to data ownership and collection, as well as issues related to the utilization of the actual product, be defined and agreed.

What next after circular economy

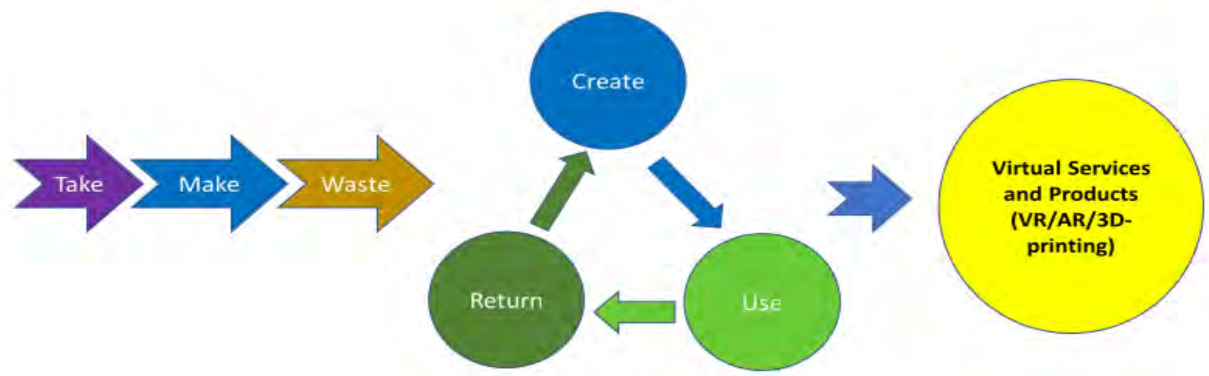
Circular economy thinking is becoming more common in line with the needs of material efficiency and environmental issues. The development of technology has played a significant role in enhancing the efficiency of the circular economy.

With the integration of technology and the physical and virtual worlds, it is clear that new intangible value chains will emerge alongside new models of sustainability and material efficiency, centered not on materials but on new virtual services brought about by data. That is foundation also for new paradigm shift (figure 6).

The COVID pandemic has shown direction for the exploitation of new technologies, the main phenomena of which are e.g. teleworking, home delivery of food, e- commerce and virtual meetings. Although the technology has long been available, it has not been exploited and deployed in large-scale.

With the development of technology, new forms of communication are emerging over the telecommunication networks. These new virtual possibilities will inevitably displace some of the activities of the physical world. With this development, traditional innovation ecosystems will also become more real-time and continuous and are developed based on the utilization of fact-based information.

Figure 6: Future paradigm of virtual economy



Renewal is sought from data obtained from the interfaces of different functions and industries. As a result, large masses of people will inadvertently participate in the operation and innovation in such innovation ecosystems. That happens by human involvement and participation through gaming, mobile equipment and use of sensor data.

Conclusions

The traditional thinking and operating model try to make value chains more efficient by utilizing digitalization. With digitalization, data and new technology, the materials of value chains at the center are shifting to thinking where data is at the center. New ICT-based technologies and the growing amount of data enable the development of new types of value chains virtually and in accordance with sustainable development.

COVID19 has already triggered the development of virtual products and services and virtual business direction. Through the integration of the virtual world and the physical world, it is possible to move from circular economy thinking to the next stage of development.

In this article has been introduced a framework of data centric service value chain, which will complement the traditional material centric value chain thinking. That is leading business and society transforming service business towards virtual service value economy.

It is essential to create an innovation ecosystem for value chain development that supports the integration of the physical and virtual worlds in the search for solutions. Future innovation system should boost the sustainable development beyond the circular economy.

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Automatic Generation of Word Problems for Academic Education via Natural Language Processing (NLP)

Stanley Keller (CAS Heilbronn)

Introduction

Motivation for on-demand Education Resources

The era of online education comes with new opportunities in terms of student engagement. Digital learning platforms enable students to learn on a flexible and individual schedule as well as providing instant and thorough feedback mechanisms (cf. [3], p. 7). Individual student errors can be highlighted in solution paths and taken into account for future training exercises. One area where the aforementioned aspects are present is regarding training exercises for STEM education. Many topics in that field require students to solve numerous training exercises in order to grasp and abstract underlying concepts (cf. ([1], p. 122), ([22], p. 4)). It is apparent that there are restrictions in classical offline education in terms of teacher and exercise availability, which prevents the fulfillment of truly individual education, both in terms of quantity and individuality of training data.

The resulting demand for a practically unlimited amount of training data currently leads to limitation of exercise diversity. As training exercises need to be verified for validity in order to be useful, the verification process, which almost always implies human engagement, imposes a bottleneck for exercise generation. A common remedy has been to reduce verification efforts by limiting exercise complexity. This is achieved via populating a pre-validated exercise-skeleton with varying values, i.e. exchanging numbers (cf. ([16]), ([7])). This tradeoff, in many cases, entails repetitive exercises.

Repetitive training exercises lead to inferior real-world applicability of concepts (cf. [8], pp. 28-32). This symptom is borne in the observation that students, once they have identified a structured approach to solving an exercise, will preferably apply the same approach to a new problem instance. If the learned approach is rather shallow, which is the case if students merely remember which numbers to plug into which formula based on number location in an exercise, it cannot be applied to real-world situations that most likely do not adhere to the same learned structure (cf. [8], pp. 28-32). Exchanging numbers in a rigid exercise-skeleton leads to the adoption of such a shallow structure (cf. ([20], pp. 102-103), ([17], pp. 166-167)). Diverse training exercises and participation in exercise generation, on the other hand, enforce the adoption of a thorough understanding of underlying concepts (cf. "active involvement" in [8], p. 30). In order to enforce abstraction the constituent structure of the exercise should vary instead of merely exchanging numbers and contextual entities. To allow for the generation of diverse exercises, the verification bottleneck needs to be alleviated or avoided altogether.

Contributions of this Thesis

Figure 1: Examples of requirements posed on word problems in mathematical statistics (own illustration)

Example	Issue
Human height can be assumed to be normally distributed with a mean of 1.8m. What is the chance that a person's height is measured at above 1.9m?	Missing information about the standard deviation → not complete
A traffic light is red with a chance of -10% or green with a chance of 110%.	Information does not adhere to mathematical assumptions → not correct
A traffic light is either red with a chance of 60% or green with a chance of 65%.	Conflicting information → not consistent
Dogs live 8 years on average, whereas cats live 10 years. Waht is the average lifespan of an animal?	Unclear task → not unequivocal

This thesis is guided by the research question of how diverse word problems in mathematical statistics can be synthesized in an automated fashion. In addition to requiring the generated language to be grammatically correct, the nature of word problems implies additional constraints on the validity of contents.

For the scope of this thesis a word problem is defined as an ordered set E = (C, Q), consisting of an exercise context C and respective questions Q. In contrast to basic language modelling, word problems underly the constraint that, in addition to containing fluent and coherent text, they must be valid. An exercise is defined to be valid if it meets the following requirements:

- **Completeness**
  The context must contain all information required to answer all questions
- **Correctness**
  Information contained in the context must satisfy mathematical assumptions implied by the exercise type
- **Consistency**
  Information contained in the context must not contain any contradictions
- **Unequivocacy**
  All questions and all context information must be unambiguous

Examples for each requirement are listed in figure 1.

The desire for diversity among generated exercises originates from the intention to prevent memorization of surface structure and instead encourage abstraction capabilities of students. To enforce abstraction the constituent structure of the exercise should vary instead of merely exchanging numerical values and contextual entities in a fixed structure. Similarly, exercises should not only respect grammatical rules, but also maintain semantic coherence across sentences. Simply embedding relevant information into a general context without any coherence would again lead to memorization of surface structure, since relevant information could easily be distinguished by irrelevant information.

Consequently, a system that is tasked to adhere to all aforementioned requirements has to ensure both text fluency and diversity as well as guarantee content validity. This in turn requires managing the tradeoff between methods associated to those requirements, namely Neural Language Models (NLM) and template-based techniques. NLMs have empirically proven their ability to generate human-like, fluent text (cf. [2], p. 28), though they are hard to control with respect to validity constraints (cf. [10], p. 1). Template-based techniques on the other hand allow the developer complete control over generated phrases but, being predefined by nature, lack diversity.

Based on the introduction above the following research objectives are derived:

Research Question:

How can diverse word problems in mathematical statistics be synthesized in an automated fashion?

Research Objectives:

1. Develop a novel approach to synthesize natural language subject to general content validity constraints

2. Apply the novel approach to the task of word problem generation for academic education in mathematical statistics
3. Demonstrate the effectiveness of the novel approach in an experimental setting

The remainder of this thesis is structured as follows. Chapter 2 presents related work on word problem generation. Chapter 3 details the proposed method for word problem generation and highlights key design choices of the approach. Chapter 4 presents the results of experiments conducted in the light of research objective 3. The remaining chapters are used to discuss the approach ex-post and conclude the thesis.

An extended version of this thesis is available at Arxiv.

The source code for this thesis is available at https://github.com/Stansuro/ExGen.

An interactive online demo of the code is available at Google Colab.

Related Work

In ([24], pp. 494-503) the authors aim to generate word problems by encoding both the target equation and the desired context into a single embedding and decoding it into the tokens of the word problem. While they employ simple lookup embeddings for the desired context, the equation decoder is based on recurrent neural networks.

A similar approach is chosen by ([11], pp. 3-6). The authors deviate from ([24]) by encoding the target equation via a Graph Neural Network and incorporating a VAE architecture into the generation process. This approach allows them to sample from a distribution of problem embeddings at decoding time, enabling a great deal of exercise diversity. Additionally, they incorporate a commonsense knowledge graph that is also embedded by a Graph Neural Network to introduce even more diversity. While the generated exercises show strong diversity, the authors note that their model in some cases has trouble generating valid exercises in that it sometimes breaches the constraints for completeness and language fluency as documented in figure 2.

Figure 2: Typical problems of word problem generation (cf. [11], p. 9)

Missing information	Teacher Mr.Huang and his 35 students come to row the boat. They find 6 more small boats than big boats. There are 10 more students in the small boat than in the big boat. How many big boats are there?
Language disfluency	There are two types of heads: cockroaches and ants, cockroaches have 1 more head than ants, and cockroaches have 0 more than ant legs, how many cockroaches and ants respectively?

The authors of ([12], p. 3) also identify the task as constrained text generation and define the following constraints:

1. **Mathematical Correctness**
   In their case referring to the size relation between two values or algebraic satisfiability
2. **Unit Correctness**
   Their generation approach should assign correct units to the variables (e.g. milk should be measured in liters, not in seconds)
3. **Coherence**
   The two variables introduced in their approach should be coherent to a joint context

The system proposed by the authors takes as input only a user defined prompt. They choose to generate text conditioned on this prompt and apply constraints afterwards by identifying critical constituents (in this case words) via POS tagging and adjusting the tokens that are identified to invalidate constraints. This Checking strategy requires the manual definition of POS tag sequences as well as mathematical rules to identify relevant tokens and check for validity. The model that is used for text generation has been trained on a dataset of exercises similar to the desired output exercise. This limits their approach in that the structure of exercises generated by the approach is still very similar among exercises. In addition to this, the presented examples are missing punctuation and inflections are not always correct.

In ([13], p. 4709-4716) the same authors adapted their model to alleviate the need for manually defining the aforementioned checking strategy. They achieve this by incorporating POS tags into the training data. Thereby the updated model is able to learn the checking strategy itself, given sufficient training data. The exercises still remain rather similar in their constituent structure though, since the same training data has been used as for the previous model.

The system proposed by the authors of ([18], pp. 381-388) takes two sets of requirements as input. One set contains tutor requirements, e.g. the type of operations and equations an exercise shall contain. The second set contains student requirements, such as the context of the exercise, the actors and their relationships.

Their approach first constructs a valid logical graph for an exercise and afterwards realizes this graph into text though a realization engine. In this context valid means that the generated logical graphs adhere to all requirements set by tutor and student. In addition to the user defined requirements the system aims to generate plots that tend to be interesting by introducing discourse tropes. Discourse tropes are facts that do not add to or interfere with the mathematical problem at hand but make the plot more engaging and lively.

This approach differs greatly from the previous approaches, since it is strongly logic based and uses no NLM components. It therefore requires far more details for generating an exercise in the form of structured user input as well as predefined ontologies. These ontologies are required for the model build its logical graphs and therefore pose a bottleneck in scaling the model to arbitrary contexts.

Finally, some consolidating observations are noted:

1. All authors generate text exclusively via neural methods or templating methods
2. Authors opting for neural text generation methods additionally pose the task of constraint satisfaction onto the NLM
3. All authors take as input exclusively either structured (e.g. equations) or unstructured (e.g. prompts) inputs. Those authors that only use unstructured input rely on their model to define structure based on the data it has seen during training time, therefore limiting the possible structures

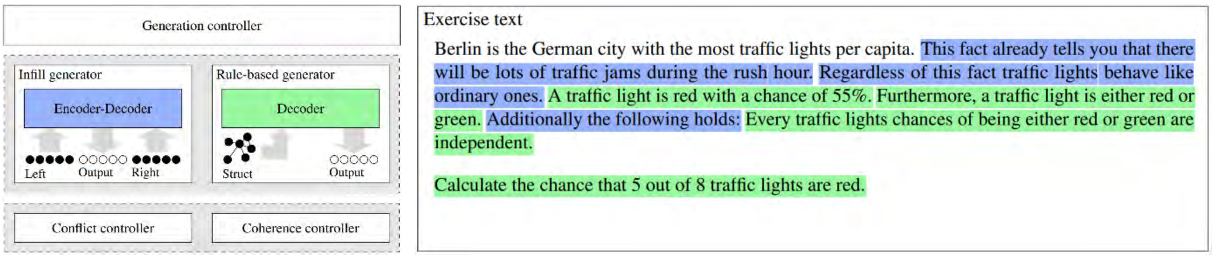
Proposed Method for Word Problem Generation

General Approach for generating Constrained Text

The key design choice of the presented approach is to disentangle the task of generating validity constrained text into generating distinct text constituents and combining them in a controlled manner. This allows for the introduction of a generation controller that is able to adapt the generation strategy depending on whether constituents must adhere to content constraints or not. Specifically, this distinction is defined to take place on sentence-level. The overall architecture is presented in the left part of figure 3.

The proposed model takes as input two types of user provided data. Unstructured user input, namely a prompt for setting the context of the exercise to be generated, and structured user input, encoding the exercise specification in terms of exercise type and hardness.

Figure 3: Model architecture and example exercise, color indicates generator (own illustration)



Constrained generation can rely on the determinateness of template-based approaches, i.e. realization engines, guaranteeing constraint satisfaction at the cost of restricting diversity. Though, through designing templates in an adequate manner, diversity is reasonably retained. This type of generation is based completely on structured user input. Unconstrained generation on the other hand can harness the creativity of Neural Language Generation (NLG) approaches, i.e. NLMs, to produce diverse content. This type of generation is mostly based on unstructured user input.

Combining both constrained and unconstrained constituents is facilitated through first arranging them in a varying order via the generation controller and generating connecting text segments to merge constituents. The constituents being generated in this manner provide semantic continuity to the overall text. The arrangement of constituents as well as the amount of additional context incorporated into an exercise is dependent on the desired hardness of the exercise.

To clarify the previously introduced concepts, figure 3 displays an example exercise including labeled constituents. Color indicates which generator was used, no color means user input is adopted without change.

Constituents generated via NLMs are programmatically checked for constraint satisfaction by a conflict controller. Concretely, every non-constrained constituent is checked against every constrained constituent via Natural Language Inference (NLI) methods. Since constrained constituents are guaranteed to satisfy all constraints, they can be used as a ground truth assumption. If a contradiction is detected, the generation controller discards and replaces the constituent. This way all constituents are guaranteed to be valid.

Contrasting this approach to the approaches presented in the related work section, several new ideas are prevalent:

1. The task of text generation is split into template based approaches and NLG
2. Constraint satisfaction is not directly incorporated into the NLM but rather outsourced to a specialized NLI model
3. The user can directly influence the generation style of the system instead of giving full control to a pre-trained NLM, allowing for e.g. adjustable hardness of exercises

The pursuit of modularity has been a top priority in designing the proposed approach. One positive aspect of this modularity is the fact that individual building blocks can be scaled, improved and exchanged flexibly. Thereby, one can freely interchange implementations of each building block to keep up with the State of the Art (SOTA) of the respective subtasks. Doing the same with an end-to-end model would require a full retraining.

Finally, having generated constrained constituents in a determinate manner allows for the simultaneous generation of a structured representation of the exercise in addition to its textual form. This in turn enables downstream tasks such as solution explanation and error highlighting to maximize learning effectivity. Again, such a structured representation is not easily extractable when utilizing a single end-to-end NLM.

Technical Details

The following sections outline the technical details of the implemented Proof of Concept (POC). Each section focuses on an individual module of the proposed method and highlights key design choices. The POC supports the generation of exercises that cover both the Binomial distribution as well as the Normal distribution. Both exercise types will serve as examples in the upcoming section.

Data Input

The data input to the POC is implemented as a simple command line interface (CLI). As outlined above two types of input are provided by the user, an exercise context and an exercise specification. The exercise context is provided through a user prompt that sets the scene for the exercise. This prompt is the basis for generating constraint constituents and embedding them in a joint context.

Based on the initial context the user provides an exercise specification containing all required information for constrained generation. This is facilitated through a guided dialog that interactively requests necessary information from the user depending on the exercise type. The inputs to this dialog are process via SimpleNLG, yielding non-canned constituents. These constituents allow for correct inflections when realizing text.

Finally, the user instructs the generation controller on how to generate the exercise. To preserve a lean interface to the user only one parameter needs to be set in this regard, namely the exercise hardness. This parameter in turn affects multiple hyperparameters of the generation controller i.e., question sampling, constituent generation and constituent arrangement.

Generation Controller

The generation controller takes as input the prompt and exercise specification from the input dialog. The general generation strategy is presented in consists of the following steps:

1. Generate constraint constituents
2. Arrange constraint constituents and placeholders for connecting constituents
3. Generate connecting constituents and insert into placeholders
4. Check constituent validity
5. Check constituent coherence

As previously hinted to, hardness parameter affects both the sampling of questions and the arrangement of constituents. The arrangement is affected by appropriately setting the parameters outlined in the sampling algorithm outlined above. A hard exercise tends to contain more connecting constituents, with relevant information being scattered sparsely among them. In contrast, easy exercises tend to present relevant information to the student without a lot of obfuscation. Additionally, a hard exercise samples more and harder questions from the questionpool than an easy exercise.

The generation of the respective constituents as well as the content checks performed by the generation controller will be outlined in the following sections.

Constrained Generation

Since the POC focuses on the use-case of generating word problems for mathematical statistics, two constituent types are identified to require constraint generation:

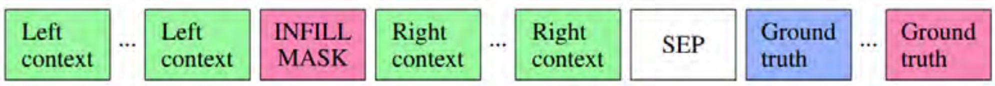
1. **Statements**
   Statements include all information that is required for the student to successfully solve the exercise. In the context of mathematical statistics, this includes all assumptions needed to identify both the relevant random variable as well as its underlying statistical distribution. Additionally, all relevant distribution parameters need to be included, either implicitly or explicitly.
2. **Questions**
   Questions include all questions related to an exercise context. These questions need to be consistent with the context so as to make sure that they can be answered without any additional information.

The distinction between statements and questions is made because they are affected differently by the constraints of the use-case (Figure 1). Statements need to be embedded in the exercise context, whereas questions are disentangled from the context. Enforcing constraints on statements is required to guarantee completeness and correctness. Additionally, they indirectly allow for enforcing consistency and unequivocality by providing a ground truth to check all remaining constituents against. Questions, in contrast, are subject only to satisfying correctness and unequivocality. Completeness does not apply since there is an infinite set of possible questions and consistency is not required since each question is defined to be independent of others.

As a part of the guided input dialog the user implicitly specifies the type of exercise to be generated. As the POC only supports two exercise types, this specification solely depends on whether the random variable takes on discrete or continuous values. Depending on this input, specific statements and questions for each exercise type are generated via the SimpleNLG generation engine.

An exercise class is instantiated with a predefined set of canned and non-canned constituents. These are then integrated into predefined randomized templates of both statements and questions. These templates are then realized to human readable text. The amount of statements and their semantic content is always identical across exercise instances of the same type since the information required to an exercise type is always the same. To introduce additional variance besides randomized templates, the order of statements is varied.

Figure 4: ILM training objective (own illustration)



Questions on the other hand can differ substantially depending on the hardness of an exercise. Therefore, instead of a fixed set of questions, a questionpool is generated. This questionpool consists of ordered sets (Q, H) where Q is a realized question and H is its assigned hardness level. This allows the generation controller to sample questions from this questionpool depending on the desired exercise hardness. The order of the questions is varied under the precedence constraint that easier questions should precede harder questions.

Unconstrained Generation

All connecting constituents, also referred to as connections, are generated in an unconstrained fashion via NLG methods. To ensure fluency in the generated exercise, these constituents need to be coherent with their preceding and succeeding constituents. To incorporate both left and right context when generating a constituent standard NLM approaches need to be augmented. Among various approaches presented in the literature (cf. e.g. ([21], pp. 5233-5239), ([14], pp. 2-4)) the author opts for an approach based on ([6], pp. 2-3) since it empirically produces the most viable results in terms of content coherence.

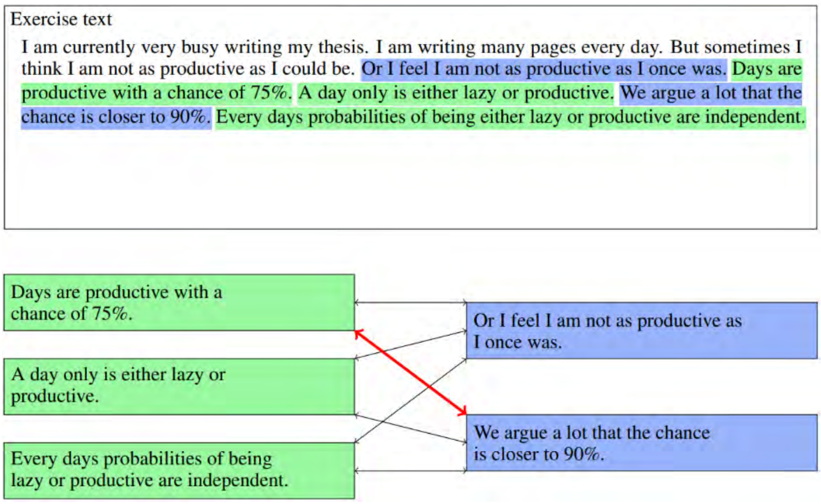
Donahue et al. finetune an instance of GPT-2 to predict masked spans with varying lengths in an input context. Specifically, they use spans masking paragraphs, sentences, ngrams and single words. They call this training objective Infill Language Modelling (ILM). An exemplary record of their training dataset is shown in figure 4. The current token to be predicted is highlighted in blue color, context tokens that can be considered by the model are highlighted in green color and masked tokens are highlighted in red color.

By casting the problem of text infilling into this structure, a classical NLM is able to incorporate the context on both sides of the masked segment and its position in the context into its autoregressive generation of tokens. That way, the creative NLG capabilities of pre-trained NLMs like GPT-2 can be harnessed in generating connecting segments of text.

For the POC, their model is specifically finetuned on only considering sentences with left and right context. Additionally, the special mask tokens for predicting paragraphs, ngrams and words are omitted so that the model solely learns to generate a single sentence. This allows the generation controller to give precise instructions on how many connecting constituents shall be generated. The custom finetuning dataset is based on the ROCStories dataset (cf. [15], pp. 3-6).

Constraint Checking

Figure 5: Exemplary conflict check (own illustration)



Constraint checking is facilitated via an NLI model that checks for conflicts between those constituents that have been generated in an unconstrained fashion and those that have been generated in a constrained fashion. Specifically, every inter-constituent relationship is checked. This method is chosen since, even though one would attribute transitivity properties to conflicts between sentences, current NLI methods are not robust enough to reliably detect all conflicts when only checking a reduced inter-constituent graph.

For the implementation of the POC the author chooses a DeBERTa ([9], pp. 3-5) encoder for the sole reason that it achieves SOTA performance in numerous NLI tasks. As outlined in the introduction of this chapter, modularity allows for easy integration of a different model when the SOTA advances.

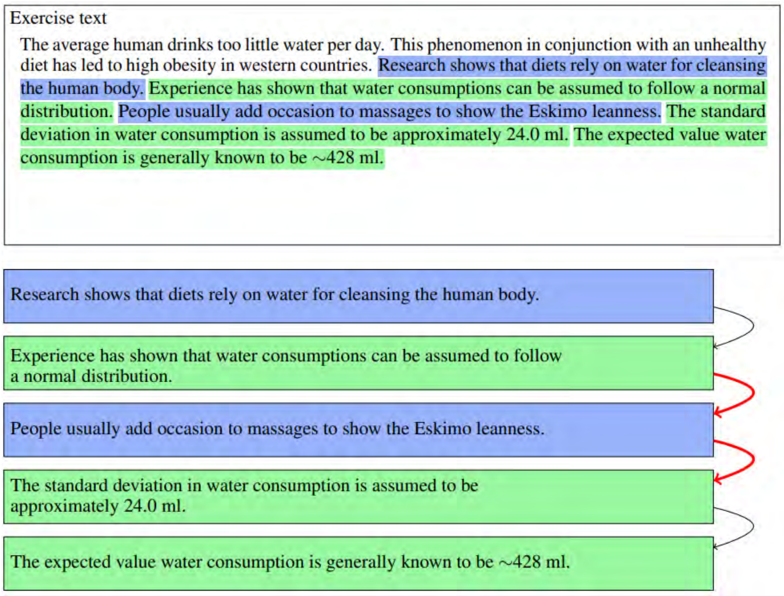
The constraint checking function expects both a ground truth, namely the statements orginitating from constrained generation, and candidates to be checked against this ground truth, namely the connections originating from unconstrained generation, as input. It checks each edge of the inter-constituent graph via two loops and detects conflicts based on a predefined condition. Since the employed NLI model outputs probabilities for each of the three possible classes 'entailment', 'neutral' and 'conflict', a strategy on detecting true conflicts based on these probabilities needs to be defined. The POC employs the condition defined on line 14 of figure 8. The optimal parameters of this condition have been identified in the course of conducting the experiments outlined in section 4. The function returns a boolean value that indicates whether any conflict has been detected. Additionally, early stopping is implemented for improved performance. That way, if a conflict is detected on checking the first edge of the conflict graph, no further edges are checked and the function returns its output early.

An exemplary conflict check is presented in figure 5. Conflicting edges are highlighted in red color.

Coherence Checking

Coherence checking is performed without a distinction between the generation strategy of individual constituents since it focuses solely on semantic fluency. Specifically, only local coherence is checked, meaning that only adjacent constituents need to be coherent.

Figure 6: Exemplary coherence check (own illustration)



This decision is grounded in the assumption that by providing local coherence sufficient fluency is provided to an exercise. Additionally, since constituents generated in a constraint fashion most definitely are coherent with the prompt of the exercise and one another, enforcing local coherence around those scattered constituents implicitly leads to some degree of global coherence.

The POC combines two measures of coherence, semantic similarity and sentence order. Semantic similarity is measured in the cosine distance of sentence embeddings. These embeddings are calculated by a finetuned MPNet encoder ([19], pp. 2-6), chosen for its SOTA performance. For assessing sentence order a standard BERT encoder ([5], pp. 3-5) is finetuned on ROCStories ([15], pp. 3-6) with only next sentence prediction (NSP) as the training objective. This finetuned model is then used to assess the sentence order between constituents.

An exemplary coherence check is presented in figure 6. Incoherent edges are highlighted in red color.

Experiments

Experimental Setup

Recalling the research objectives defined in section 1.2, the effectiveness of the proposed method shall be testified in three dimensions.

Dimension 1 - Quantification of the validity of generated exercises

To testify the validity of the exercises being generated a set of 100 exercises is being generated and checked for validity by humans. Specifically, the previously defined criteria for the validity of word problems in mathematical statistics apply. Dimension 1 is captured via the metric $\mathit{valid}_{\%}$, namely the fraction of exercises that have been manually rated as valid by humans considering the set of 100 exercises.

Dimension 2 - Quantification of the coherence of generated exercises

In a similar fashion the same 100 exercises are rated for coherence. In this context coherence specifically refers to the concept of semantic fluency introduced in section 3.8. Dimension 2 is captured via the metric $\mathit{coherent}_{\%}$, defined analogously to $\mathit{valid}_{\%}$.

Dimension 3 - Quantification of the diversity of generated exercises

For the purpose of quantification, diversity is defined as the heterogeneity in constituent arrangements. If the model can generate heterogenous arrangements and does not fall back to simple arrangements for every exercise, it is considered to be able to generate diverse exercises. Content generation diversity is not being rated since it is mostly predefined by the exercise prompt and definition and thereby up to the user. What is rated though is the methods capability to handle diverse contents provided by the user. This is done to prevent the model from being great at generating exercises only if their content is about foxes, but fail when their content is about cars.

Both aspects of dimension 3 are captured in terms of entropy, defined as

$$H = -\sum_{i=1}^{N} p(x_i) * \log(p(x_i))$$

with $[x_1, \cdots, x_N]$ being individual realizations of a random variable, $p(x_i)$ being the realization probability and log being a standard base 2 logarithm. In the use-case at hand, the random variable might be the arrangement of constituents that can take different forms. Entropy is, put in layman's terms, a measure of expected surprise when sampling a random variable. The higher the expected surprise, the higher the entropy. It therefore serves as a viable metric for heterogenity in realizations. Consequently, dimension 3 is captured via the metrics $arrangement_H$ and $content_H$.

In addition to the responses for each dimension, a proxy for the time taken to generate the representative set of 100 exercise instances is measured. $success_{\%}$ is defined as the percentage of generated exercises that the system labels as valid. For example, if $success_{\%}$ = 10% holds, then for each supposedly valid exercise 10 exercises need to be generated, implying computation overhead and waiting times.

The model configuration is varied in several aspects to find the optimal parameters for diverse exercise generation. Namely, the following parameters are varied:

1. $\text{generation}_{\text{hardness}}$
   The exercise hardness affects both the hardness of questions and the complexity of the constituent structure
2. $\text{generation}_{\text{nucleus}}$
   The nucleus parameter of the decoding strategy for unconstrained generation

Figure 7: Connection of derivations to measurements (own illustration)

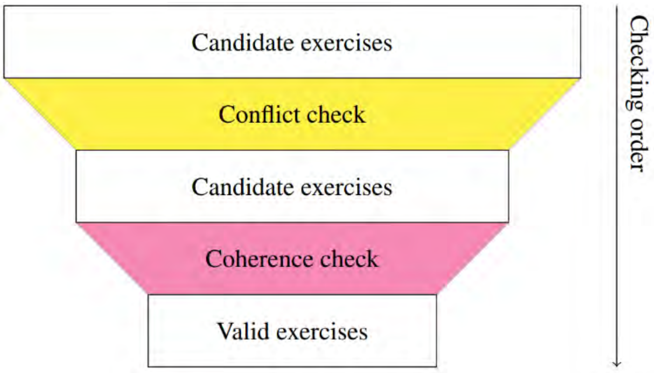


Figure 8:Exercise checking funnel considered for ablation study (own illustration)

Correlation	$success_{\%}$	$coherent_{\%}$	$valid_{\%}$	$content_H$	$arrangement_H$	abs. Effect
$generation_{hardness}$	-0.33	0.22	-0.31	-0.18	0.78	**1.81**
$generation_{nucleus}$	-0.37	-0.56	0.14	0.49	-0.10	**1.66**
$coherence_{cosdist}$	0.46	-0.21	-0.19	0.47	0.23	**1.57**
$coherence_{NSP}$	-0.45	0.37	0.01	-0.34	-0.20	**1.37**
$conflict_{condition}$	0.29	-0.25	-0.06	0.30	-0.06	**0.96**

Figure 9: Measured correlation of (parameter, response) pairs (own illustration)

Observations	$success_{\%}$	$coherent_{\%}$	$valid_{\%}$	$content_H$	$arrangement_H$	abs. Effect
$generation_{hardness}$	8		8		7	
$generation_{nucleus}$	1	2		3		
$coherence_{cosdist}$	5			6		
$coherence_{NSP}$	5	4		6		
$conflict_{condition}$						

3. $conflict_{condition}$
   The condition for detecting conflicts from the three class probabilities of the NLI model
4. $coherence_{NSP}$
   The condition for detecting incoherencies from NSP score
5. $coherence_{cosdist}$
   The condition for detecting incoherencies from cosine distance score

The dataset created for testing contains records consisting of a prompt as well as its respective exercise configuration. The contents of these prompts have been chosen arbitrarily with heterogeneity in mind.

In order to better understand the contributions of individual modules an ablation study is performed. In doing so, individual modules in the exercise checking funnel are removed temporarily. The two relevant modules are highlighted in figure 7.

All aforementioned tools and datasets are available at https://github.com/Stansuro/ExGen

Results

Figure 8 presents the measured correlation coefficients of a (parameter, response) pair. Every coefficient that satisfies $|r| > 0.30$ is regarded as significant and a derivation is stated. The connection between measurement and derivation is defined in figure 9. The following section outlines the aforementioned derivations.

1. More diverse generation entails more waiting time
   A higher value for the $generation_{nucleus}$ instructs the NLM to generate more creative text. This leads to more exercises that are labelled as invalid by the system, therefore entailing lower $success_{\%}$

2. Less diverse generation entails more coherent constituents
   A lower value for the $generation_{nucleus}$ instructs the NLM to generate less creative text. This leads to less deviations from given contexts and therefore entails higher $coherent_{\%}$
3. More diverse generation allows for more diverse exercise contexts
   A higher value for the $generation_{nucleus}$ instructs the NLM to generate more creative text. This allows the model to generate coherent text for more diverse exercise contexts and entails higher $content_{H}$
4. More strict coherence requirements entail more coherent constituents
   A lower (higher) threshold for detecting incoherencies via $coherence_{cosdist}$ ($coherence_{NSP}$) leads to more exercises that are rated as coherent and therefore entails higher $coherent_{\%}$
5. More strict coherence requirements entail more waiting time
   A lower (higher) threshold for detecting incoherencies via $coherence_{cosdist}$ ($coherence_{NSP}$) leads to more exercises that are labelled as incoherent by the system, entailing lower $success_{\%}$
6. Less strict coherence requirements allow for more diverse exercise contexts
   A higher (lower) threshold for detecting incoherencies via $coherence_{cosdist}$ ($coherence_{NSP}$) leads to less exercises that are labelled as invalid by the system, allowing for more diverse exercise contexts at the cost of coherence. This entails higher $content_{H}$ and lower $coherence_{\%}$
7. Harder exercises allow for more diverse constituent structures
   Harder exercises (higher $generation_{hardness}$) lead to more complex constituent structures, as this is a design choice of the generation controller for the POC
8. Harder exercises entail more waiting time
   Harder exercises (higher $generation_{hardness}$) lead to more complex constituent structures with more constituents that are generated in an unconstrained fashion. This in turn leads to more chances for conflicts and incoherencies, entailing lower $success_{\%}$

Finally, it is observed that $valid_{\%}$ is not significantly affected by any parameter except exercise hardness. This is due to, as will be shown in the ablation study, that any parameter value for $conflict_{condition}$ has been sufficiently effective to identify invalid exercises. Therefore, there was no clear distinction between its individual parameter values. As the ablation study will show, having no conflict checking included at all entails significantly lower $valid_{\%}$.

Ablation Study

The following section presents the results of the ablation study. As outlined above in figure 7, the following configurations of the system are tested:

1. None
   Conflict checking and coherence checking are omitted
2. Conflict
   Conflict checking performed, coherence checking is omitted
3. $Coherence_{cosdist+NSP}$
   Coherence checking performed with cosine distance and NSP criteria
4. $Conflict+Coherence_{cosdist}$
   Conflict checking performed, coherence checking performed only with cosdist. criteria
5. $Conflict+Coherence_{NSP}$
   Conflict checking performed, coherence checking performed only with NSP criteria
6. Full
   Nothing is omitted

The ablation study is performed with parameters optimized through the insights provided in section 4.2, namely:

- $generation_{nucleus} = 0.5$
- $coherence_{cosdist} = 0.3$
- $coherence_{NSP} = 0.99$
- $conflict_{condition} = (0.5, 0.2)$

Figure 10 shows the response coherent$_{\%}$ in regards to different system configurations. It is observed that easy exercises with less complex constituent structures are not affected as heavily by omitting checking procedures, whereas harder exercises show significant degradation of coherent$_{\%}$. This is in line with expectations, as simple constituents structures can more easily be generated in a first-time-right fashion than complex arrangements, which require thorough quality control. It shall be noted that different parameter configurations than defined above lead to, as one would expect, the highest values for coherence$_{\%}$ for easy exercises, namely 90%. This can be achieved by setting coherence$_{cosdist}$ = 0.2. This anomaly, where exercise coherence degrades with simpler constituent structure, is to be evaluated in further studies.

Figure 11 shows the response of valid$_{\%}$. A clear dependency of valid$_{\%}$ on Coherence$_{cosdist}$ is evident. This is in line with table 3, where coherence$_{cosdist}$ displays the largest absolute value of correlation to valid$_{\%}$ excluding exercise hardness. Additionally, a less significant contribution of dedicated conflict checking is evident. Coherence checking and confidence checking therefore cannot be separated completely, though, on further inspection of records, it is evident that Conflict is especially valuable in detecting numerical conflicts. The sentence embeddings employed by Coherence$_{cosdist}$ seem to not detect such details and instead focus on semantic attributes.

Figure 12 shows the response of success$_{\%}$. Again, a strong dependence on Coherence$_{cosdist}$ is evident. This entails that most exercise instances are labelled as incoherent by the system. On closer inspection it is noted, that this procedure also leads to numerous false positives, i.e. exercise instances being excluded for incoherence even though human ratings find them coherent. This implies a tradeoff for the user of the system between waiting time and exercise validity. Recalling table 5 and table 6, one can argue that at least for easy exercises a faster version of the system with only conflict checking can serve as an interesting option for interactive deployments. Since the degradation of coherent$_{\%}$ is not as drastic for easy exercises as for harder ones, this tradeoff might be worthwile considering.

Finally, figure 13 shows the response of content$_{H}$. As expected, content$_{H}$ decreases with more checking mechanisms. Interestingly, the complete system without any omissions performs very similar to Coherence$_{cosdist+NSP}$, implying that most of the decrease in content$_{H}$ can be attributed to both Coherence$_{cosdist}$ and Coherence$_{NSP}$. The observation that Conflict entails only a slight decrease of content$_{H}$ in comparison to None supports this derivation. Again, coherence checking is at the heart of a tradeoff, in this case between diversity and validity. Similar observations are made for arrangement$_{H}$.

Coherence$_{\%}$	*Easy*	*Medium*	*Hard*
None	71	57	52
Conflict	70	59	57
Coherence$_{cosdist+NSP}$	73	73	63
Conflict + Coherence$_{cosdist}$	72	70	66

Figure 10: *coherence$_{\%}$* in response to ablation of modules (own illustration)

Valid$_{\%}$	*Easy*	*Medium*	*Hard*
None	91	83	82
Conflict	94	97	96
Coherence$_{cosdist+NSP}$	100	100	99
Conflict + Coherence$_{cosdist}$	100	99	100
[illegible]	[illegible]	[illegible]	[illegible]

Figure 11: *valid$_{\%}$* in response to ablation of modules (own illustration)

Success$_{\%}$	*Easy*	*Medium*	*Hard*
None	100	100	100
Conflict	86	74	76
Coherence$_{cosdist+NSP}$	7	3	3
Conflict + Coherence$_{cosdist}$	11	8	6
Conflict + Coherence$_{NSP}$	56	42	36
Complete	6	2	2

Figure 12: *success$_{\%}$* in response to ablation of modules (own illustration)

Content$_{H}$	*Easy*	*Medium*	*Hard*
None	5.40	5.40	5.40
Conflict	5.35	5.32	5.33
Coherence$_{cosdist+NSP}$	4.78	4.50	4.80
Conflict + Coherence$_{cosdist}$	4.95	4.93	4.93
Conflict + Coherence$_{NSP}$	5.15	5.11	4.91
Complete	4.70	4.80	4.66

Figure 13: *content$_{H}$* in response to ablation of modules (own illustration)

Discussion

The results presented in section 4 testify the ability of the proposed approach to be effective in generating valid, coherent and diverse training exercises in the field of mathematical statistics. A tradeoff between generation time and exercise validity is evident, which can be chosen flexibly according to specific needs. In an environment where teachers are readily available to resolve any conflicts manually and exercise throughput is key, generation speed can be favored. On the other hand, in an enviroment implies full automation without the possibility of human intervention, validity can be prioritized.

One positive aspect of the approach proposed in section 3 lies within its modularity, allowing for individual scalability of submodules and clear attribution of specific subtasks. Though, in the course of the development of the POC, specific tailoring of the interaction between the submodules has proven to be a vital aspect for the system as a whole. An example of this is the interaction of the submodule for constraint checking and constraint generation (recall figure 2). In order to increase the ability of the constraint checking module, the design of generation templates needs to be tailored to contain certain keywords such as ’only’ or ’exclusively’ so that conflicts become more pronounced.

In a similar fashion, the user benefits from being aware about these interactions when planning their inputs, i.e. the exercise prompt and exercise definition. For example, by setting up the prompt in a way that allows smooth transitioning to the automatically generated constraints the user can generate valid exercises much quicker than otherwise. Though helpful, no specific knowledge of the inner workings of NLMs is required for this. The nature of these precautions includes formulating the prompt in an open ended fashion and containing enough context information in it for the unconstrained generation module to follow up on. This skill can be acquired through generating a handful of exercises.

Finally, in addition to the desire of being able to generate diverse training exercises in order to allow students for abstraction of underlying concepts instead of shallow surface structure, the author notes that another perspective on supporting the learning experience has been noticed in the course of testing the system. The mere act of thinking ahead for the system in terms of planning how both the prompt and exercise configuration are provided to the system has proven to be a valuable change of perspective for understanding the concepts at hand. This design choice entails the (coincidental) positive aspect of forcing the student in the position of a teacher, leading to an understanding of exercises from a completely different perspectives. The detailed thought process of questions such as "What even is the random variable at hand?" and "How does my variable fit into the provided context?" might lead to further boosts in the abstraction of concepts of interest.

Conclusion

This thesis proposes a novel approach to synthesize natural language subject to general content validity constraints. This approach is applied to generating word problems for mathematical statistics and is proven to be effective in terms of constraint satisfaction and diversity. In contrast to related work that focuses largely on monolithic approaches, the proposed method harnesses the benefits of a modular design, namely independent scalability of subtasks and straight forward extension of scope without complete retraining. The experimental results present a tradeoff between generation time and exercise validity. The system can easily be parametrized to handle this tradeoff according to the requirements of specific use cases. For future work, it is worth exploring ways to extend the scope of applicability of the proposed system by including additional functionality, striving for an integrated solution to facilitate the complete process of exercise design, exercise processing and solution checking.

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- Figure 10: coherence% in response to ablation of modules (own illustration)
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- Figure 12: success% in response to ablation of modules (own illustration)
- Figure 13: contentH in response to ablation of modules (own illustration)

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The Impact of InsurTech on the Transformation of the Insurance Sector

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Problem/Goal

The insurance sector is the organization and management of a pool of risks to provide insurance coverage to multiple customers (Fjeldstad et al., 2006), offering a protection service to individuals and companies. The insurance sector has been slow to adopt digital technologies because traditionally high entry barriers, product complexity, capital reserves, solvency, as well as regulatory requirements, have prevented new participants from competing in the sector. Consequently, many established insurers have had little reason to transform their business model by adopting new technologies, lagging behind other sectors in terms of digital maturity, operating with a business structure over 300 years old (Yan et al., 2018; Puschmann, 2017).

As a result of the emergence of technological innovation, the insurance sector has undergone a transformation as a consequence of the impact of InsurTech (Catlin et al., 2017; Lee et al., 2018; Yan et al., 2018). An InsurTech is any innovation driven by technology in the insurance sector (Braun et al., 2017). Key trends in explaining InsurTech innovation has investigated how the Insurtech ecosystem is configured and its strategic implications in the insurance sector (Greineder, et al., 2020) including which characteristics and transformational capabilities of InsurTech innovations to understand insurance value creation in a digital world (Stoeckli, et al., 2018).

However, to date, despite the growing body of literature investigating the InsurTech phenomenon, there is a significant research gap to understand how InsurTech has transformed the traditional structure of the insurance sector leading to the current configuration. Hence, the purpose of this investigation is twofold, first identify what drives InsurTechs, and second, understanding what type of innovations have transformed the insurance sector.

Methodology

Qualitative research has been carried out. Based on the grounded theory methodology (GTM), 150 key global insurance technology innovations (InsurTechs) have been analysed, building the theory inductively from the data. In line with the flexibility of GTM an exploratory research design has been defined. A data collection procedure has been carried out through a coding process, using the comparative analysis method, by means of an iterative approach (collection-analysis), until saturation of categories was reached. A data analysis has been implemented into three levels (open coding, axial coding, selective coding), providing the scientific rigor used during the research design. In addition, a series of interviews with open-ended questions were conducted with 14 professionals from insurance companies and consultancy firms. Finally, to enrich the coding procedure, additional sources of knowledge have been considered by attending 7 presentations and 9 panel discussions at the Global InsurTech Summit 2021.

Results

InsurTech has proven to be responsible for the transformation of the insurance sector. Research findings have identified five InsurTech driving capabilities that have been instrumental in boosting innovations in the insurance sector. These can be defined as the technological capabilities for applying innovation in the insurance sector. These InsurTech driving capabilities are: (A) Implementation of digital capabilities, (B) Data-driven solutions, (C) Integrated services and customer experience, (D) Creation and development of digital insurance offer, and (E) Digital insurance distribution. According to what has driven InsurTech, these capabilities suggest fifteen types of innovations that have transformed the insurance sector:

The (A) Implementation of digital capabilities - are mainly captured (1) by developing configurable modules by means of cloud-native platforms and solutions, (2) providing efficiency through real-time automation of insurance transactions, (3) which are improving the operational workflows and work processes of companies across the entire value chain. The (B) Data-driven solutions - are (4) empowering companies with analytical tools through real-time data modelling, (5) allowing them to increase the value of this data by calculating insurance premiums accurately, (6) which improves substantially risk assessment and prediction results in the different areas of the value chain. The (C) Integrated services and customer experience - are (7) automating virtual advice in customer service as well as interactive communication with consumers, (8) unlocking new service possibilities integrating them into the value chain, (9) which transforms digital communication and improving customer retention. The (D) Creation and development of digital insurance - is (10) tailoring the insurance offer according to the typology of customer demand in real time, (11) accessing new risks through the creation of new insurance products, (12) configuring and dynamizing the insurance offer in line with the specific needs of customers, at the different points of contact in the value chain. The (E) Digital insurance distribution - is (13) allowing customers to cover their risks in a fully digital way, (14) facilitating them in real time the access to a wide offer of insurance products, (15) which enables a substantial increase in insurance policy sales as well as optimizing the conversion results in marketing campaigns.

Based on the findings presented, it can be noted that each innovation represents an overall building block according to its type and origin, where each innovation can manifest itself, either individually as incremental innovations, or in combination with others leading to disruptive innovations. From a general approach, the combination of the innovations themselves for transforming the insurance sector could be summarized by the ability to establish real-time remote connectivity, which is essential to continuously improve data-driven decisions, using technology to hold digital conversations and provide virtual advice to consumers. This also supports the automated formulation of a new insurance offer tailored to the needs of the consumers, which facilitates a greater penetration of digital insurance distribution. To be more precise, the potential of these fifteen innovations in transforming the insurance sector has emerged from the combination of the innovations themselves. Therefore, it can be stated that the simultaneity of occurrence of innovations and their connections to each other, has resulted in the transformation of the insurance sector, applying technological innovation in all the areas that compound the value chain.

It is therefore understood that if Insurtechs must be seen as innovations, all these innovations can be summarized into three categories of InsurTech depending on their level of vertical integration in the insurance value chain (Distributors, Enablers and Full Carriers) as set out in the Capgemini Research (2020) classification. This leads us to suggest that the earliest innovations at the beginning of the transformation of the insurance sector may have been based on distribution by dispensing insurance products, improving the customer experience by empowering users with more information and offering potential price savings. As a consequence of such innovations, due to the threat of insurers losing direct access to end customers in the personal insurance market (Stoeckli, 2018), there arose the need to enable innovations to provide software solutions for insurers seeking to both enhance their technological capabilities and adapt their business model. Finally, once all stages of the customer journey and value chain were affected by the InsurTech phenomenon (Cappiello, 2020), it was when the combination of innovations converged into full InsurTech carriers that decided to both develop and distribute insurance products, reflecting how InsurTech has transformed the traditional structure of the insurance sector leading to a dynamic user-centric ecosystem.

Digital transformation in Colombia´s public administration

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Abstract

The National Civil Service Commission of Colombia (CNSC, as its Spanish acronysm) was created by the National Constitution as an autonomous and independent institution of the highest level in the structure of the State. Its mission is to guarantee the principle of merit in the admission, term, and promotion of public administrative career jobs in the country. To fulfil this mission, it conducts merit contests to select the applicants who will perform these jobs, runs the Labor Performance Evaluation of the government employees, and oversees compliance with the administrative career regulations in the country, among other functions.

Its target population is more than 2.5 million citizens who regularly aspire to these jobs, 5,164 public entities, and 245,805 employees; all of them demand the implementation of multiple processes and the processing of more than 45 million documents with more than 50 million pieces of data. All this information had been done in a fragmented, manual, analogical way and with disintegrated information systems. This is why a digital transformation project was designed and implemented. It was supported by an Enterprise Architecture methodology and focused on updating the entity's strategic direction.

It was possible to standardize and integrate the information systems into a single one called the Information System for Equality, Merit, and Opportunity (SIMO 4.0). This is a tool that through the application of emerging technologies (Artificial Intelligence, Big Data, Machine Learning, Business Intelligence, Predictive Analytics, ChatBot), the support of a new system called SIMO 4.0, the use of an Electronic Document Management System for Archives, the knowledge management, the last generation BPM and the Innovation System, it has enabled the automation of the processes and services provided to society. In this single information system public entities, universities, citizens and civil servants interact and the entire process of selection, admission, registration, evaluation, permanence, and promotion in public employment in Colombia is managed.

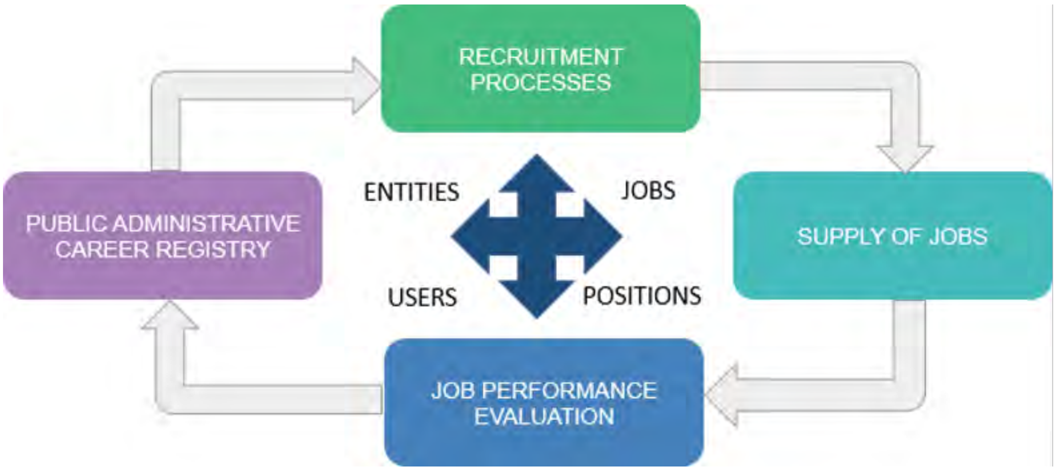
The consolidation of this digital ecosystem has substantially improved in terms of functionality, usability, accessibility, time, costs, and error minimization of the services that we provide to our users, generating relevant knowledge that helps us improve decision-making in the entity.

Keywords: Digital transformation, Public Administration, Public employment.

General Context

The National Civil Service Commission of Colombia was created by the National Constitution as an autonomous and independent institution of the highest level in the structure of the State. Its mission is to guarantee the principle of merit in the admission, permanence, and promotion in public administrative career jobs in the country, with exceptions established by the Political Constitution itself. To fulfil this mission, it conducts merit-based competitions to select the applicants who will perform these jobs, run the Evaluation of Labor Performance of these public servants, and oversees compliance with the administrative career rules in the country, throughout the basic career cycle, as follow: (1) Selection Process, (2) Job Provision, (3) Public Registry of Administrative Careers (4) Job Performance Evaluation.

Figure 1: Basic Cycle of the Administrative Career



It is important to note that the functions of the CNSC are described in Article 11 of Law 909 of 2004, duties that are related to the responsibility for the administration of the administrative career, which stipulates:

- To establish and develop, by the law and regulations, the general guidelines for the selection process that will provide the administrative career jobs in the entities to which this law applies;
- To accredit the entities to carry out selection processes according to the regulations and to establish the rates for contracting competitions, under the provisions of Article 30 of this law;
- To prepare the calls for competitions for the performance of public career positions, by the terms and conditions outlined in this law and the regulations;
- To establish the necessary instruments for the application of the rules on performance evaluation of administrative career employees;
- To form, organize and manage the National Bank of Eligible Lists; the Data Bank of former employees with career rights whose positions have been eliminated and who have opted to be incorporated, and the Data Bank of career employees displaced for reasons of violence;
- To send to the entities, ex officio or at the request of the respective nominators, the lists of people with whom the administrative career jobs that must be filled, by the information contained in the data banks mentioned in the previous paragraph;
- To administer, organize and update the public registry of employees listed in the administrative career and issue the corresponding certifications;
- To issue instructive circulars for the correct application of the rules governing the administrative career;
- To conduct the selection process for public employment admissions through public or private universities or institutions of higher education;
- To prepare and communicate information on the administrative career;
- To prepare and communicate studies on general or specific aspects of the management of public employment about entry, career development, and performance evaluation;
- To answer any queries that may be submitted, regarding administrative careers.

The CNSC's target population includes more than 2.5 million citizens who regularly apply for the jobs, 5,164 public entities, and 245,805 government employees, which require the execution of multiple processes and the processing of more than 45 million documents with more than 50 million pieces of data.

In the beginning, the CNSC managed the process and operations in a fragmented and analogical manner, based on a paper-based operation and manual procedures for registration admission, permanence, and promotion in the country's public administrative career jobs. It represented great difficulties for fulfilling the entity's functions, generating an extensive inventory that was hard to manage with latent risks for its preservation and integrity.

In response to these difficulties and taking advantage of the evolution of digital information processing and integrated process management systems, the CNSC designed a Digital Transformation Project. The project uses an Enterprise Architecture methodology that seeks to update the entity's strategic direction and all the processes. The goal is to achieve standardization and integration of the information systems called Information System for Equality, Merit and Opportunity (SIMO 4.0). This was developed to transform a modern organization like the CNSC that needs to grow, become more efficient, effective, and competitive.

This was achieved by enhancing the entity's information systems and promoting its use, which allowed the automation of the CNSC's mission processes. The system for merit-based competitive examinations (SIMO 1.0) was the first highly significant achievement that enabled the CNSC to centralize and standardize the administrative career activities that the entity carries out.

This first module allowed citizens to digitally register to the selection processes, make the payment of participation fees, upload the documents that show their studies and experience background and update any documentation relevant to the process they wish to participate. It also strengthened the management of the CNSC by centralizing the data associated with the processes, the entities, the career jobs public offers, and the applicants for permanent positions in the country.

However, in the course of this ongoing phase, groups of isolated information were created as a result of the lack of articulation of SIMO 1.0 between the institutional processes, the different stages of these merit-based competitions and the following stages related to the admission, permanence, and promotion in the public administrative career jobs in the country.

To solve the above, SIMO 4.0 was designed and developed to overcome those challenges and problems related to the entity'integrity, security, availability, functionality, and use of information. The new system makes it possible to offer citizens, universities, officials and government entities more efficient and effective solutions by

the CNSC. Three other solutions were added to the platform: An Electronic Document Management System, a state-of-the-art BPM, and an Innovation and Knowledge Management System.

These integrated solutions have allowed the automation of the processes and services provided to society, including the entire recruitment process, admission, registration, evaluation, permanence, and promotion in public administrative career employment in Colombia.

This digital transformation process was based on good business and technological practices, including the use of emerging technologies, the reinforcement of management skills, and the control of the administrative career by the entity.

Therefore, digital transformation for the CNSC means the integration and application of emerging technologies, which involve the convergence of disruptive technologies with the potential to impact the public employment sector in Colombia. This digital transformation is focused on creating an effective model for the CNSC where each point of contact with users (internal and external) is digital, which involves optimizing institutional processes and achieving high standards of excellence in the provision of services using technology.

From this perspective, the purpose of the digital transformation for the CNSC is to make the interaction with the citizens so much easier, achieve greater transparency and involve citizens in the generation of a higher public value.

However, the conversation around digital transformation gives relevance to data as the basis of information. For an entity such as the CNSC that interacts with users through digital channels, and manages information systems for its processes, data represents power and value. So the use of tools such as Big Data, Artificial Intelligence, Machine Learning, Business Intelligence, Predictive Analytics, and other emerging technologies has been valuable for processing high volumes of information produced or received by the entity. This generates knowledge that helps to improve decision-making in the CNSC, in terms of functionality, accessibility, use, time, costs, and minimization of errors, in the services provided to users.

The evolution towards a new digital ecosystem that responses to the strategic vision of accessing the new era of knowledge and digital transformation, improve the capabilities of the services provided by the CNSC in terms of functionality, accessibility, use, time, costs, minimization of errors and timely decision-making, as well as improving the efficiency and value of the services provided to citizens.

Enterprise Architecture approach for the CNSC Digital transformation

The CNSC's "Digital Transformation Project" includes the transformation approach based on an Enterprise Architecture methodology, which focuses on updating the entity's strategic direction and, from there, on the standardization and integration of its information systems.

It is important to mention that the CNSC carried out individual developments for each of the processes, which resulted in solutions that, although they adequately addressed specific parts of the career cycle, since they were developed at different times and with objectives limited to particular problems, they did not have a global vision of the cycle mention above. Therefore, it generated disconnected information difficult to consolidate for effective decision-making and to know and preserve the continuity of public employment in Colombia.

Accordingly, the information systems available to the Commission were (1) SIMO 1.0, in charge of the selection processes; (2) National Bank of Eligible Lists, in charge of the administration of lists for the provision of public jobs; (3) Evaluation of Labor Performance, in charge of supporting the evaluations of staff and probationary public servants of the Colombian state entities, and (4) Public Registry of Administrative Career, in charge of recording the annotations of public servants from their entry until their retirement.

This implied a reengineering of the processes by the future needs of the management of the administrative career in the country. This implied reorienting the activities developed in each of the processes of the career cycle, with a digital perspective and under security principles, as well as the ease of use and access to the modules that support such processes. This allowed the elimination of physical documentation, and led to the transformation of the protocols historically used, as well as the technical aids for the development of the actions associated with the entity's procedures and services.

This reengineering allowed the development of the CNSC's institutional transformation project, which is based on the use of emerging technologies that support the processes automation, including those that support the operations of the administration and oversight of the administrative career in Colombia.

Accordingly, the CNSC adopted standards for the inclusion of disruptive elements for improvement, and the strengthening of relations with other public entities, administrative career civil servants and citizens in general. In this way that, aligned with the digital transformation policies of Colombia, the CNSC has initiated innovation processes that will provide more and better services, to contribute to the quality of transactions and interactions with the different stakeholders.

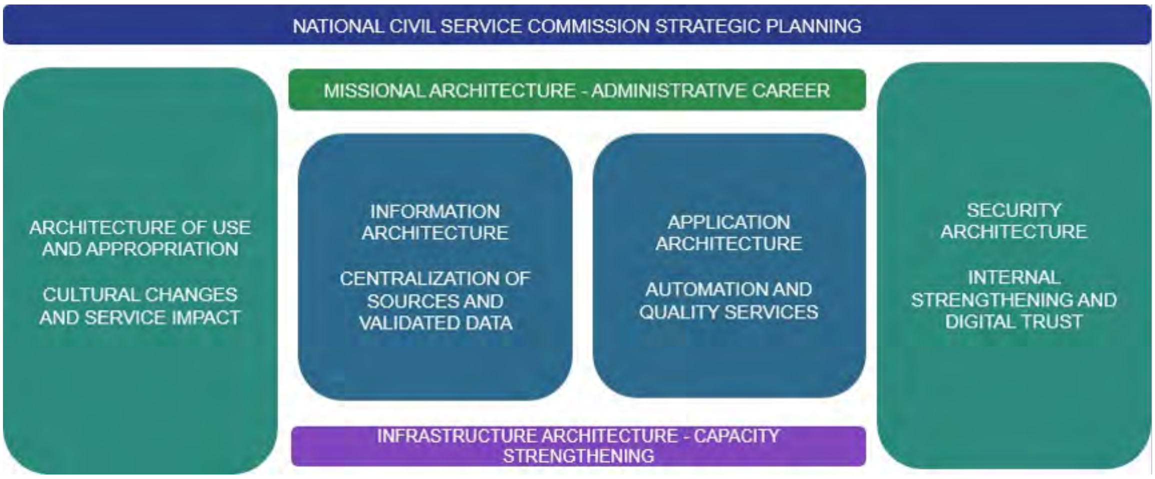
Specifically, and in compliance with the objective of institutional transformation, the CNSC focuses its technological efforts on three (3) purposes of the Digital Transformation Framework for the Colombian State:

- **Digital services of trust and quality:** To allow the execution of procedures and the use of services for admission, permanence, and promotion to the administrative career through emerging technologies on the Internet; and the centralization and strengthening of existing systems, which allow the reduction in the execution time of the processes.
- **Secure and efficient internal processes:** To strengthen the administration and oversight of the cycle of the administrative career through the unification, validation, and assurance of information sources related to public jobs, their entities, and their interactions with Colombian citizens; which allows knowing in real-time the status of the provision of each of the positions of the Colombian state.
- **Decisions based on data:** To make efficient use of the information acquired and produced within the framework of the entity's processes, which allows for continuous improvement internally, in terms of efficiency and effectiveness, as well as the exposure of public data for the strengthening of other state actors and the academia.

To fulfil the purposes described above, the TOGAF Enterprise Architecture Reference Framework was adopted as the development framework and the IT Architecture for the Colombian State as the management model.

The following are the domains that the CNSC is currently working on, according to the adopted standards:

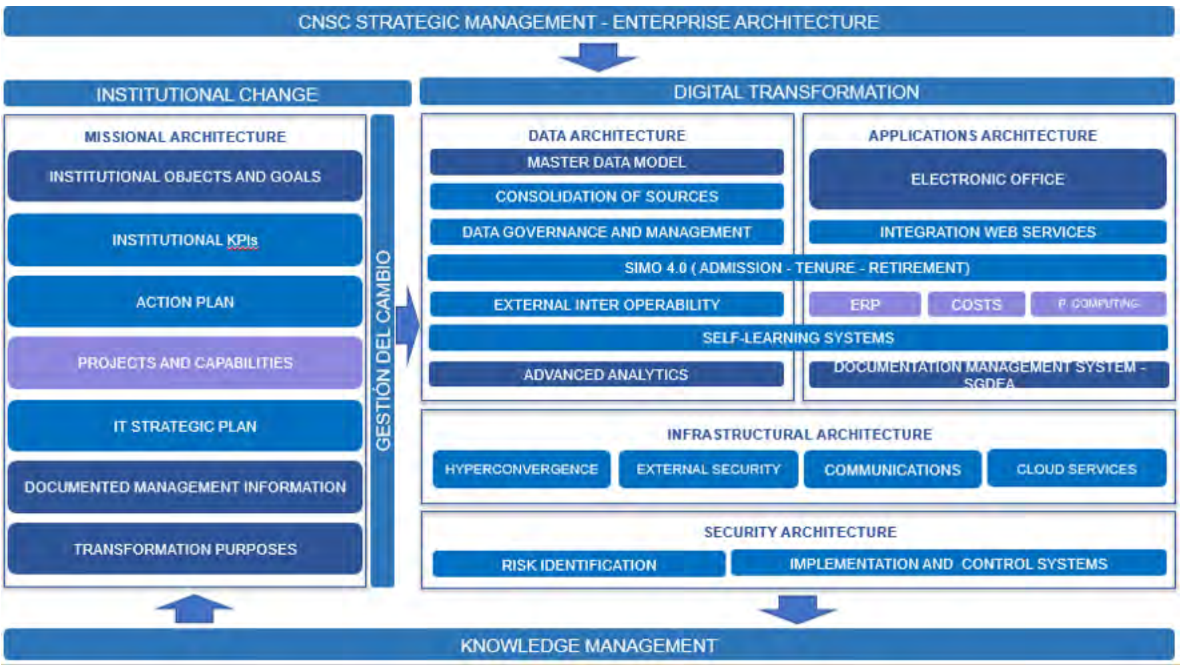
Figure 2: Domains of the CNSC's Enterprise Architecture from the MAE IT



The CNSC adopts six (6) business architecture domains: 1. Mission, 2. Information, 3. Applications, 4. Infrastructure, 5. Security and 6. Use and appropriation, which configure the elements of institutional and digital transformation in the CNSC.

The main elements of the CNSC's transformation, based on the described architecture, are shown below:

Figure 3: Strategic Management of the CNSC based on the architecture described



The strategic vision towards a CNSC 4.0 in the era of digital transformation is framed in the consolidation of the so-called 4RI – Fourth Industrial Revolution. This revolution has configured a new model of society with intelligent organizations, which are supported by the intensive use of digital technologies and promote constant innovation and disruption in the provision of services through the use of artificial intelligence and the reconfiguration of intra and inter-organizational power relations.

Using the advantages of IT, the CNSC designed the Digital Transformation Project, where it integrates the information systems through the Information System for Equality, Merit, and Opportunity (SIMO 4.0).

SIMO 4.0

Since its foundation, the National Civil Service Commission has been working on implementing technological solutions to leverage the entity's processes and activities related to the administration and monitoring of the administrative career.

It is important to note that the development and implementation of the technological solutions designed by CNSC have been generated at different times for different needs, which has caused difficulties regarding the traceability of the cycle associated with these activities.

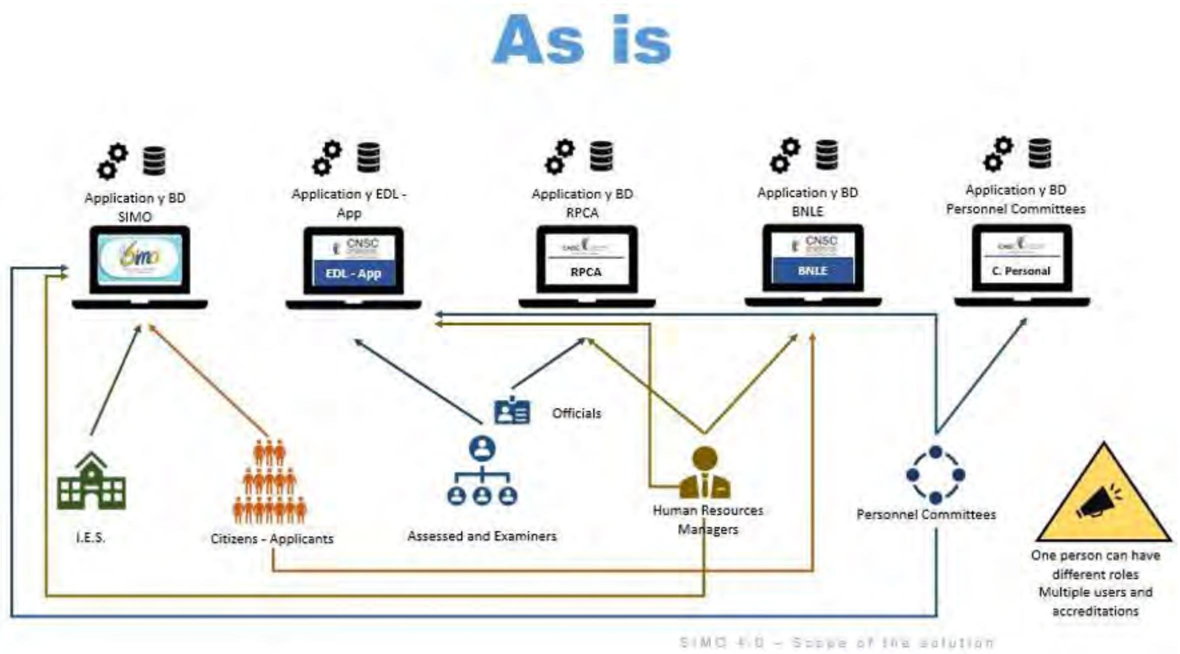
However, given the diversity of the information systems, their technical characteristics and the lack of unification of some of them, we find problems in the integration process, such as the following:

- Duplicated data in different information systems.
- Lack of integration of data and processes, which did not allow for a consistent life cycle of business concepts.
- Complex maintenance due to the diversity of implementation technologies.
- Low coupling between components.
- Development life cycle oriented to the specific needs of permanent refactoring.
- Container diversity (Tomcat, JBOSS WILDFLY, Apache 2, among others).
- An individual database, instance and schema for each application, which generated isolated information

This led to the need to design a new transition architecture, leveraging the potential of the entity's hyper-convergence infrastructure.

The following chart shows the initial state (As Is) of the multiple IT solutions developed in the CNSC and their disarticulation.

Figure 4: Disjointed CNSC information systems



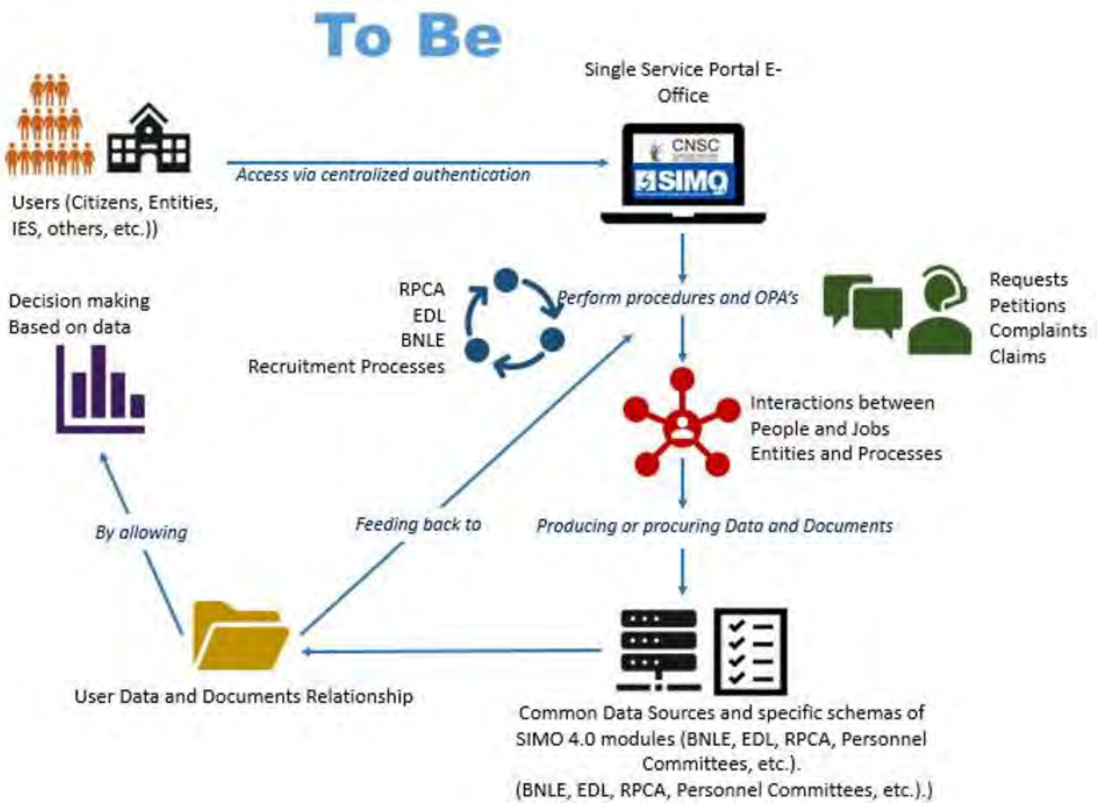
The transition process from the CNSC Information Systems to SIMO 4.0 responds to the following objectives:

- Unify authentication with the management of roles, users, permissions, and menus in a centralized and dynamic scheme.
- Create a unique login portal with the existing applications, using the User Account Authentication (UAA) component and baseline authentication microservices instead of the individual authentication.
- Enable the connection of each application to the database in an independent scheme within a single transactional database engine.
- To guarantee the continuity of the system operations, independently from the others, but allowing primary interoperability between them to leverage the life cycle of career information around the management of Employment and Position.

By the objectives described above, the purpose of SIMO 4.0 is to integrate the different applications that support the administration and monitoring process of the administrative career. So through single access, users can access all the activities for which they have privileges in terms of admission, permanence, promotion and retirement in the administrative career, based on a centralized data repository. The platform allows knowing and properly managing the trace of the permanent jobs and their associated positions and the interactions of the Colombian citizens with them.

This integration is shown in the following graphic:

Figure 5: Integrated CNSC Information Systems



Information System Integration Process for the design of SIMO 4.0

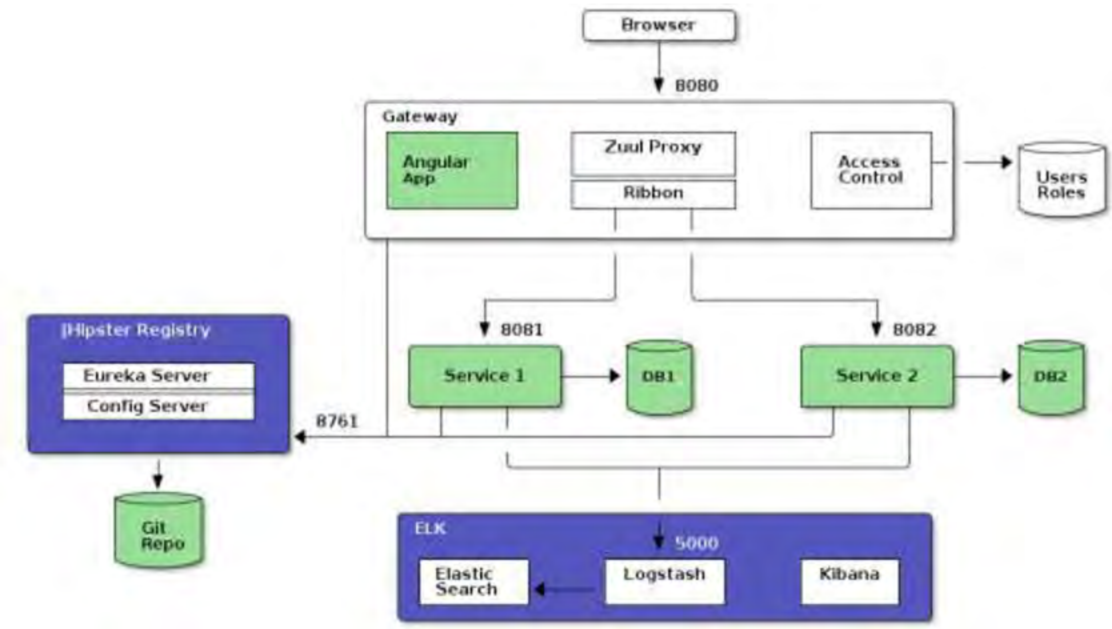
The following is the process of the information system integration for the design of SIMO 4.0, in three components: (1) Unification of the technological development tools, (2) Interoperability between the Information Systems and (3) Unification of common data sources.

Unification of technological development tools

The methodology for consolidating the technological tools was integrated through a development framework, which is a code generator that uses AngularJS (Front End) and the Spring Boot API (Back End) to create monolithic applications and separate them into Gateway and microservices.

The following graphic represents the services architecture used by the development framework in the CNSC.

Figure 6: Jhipster Service Architecture



The standardization of development tools in the CNSC through the implementation of the unified development framework (Jhipster), presents the following advantages for SIMO 4.0.

Figure 7: Advantages of the implementation of a development framework

In addition, the following table describes the advantages of standardizing the development tools for the CNSC.

Table 1: Advantages of the application of the Development Framework. Source: Own construction

Streamline Implementation	Streamline incident detection and resolution	Guaranteed performance	Guaranteed Security
▪ Adoption of Jhipster as the basic cycle generator. ▪ Uses the technologies chosen by the IT Advisory Office - OAI for development (Spring Boot, Angular, Bootstrap). ▪ Reduces implementation costs by at least 50%. ▪ Developments come out in half the time and with the best practices. ▪ Eliminates opportunity costs because it automatically generates the basic functionalities: ▪ Security functionalities CRUD functionalities Unit tests ▪ Sending emails Monitoring ▪ Microservices and balancing of microservices ▪ Reduces maintenance costs ▪ Eliminates learning curves between projects (all are identical).	▪ Continuous integration ▪ Unit testing ▪ Static code analysis ▪ Acceptance testing environment and REC ▪ REC testing ▪ Vulnerability testing	▪ REC Testing ▪ Detect and eliminate bottlenecks ▪ Find optimal system configuration ▪ Acceptance test environment identical to the production environment ▪ Leverage best available infrastructure	▪ Implement validations in the backend ▪ Vulnerability testing

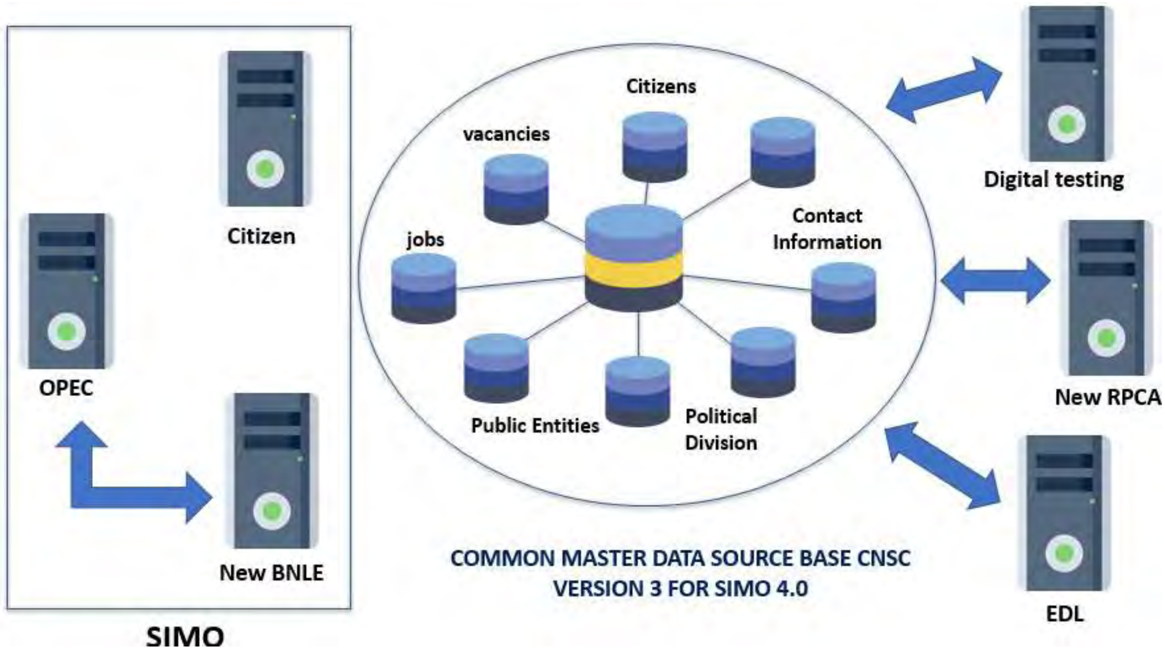
Interoperability between Information Systems

Due to the current dynamics of the administrative career process, supported by the CNSC's information systems, a continuous and reliable exchange of information is required. Therefore, these systems must operate according to this need. It implies the consolidation of efforts so that these information systems are increasingly interoperable with each other.

To achieve this, it was necessary to build information exchange services between applications, integrate the systems into a regular data model that governs the primary information entities of the administrative career cycle, the technological transformation of some systems that operate under technologies different from the adopted standard, and the definition and administration of the fundamental information units, from their acquisition or generation.

The following diagram shows the designed interoperability between the different information systems of the CNSC.

Figure 8: Interoperability Model between the Information Systems



Consolidation of common data sources

The unification of the CNSC's Information Systems was achieved through the definition of master data and the design of a new data model (Common Data Sources - CDF), which facilitates the operability of the information systems, following the logic of the institutional processes.

Further on this purpose, it was necessary to prioritize the centralization of information in a single database that tends to cover the entire entity along with other components of a single system, for the following purposes:

- Categorize in the databases if it's a table belonging to a mission system and related to other tables of other systems that can be considered components of one.
- Take advantage of the referential integrity functionalities to ensure that the same record is being discussed, that there are no duplicates or orphan records.
- Perform queries that include information from multiple systems.
- Improve performance.
- Optimize development costs by requiring each table to be managed in only one part of the code.
- Eliminate the need to synchronize, validate and update through REST services between different modules of the same system.

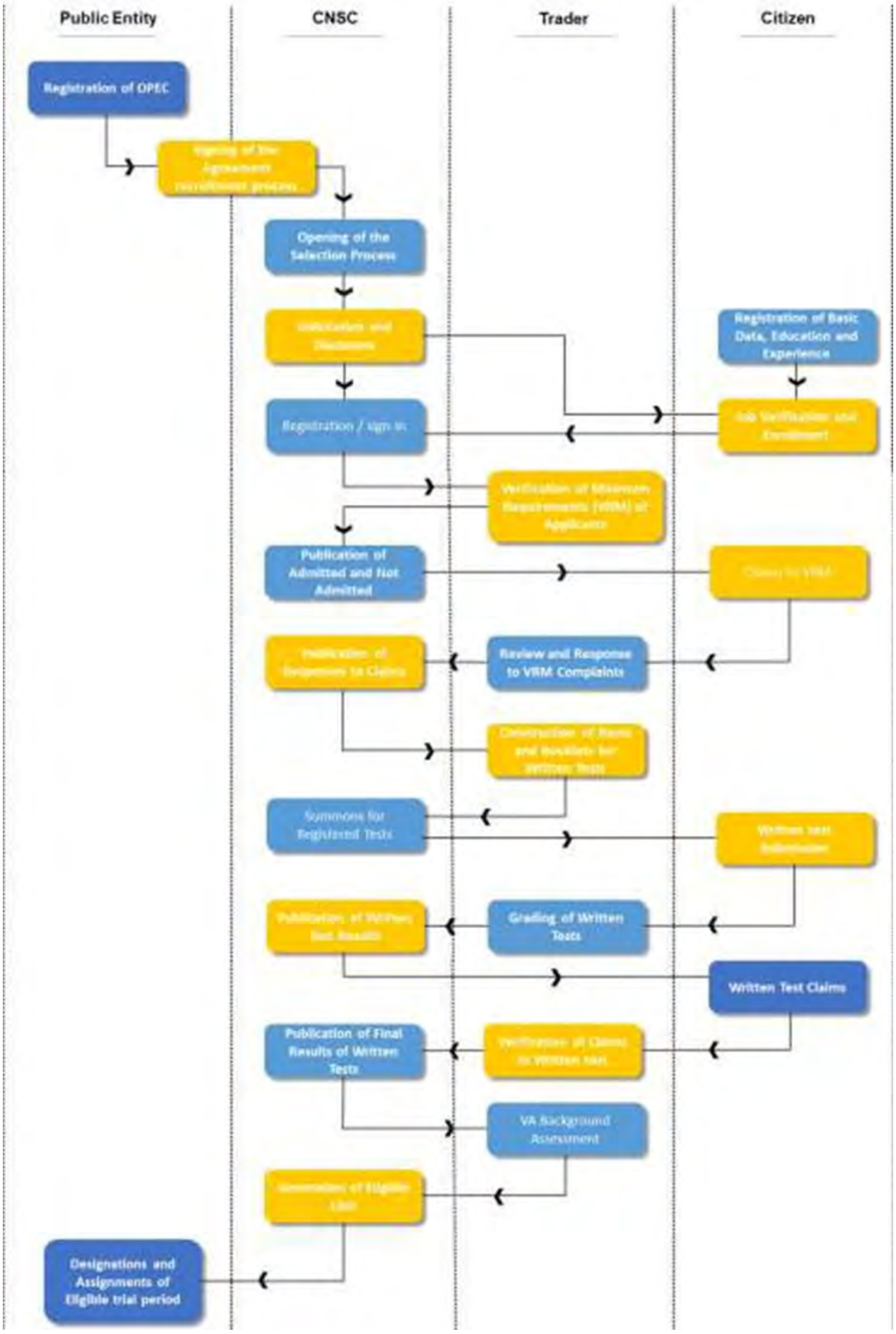
Development of SIMO 4.0 modules

Recruitment Processes Module

The recruitment processes module integrates and allows managing the data of the recruitment process and merit-based competitions carried out by the CNSC. It supplies the definitive vacancies of career jobs, which are done based on the Public Offers of Career Jobs (OPEC), that should be reported by the entities in SIMO, and the participation of citizens in these competitions. The module has been designed for the interaction of all the actors involved in the different stages of the processes, such as the CNSC, public sector entities that offer career job vacancies, citizen applicants, and operators of these recruitment processes (higher education institutions accredited for these purposes).

For greater clarity, the following illustration shows the stages of the Recruitment Processes and those responsible for them.

Figure 9: The stages of the Recruitment Processes and those responsible for them.



This management tool, supported by the CNSC's development and under open codes software policies, allows a single registration of citizens to participate in recruitment processes and has a centralized repository of data and documents of registered citizens so that each user can attach their training and work experience documentation and compete in the selection process they applied.

Table2: Background and improvements to the Recruitment Processes Module

Background	Improvements
There was no a way to control the OPEC data upload by the entity since the system did not have fields and labels for the standardization of the information to be recorded, and warning messages to avoid discrepancies or errors between what was uploaded and other regulations that apply according to the entity that is making the record.	Tag structure for the new OPEC module, which will allow public entities to register, through parameterized and controlled fields, the information of the definitive vacancies of the career positions of their personnel, validating it with the regulations in place. This reduces the possibility of error in the registration and allows for consistent data.
There was no way to separate the vacancies that the entity must constantly report, from the jobs that are required to be offered through the merit-based competition, or that are necessary for the Eligible Lists or other mechanisms (reinstatement, relocations).	Mechanism of separation of specific variables of the vacancies associated with the jobs offered that allows the registration of particular values of the position such as dependence, geographic location and if they are provided in provisionality by people close to causing their pension rights, which allows the registration of a single OPEC for each job, giving greater opportunity to the applicants to be on the eligible lists with the possibility of appointment, as well as protecting the provisional ones close to retiring according to Law 1955 of 2019.
The entity was not alerted when it registered a job with the same characteristics as another.	A warning is implemented in the system informing when a job is identified with the same level, denomination, code, grade, and purpose data as another job, which facilitates the entity's management and prevents duplicity or fragmentation of offers.
There was no way to keep track of the jobs that are offered over time since there are several offers for the same job without being able to distinguish that it was the same one.	A report has been implemented to generate information on jobs registered in OPEC 4.0 by the entity so that those who have information registered in the new OPEC can export the report in .xls format.
Extensive Test Structures definition processes.	A new section called "Test Structures Consolidation" was created to list the job structure. The functionality for "Validate Test Structures" was created so that once the association of test structures is done, they can be validated and approved. The system will be able to allow the consolidation of test structures once they have been validated and grouped.
Inconsistency in the information registered by the citizens regarding names and ID info, such as date of issue and place of birth.	The use of a web service that interoperates with the National Registrar's Office and uploads the data of the citizen who registers in SIMO is implemented. In addition, this service is implemented when registering in the OPEC 4.0 employment information from the officer who temporarily occupies the vacancy reported by the entity.
Payment of registration fees only over the counter at the bank, using a receipt generated from SIMO, which makes the payment at any of the bank's branches.	SIMO allows the purchase of registration fees completely online through PSE, in addition to the traditional payment method at the bank, so that the interested parties no longer have to travel to make the payment of the required amount, facilitating this procedure and reducing the time in which the registration process is carried out.
Impossibility of changing employment once payment has been made.	New functionality to transfer payment (job change) is implemented so that it only allows transferring to jobs of the same type of process (promotion or open) within the selection process.
Existence of multiple channels for processing selection process complaints, which made it difficult to consolidate them and provide a prompt response.	Processing of claims, appeals, notifications, communications and other administrative actions through SIMO as the only official channel.

In the development of the reorganization of the recruitment process module, we make it more convenient for the administration of the public jobs to be offered as well as for the participation of the applicants in these jobs. One of the achievements of this new version is the restructuring of the data model, which allows the loading of OPECs through a new labeling system that facilitates their characterization. Likewise, the possibilities for sociodemographic analysis of citizens have been expanded.

Public Registry of Administrative Career Module (RPCA)

The Public Registry of Administrative Career (RPCA) module allows for the registration, updating, and cancellation of the registry of civil servants who hold career rights in public administrative career jobs, through the provision of online mechanisms that facilitate the interaction of public entities with the CNSC, led by the heads of human resources (HR) departments or whoever is acting in their name.

Table 3. RPCA Module Background and Improvements

Background	Improvements
Filing RPCA entry requests by the head of the HR	Online procedures by HR Heads (e.g., registration, updating and cancellation of registration). A unique filing number is generated through web services with the SGD.
Errors in sending the supports for each of the procedures.	At the time of filing the procedure, the information and documentation required is validated, and the history of annotations and procedures in process of the public servant to be annotated is shown to prevent the head of Human Resources from re-entering applications that are already in progress.
Delays in responding to requests from the Heads of HR.	With the functionality of the RPCA system, it is possible to have control and a history of the files to which documentation requirements are requested, thus speeding up review and registration times. The system has parameterized a time limit for the heads of HR to respond to requests regarding their procedures, otherwise, the filing is automatically terminated.
Entities are not able to follow up online on each procedure requested by the head of the HR	There is now a feature that allows HR managers to follow up on their applications online and review the status of applications.
The employees are unaware of the procedures of their new developments that are being carried out by the entity before the CNSC.	Although this functionality was already active, information was migrated to be available for consultation using web services to the systems that require it, for example, the citizen file project.
The distribution of the filings is done outside the registration system.	A workflow is integrated into which the delivery module is included.
There is no history or audit of users and the modifications they make in the system because the RPCA application was used for consultation purposes, to include the entry and subsequent completion of the process under annotation or return of documents. ORFEO was a means to keep track of the management, which generates a break in the history of activities.	The system has a history that allows you to validate the status and location of the procedure.
It does not have a control panel that provides immediate global information for decision-making and statistics in general.	Integration with the data analytics tool for the creation of dashboards to determine the behavior of processes in RPCA. Standardization of information with the SIMO 4.0 project.
It is difficult for analysts to review the procedures, and tasks are performed in different applications.	Improved procedure review times and reduction of manual tasks.

In the development of the new version of the Public Registry of Administrative Career module, the goal was to register and follow up the annotation procedures in the RPCA of civil servants who hold career rights. One of the great achievements is the reduction of the time required for the procedures, as well as the control of the supports for each one of them, which significantly reduces the rejection of annotation requests due to lack of completeness.

Employee Performance Evaluation Module (EDL)

The purpose of the Employee Performance Evaluation module is to be an objective and permanent management tool aimed at assessing the individual contributions, and the behavior of the person being evaluated (probationary or permanent employees of administrative career positions) to measure the impact on the achievement of institutional goals.

Table 4. Background and improvements in the EDL Module

Background	Improvements
Filing RPCA entry requests by the head of the HR	Online procedures by HR Heads (e.g., registration, updating and cancellation of registration). A unique filing number is generated through web services with the SGD.
Errors in sending the supports for each of the procedures.	At the time of filing the procedure, the information and documentation required is validated, and the history of annotations and procedures in process of the public servant to be annotated is shown to prevent the head of Human Resources from re-entering applications that are already in progress.
Delays in responding to requests from the Heads of HR.	With the functionality of the RPCA system, it is possible to have control and a history of the files to which documentation requirements are requested, thus speeding up review and registration times. The system has parameterized a time limit for the heads of HR to respond to requests regarding their procedures, otherwise, the filing is automatically terminated.
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Table 5: Background and improvements in the EDL Module

Background	Improvements
Manipulable physical formats that did not guarantee the security or traceability of the information.	Electronic forms. With the implementation of the application, all the formats required in the employee performance evaluation process (Commitment Agreements, Partial and Semiannual Evaluations, and Definitive Qualification) are generated. The formats have the information structure required for the process and are not directly modifiable in the file, allowing file security and traceability of the information.
Manueal consolidationof commitment and behavioral competencies	The application is used to record the evaluations by be-havioral and functional commitments with the rating structure defined for the Performance Evaluation. The consolidated ratings for each semester and the final rating are generated with a single click, based on the average made during the semester. The different information query views validate the traceability of the processes registered to the employees during evaluation periods.
No control over times.	From the application, evaluation periods and each of the date ranges of the activities are configured, generating the execution of the agreement and evaluation processes by the entities in the terms, but without restricting the activities in later dates and keeping the trace of dates of registration, approval, and notification of the EDL activities.
Lack of information reported by the entities and impossibility of consolidating information	The application no longer requests additional information from the entities on the EDL process, because it centralizes and consolidates the information of the employees (basic data, employment data with the respective characteristics within the entities), and relevant information, in addition to the commitment agreement processes (behavioral and functional) and the evaluations of employees (scales of results and qualification results of the conducts associated with the behavioral ones).
Inability to do data analytics	With the capture of information from the system, the consolidation of all data generated in the EDL process is achieved. This allows the creation of data analytics dashboards, in which the functional area can determine the behavior of the processes carried out by the entities in the coordination and evaluation. Additionally, it allows the analysis of the entities, uses, and registration of information. The EDL application has developed the flow of administrative situations generated in the entities during the consultation and evaluation processes, in addition to the processes related to Evaluation Commissions, Mobility of employees between entities, management, and administration of the head of HR of the entity. Generation of information reports for the heads of HR of the entities for consultation on the agreement and evaluation processes carried out during the evaluation term.

In developing the Employee Performance Evaluation module, we seek to provide an online tool to support the EDL process for the entities that use the evaluation system proposed by the CNSC. One of the major achievements is to have complete and timely information on the status of the evaluations in the entities that use the evaluation system, and to ensure that such assessments are carried out within the stipulated periods.

National Bank of Eligible Lists Module (BNLE)

The National Bank of Eligible Person List module allows both the entities and the CNSC to manage the information concerning the lists of candidates for the vacancies offered in the selection processes.

Table 6: Background and improvements in the BNLE Module

Background	Improvements
Delays from the heads of HR in reporting new movements of the Eligible Lists, since there were no early warning mechanisms for the time required to register the new entries.	Time control for some of the operations involved in the process, through the implementation of warnings that allow those involved to track the time required to perform the operations.
The registration of new information on the list of eligible candidates was made using the in-person filing or by e-mail in the document manager, being isolated from the rest of the related information until the registration was made in the system.	Work tray for the head of HR in the new application; to register information about developments such as appointments and possessions, with their documentation supports, allowing better responding times for cases.
Eligible parties are unaware of updates of the Eligible Lists and generate daily requests about the other uses.	Online information for each person on the Eligible List, through the implementation of new queries and improvements on the existing ones.
The location on the lists were given for all the members, without taking into account the particular situation of each of the eligible candidates.	Implementation of the new rules within the list of eligible candidates, where each member of the list, according to his or her situation, will receive the information of his or her location within the list.
The data from the entire process were isolated, which makes it somewhat difficult to generate possible statistics derived from them.	Data Analytics, located in a single place the information related to the eligible lists, allowing the generation of reports and queries.

In the development of the new version of the BNLE module, the goal was to have a system that allows the control over the lists of eligible candidates and of the updates that may arise from its use. One of the great achievements of this new version is to allow the heads of HR of public entities to register and consult data and information related to the activities for the use of the lists.

Administrative Career Surveillance Module - VCA

The monitoring module provides centralized information so the verification of relevant information is quick and agile, and guarantee an efficient search, use and simpler management for decision making, both in the processing of complaints and in the administrative sanctioning processes carried out by the Administrative Career Monitoring Directorate.

This module allows the generation of early warnings regarding the incorrect or untimely application of the rules that regulate the administrative career and are generated from the control points identified and defined in the EDL, BNLE, and SIMO applications. This allows to report the situation to the public entities involved and to the professionals of the Administrative Career Surveillance Directorate.

Internal Control Module

The Internal Control module is part of the VCA module, which seeks harmonized collaboration with the Internal Control Offices of the entities managed and supervised by the CNSC, so they may report any irregularities they find in the exercise of their functions related to the application of the rules governing the administrative career.

Table 7: Background and improvements to the Administrative Career Surveillance Module

Background	Improvements
A technological tool has not been implemented to support the processes resulting from the performance of the CNSC's Administrative Career Monitoring authority. Currently, this procedure is performed manually, once the internal communication is received, the matter is assigned to one of the professionals to verify the facts reported or brought to the attention of the Directorate.	Development of the Administrative Career Surveillance Module. The application allows the Administrative Career Surveillance Directorate to consult the centralized information generated from each of the CNSC's administrative career cycle applications, so the verification of the relevant information is faster and more agile, thus guaranteeing a simpler search, use, and management for decision making.
Written requests are made to the entities to verify the occurrence of the facts. Once the written complaint or internal communication is received, one of the professionals is assigned to verify the facts. If it's within the competence of monitoring, then written requirements must be made to the entity involved to verify the occurrence of the facts and request the evidence considered pertinent. This inspection may also be carried out through on-site or virtual visits to the entity. The purpose of the written requirements may be to obtain information, documentation, or to issue an order that must be complied with within a certain term.	Generation of early alerts from the processes established in the different information systems such as SIMO, EDL, and BNLE. The notifications generated from the control points identified and defined in the EDL, BNLE, and SIMO applications will be sent to the public entities via e-mail, to achieve more reactive and effective monitoring of the administrative career.
The submission of requirements to the entities is carried out manually by the Administrative Career Surveillance Directorate through the CNSC's Document Management System, where they are submitted and forwarded to the entities.	Automatic requirements to issue an order that must be fulfilled within a term. Thanks to the parameterization of the timing of the terms and messages of the notifications for each process controlled from the CNSC applications, the alerts of requirements to the entities are filed in the document management system.
A technological tool has not been implemented to allow entities administered and supervised by the CNSC to report irregularities. Currently, when an entity identifies any irregularity in the execution of functions related to the administrative career, it informs the oversight Directorate through the channels provided for communication for this purpose: e-mail or website.	Development of the Internal Control Reporting Module for administered and supervised entities. The entities can report irregularities encountered in the performance of their duties. In this way, the CNSC seeks collaboration with the Internal Control Offices of the entities administered and supervised by the CNSC, so that they can report any irregularities they find in the performance of their duties related to the application of the rules governing the administrative career.

In the development of the new VCA module, we seek to centralize the information related to compliance with administrative career rules, as well as to alert the entities and the CNSC in the event of non-compliance with them. One of the main achievements will be to enable more effective and timely actions related to surveillance.

Module for item construction and computer-based test application

The purpose of the item construction and computer-based test application module is to manage the creation of items to be used in the selection process tests and to allow citizens registered in the platform and who are qualified to participate to execute the tests.

To achieve this objective, the development of a solution aimed at strengthening two fronts: (1). The process of construction and storage of items for their application in selection process tests and (2). The process of diagramming booklets for the application of tests and, in the short term, in a virtual manner.

Table 8: Background and improvement options for the item construction and computer-based test application module.

Background	Improvements
A technological tool has not been implemented to allow online submission of evidence with the required security and transparency conditions.	Development of a technological solution for the construction of items and application of computerized tests that allows the digitalization of the selection tests in the different stages of merit-based competitive examinations.
Higher education institutions construct the items with their tools.	The Item Construction application allows the centralization and standardization of item construction.
The Commission does not have control over the items constructed until the end of the selection process.	Administration controlled by the Commission that will allow the proper use of the items according to the thematic axes.
It is not possible to compare items already applied and the new items constructed to identify similarities.	Possibility of comparing items, using robust algorithms, to identify inappropriate similarities between what has been applied and what has been presented as new.
Printed test booklets, which have a complex security process to ensure security and confidentiality in the construction and application of the test.	Faster construction of booklets for written and/or computer applications.

In the development of the item building and compute-based test application module, the goal was to standardize and centralize the construction of items by the Higher Education Institutions (HEI) that act as operators for the development of the recruitment processes. We also wanted a structured repository of items that allows the layout of booklets and the application of tests. One of the main achievements is the implementation of actions to control the quality of the items in the construction process so they are correctly validated and there is no duplication with items already applied.

Recruitment process cost estimated module

The recruitment process and cost estimation module include the creation of a predictive model of applicants for the different recruitment processes, for which predictive analytical methods are applied.

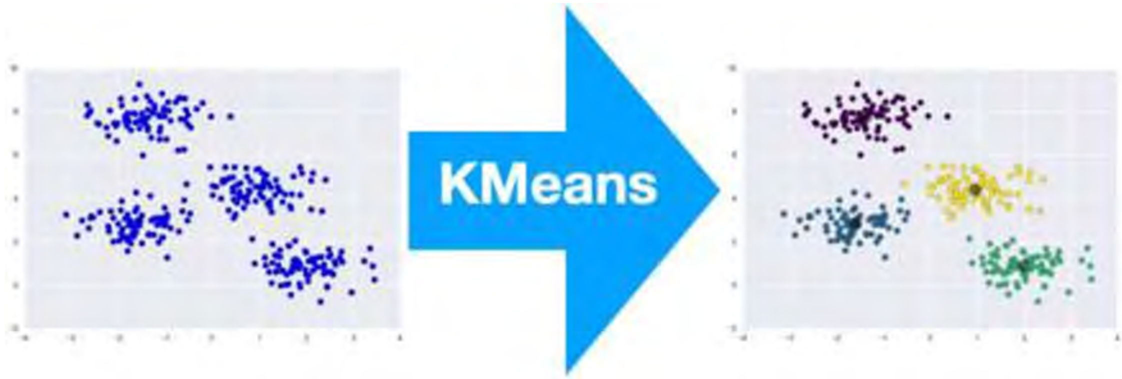
The cost estimation process is based on the analysis of the data of the recruitment processes already carried out by the Commission, to obtain an approximation of the number of applicants that may apply for jobs in a new public offer. This analysis will be based on the comparison of job characteristics, such as hierarchical level, title, salary assignment, and location of available vacancies, as well as geographic and demographic variables related to the applicants.

For which, it is estimated the design of a predictive model based on Machine Learning (ML) techniques that allow predicting the number of applicants per call and thus, automate the process that is currently performed through experience.

For the modeling, the following data grouping is planned:

- Unsupervised learning algorithm.
- The goal of K-means is simple: to cluster similar data and discover underlying patterns.
- Records are grouped into 4 data clusters.

Figure 10: Data modeling



Improvement strategies based on the use and leverage of 4.0 technologies.

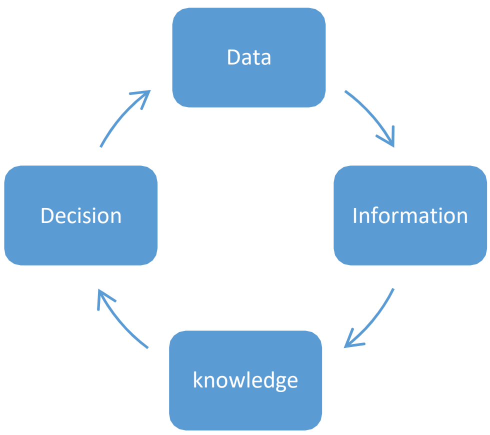
The CNSC, within the framework of the proposed digital transformation, has not only been concerned with the automation of its mission, but has also sought the integration of emerging technologies such as Machine Learning, Artificial Intelligence, Advanced Analytics, E-Learning, and Self-Management Systems based on bots. The above is done to optimize the tasks of management and monitoring of the administrative career, by reducing execution times of these tasks, minimizing errors in each of the stages of the career cycle processes, optimizing resources, and generating digital trust.

The following is a description of the technologies used by the Commission for the technology-based transformation.

Business Intelligence (BI)

The purpose of implementing business intelligence is to support and facilitate decision-making at the strategic, tactical, and operational levels based on data in the CNSC.

Figure 11: BI-Process



The objectives that the Commission seeks with the implementation of BI in the understanding of the business, are:

- To support the decision-making of the CNSC areas based on information.
- Follow up on management indicators.
- Improve response times to business questions.

- Obtain summarized, detailed and timely information from CNSC's systems and processes.
- Support the visualization of strategic issues of the CNSC.
- Centralize and unify the available information in a single platform.
- Construction of control indicators for selection processes.

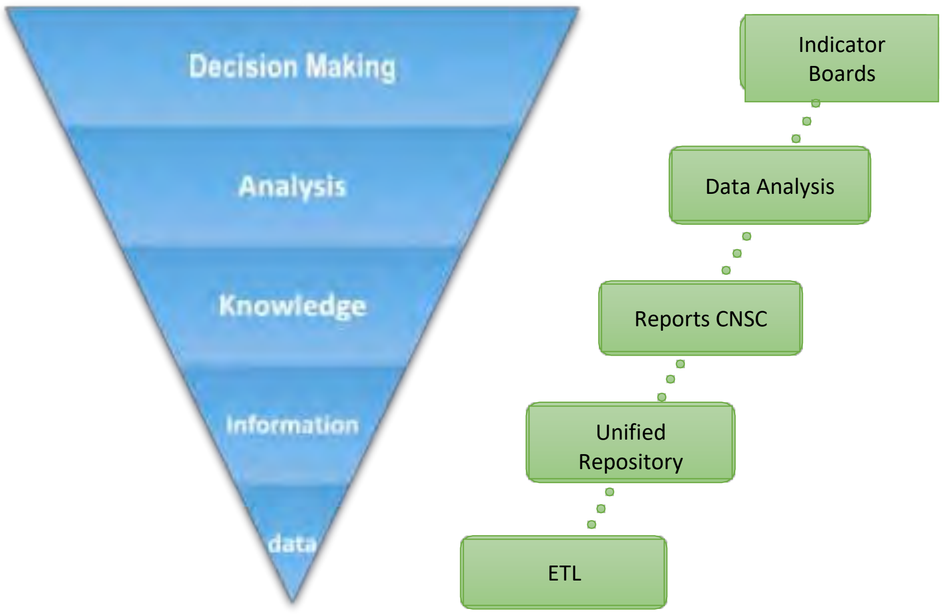
Among the main achievements since the implementation of BI are the following:

- Confirmation and implementation of a centralized data repository and/or data warehouse (DWH) for the transversal attention of information of the CNSC systems.
- Implementation of the Qlik Sense Server business intelligence platform.
- Information publication processes aimed at the integration of the open data platform of the Ministry of Communication of the Government of Colombia.
- Publication of interactive and public information of the CNSC's Administrative Career Observatory.
- Construction of control boards for internal use of the CNSC oriented to:
- Visualization and monitoring of the selection processes characterizing the most relevant variables concerning employment, citizens, and the stages of the process.
- Visualization of KPI planning indicators.

    - Follow-up of the Evaluation of Labor Performance (EDL).
    - Follow-up of the Public Administrative Career Registry (RPCA).
    - Follow-up of the System of Entities (SIEP).
    - Follow-up of the National Bank of Eligible Lists (BNLE).

The model applied for the construction of the CNSC dashboards, based on BI, is shown below.

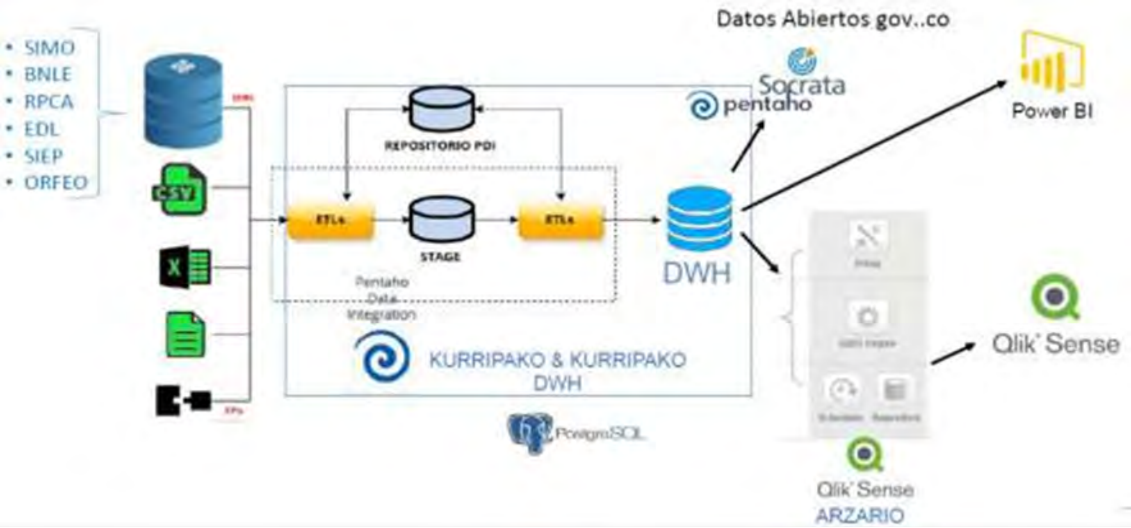
Figure 12: Business Intelligence applied to CNSC's business model



In principle, we identify the data sources that produce relevant information for the construction of knowledge, which from the analysis of the behavior of the variables related to the mission provides tools for accurate and timely decision making. These processes are carried out from the tasks of extraction, transformation, and loading of data, which are used for reports, dashboards, and the mentioned analysis.

The diagram describing the data flow in BI is shown below:

Figure 13: General Architecture



Therefore, the BI Solution Architecture is defined through: (1) Identification of data sources, (2) Extraction, transformation, and loading of data, (3) Centralized storage, (4) Construction of the data warehouse, and (5) Production of reports and dashboards, which allows having tools for decision making based on data transformed into information.

Artificial Intelligence

From the IT architecture and Technological Innovation, it is a logical result to take advantage of the progress in technologies such as Artificial Intelligence, which by using algorithms and computer programs, makes it possible for computers to perform operations that are part of Human Intelligence.

Within the initiatives proposed for the modernization and automation of the CNSC's mission processes, the entity is making efforts in the use of emerging technologies such as artificial intelligence and Machine Learning to support processes such as the Verification of Minimum Requirements (VRM) and the Background Assessment (VA) of applicants. The objective is to perform the recognition of the documents provided by each citizen; from which the classification, typification, extraction of relevant information, along with the structuring of documents is generated. The purpose of this is to obtain relevant data that allows the CNSC to identify whether or not an applicant meets the requirements to fill a vacancy offered within the selection processes carried out by the entity.

The application of this technology provides effectiveness and efficiency to the processes of recruitment and employment supply. In addition, it provides transparency and optimization of the financial resources allocated for such purposes.

Machine Learning (ML)

Machine Learning is related to the development of artificial intelligence, under which computer programs (models) are built that access large volumes of information (data), from which they can learn and generate new »knowledge«.

The CNSC has prioritized the application of ML for the VRM and VA stages; due to the large volume of documents submitted by citizens applying for specific positions in the recruitment processes. This, to automate the operations that request the verification of validity in the documents, the evaluation of their consistency and content, and certifying their correspondence, with the requirements of the job for which a citizen applies. ML provides and guarantees an advantage in controlling a large amount of information more effectively.

The technologies on which the CNSC relies for the ML implementation process are based on the Google Cloud Platform (GCP) cloud solution, which contains the following structure:

- **Google Cloud Storage**: Ephemeral storage for training and validation data (currently used for the other services).
- **Google BigQuery**: Anonymized Data Warehouse where the information for the Machine Learning model will be stored.
- **Machine Learning Platform:** Model training platform using frameworks such as Tensor Flow.
- **Google Talent Solution API:** Google Cloud platform that loads information on applicants and calls for applications, to perform a more systematic search to find the relationship between skills and requirements.

Some microservices implemented in GCP, applied by the CNSC are: (1) Extract-metadata, (2) Minimum Requirements Verification, (3) Detector (signatures), (4) Detector(similarity), (5) List-functions and (6) Firestore-export.

Additionally, the implemented ML algorithms in the GCP, are: (1) Time Extractor, (2) Date Checker, and (3) Phrase Similarity.

ChatBot – Voicebot

Bots are programs that simulate human behavior and have a conversation with a person, as well as provide automatic responses to queries made by users.

The CNSC is currently in the process of implementing a Chatbot and Voicebot in order to optimize queries about its processes; and update its citizen service channels with the purpose of improving response times, reducing the amount of personalized advice, and supplying citizens with self-management tools.

For example, during the current fiscal year, through the CNSC's telephone system channel, more than 4,640 calls have been answered by 10 human agents and through the web page chat, more than 1,664 citizens were answered by 6 human agents. With the implementation of the bots, it is expected that the number of calls will increase significantly and that the human agents will only respond to specific queries.

To do this, the CNSC is applying ML Models, in combination with Natural Language Processing, so that the machine can identify the user's intention and need and thus can provide an effective service.

Electronic Document Management and Archiving System (EADMS)

During the last few years, the CNSC saw in its current Document Management System (ORFEO), some limitations in the architecture of the application in terms of security, maintenance, and compatibility. These were caused by the normative aspects that regulate document management in Colombia.

Based on the above, the CNSC decided to acquire and implement a new Electronic Document Management System (SGDEA), to facilitate the organization of documents and control them, maintaining their historical and archival link, original order, and origin, as well as the relationship between different document collections. This allows the creation of complete electronic files and guarantees document transfers between systems and final availability per the entity's Document Holding Tables (TRD, for its acronym in Spanish).

The objective of applying this technology is to optimize the capacity of human and financial resources, in order to minimize the supply time for the jobs in different entities.

For this purpose, algorithms hosted in the cloud are built, which are responsible for the extraction of metadata from different types of documents, which are compared with the requirements defined in the Manual of Job Duties and Competencies (MFCL) of the job offered. Finally, this comparison shows whether the applicant meets the requirements and, in this sense, will be admitted continuing with the process, or not admitted due to non-compliance.

The machine is trained by the CNSC, based on verifications executed by humans in previous selection processes (Supervised Learning), and is expected to optimize the analysis process and the result of the comparison, eliminating bias.

In accordance with the foregoing, the implementation of the ERMS OnBase has begun, a system that is integrated with Business Process Management (BPM), as a tool for modeling and systematizing the Entity's processes and allowing interoperability with other internal systems. and external, without losing sight of the organizational, normative, technological and documentary perspectives

Within the framework of the Institutional Transformation, the objectives of the SGDEA are:

- Strengthen the physical, human, financial and technological resources to improve the management of the CNSC.
- Generate scenarios for social control through mechanisms that allow citizens to access the information generated as a result of administrative actions.
- Streamline administrative procedures and formalities for citizens.
- Articulate with the national policies of digital government generating:
- Online forms to be filled out online.
- Automation of procedures and services:

    - Virtual one-stop shops,
    - Electronic and digital signatures
    - Exchange of information between entities
    - Ensuring that authoritative evidence of the entity's activities is created, captured, managed and made accessible to those who need it for as long as necessary.

E- Learning

As support to the implementations carried out for the improvement of processes through technology, the CNSC has set up a platform to provide virtual courses on the aspects of administrative career for public servants of the Colombian state. This online access platform is built under the LMS Moodle and currently, it has offered courses in Evaluation of Labor Performance - EDL and Public Registry of Administrative Career - RPCA, with a total of 11,263 enrolled in 2021.

The importance of the Virtual School for the CNSC is integrated with the policy of knowledge management and innovation for the entity and with the comprehensive training strategy of the Commission, to »Ensure the effective transfer of explicit knowledge generated in the CNSC«, by conducting external training activities, which stimulate institutional transformation within the framework of the functions of administration and monitoring of the general system and specific administrative career systems.

Challenges

The digital transformation and integration of emerging technologies project is the most disruptive approach that the National Civil Service Commission has designed in terms of digital transformation in the entity because it allows the integration of all mission functions.

The consolidation of a digital ecosystem in the entity has substantially increased, in terms of functionality, accessibility, use, time, costs, and minimization of errors; in the services we provide to our users, generating relevant knowledge that has helped us to improve decision making in the entity, through the implementation of SIMO 4.0.

This system is challenging as an information system that integrates the needs of the Commission, becoming the starting point for the unification of a large number of solutions and fundamental requirements to understand the processes value chain, in an articulated manner in the CNSC. It is also a fundamental access window for citizens, which allows them to understand, how the National Civil Service Commission works and its work as a promoter of the administrative career in the country.

Likewise, the challenge of implementing emerging technologies is of interest for the generation of value in the execution of the Commission's mission processes, so that they are efficient and allow understanding how the process structure is materialized in concrete services, in meaningful records, and in decision-making data; key for the management of those who must interact with such information.

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Case of use in Digitalization, data and AI driven services: Smart Commertial Street Project of Zaragoza

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Problem/Goal

Zaragoza is a city with more than 700,000 inhabitants in north-western Spain. As in many other cities throughout Europe, the proximity retail sector of Zaragoza suffers due to the competition of e-commerce and malls located in the suburbs. This competition leads to the closure of traditional shops. These closures bring, in addition, a loss of proximity service and economic deterioration in the city. They also influence the quality and habitability of the affected urban space.

We have observed this effect for years, but when the COVID19 pandemic brought partial closures and capacity restrictions to the retail sector, together with an enormous rise of e-commerce, the impact has accelerated dramatically, with significant deterioration rates.

To soften this effect, the City Council has put in place, first of all, a series of contingency plans. But additionally, also longer-term strategic action plans are being developed. Among them is the Commercial Urbanism Plan of the city, developed with the collaboration of IDOM, the company that I represent.

The plan starts from two main concepts:

- First, not to start from scratch, but work in the existing commercial areas. This approach provides an acceptable level of operation of the city markets and works on its consolidation and reinforcement.
- The second concept is to provide the local retail with those characteristics that make their competitors (the online sales platforms and the shopping malls) strong.

Specifically, from online sale platforms, we take elements to engage with the customer, know them, and create a personalised shopping experience. We also consider relevant the inclusion of other highly digitized processes such as digital marketing, and home delivery services.

From shopping malls, we will mimic the massive acquisition of operational data and its integrated management for a better knowledge of shopping habits.

This provision of digital support becomes an essential component of the Commercial Urbanism Plan, and it acquires the entity of a project, namely Digitization: Smart Commercial Street.

This component uses data from different sources, plans to incorporate state-of-the-art technologies such as video analytics or 5G, and deploy artificial intelligence tools. Thus, we expect machine learning schemes to provide a better understanding of the behaviour of the clients under some environmental constraints and predict demand, client affluence and level of spending, and thus being able to predict profits and other economic KPIs.

The Commercial Urbanism Plan defines twelve urban commercial galleries to implement in the coming years.

The Digitization project contemplates two of them as pilot areas were to proceed to carry out the initial implementation and the setup and optimization of the work methodology. These two areas are:

- The historic centre of the city, core of the urban social activity, and
- The neighbourhood of Delicias, one of the most densely populated neighbourhoods of the city.

Methodology

The project's aim is to answer two main questions:

Question 1: Who is my client? For this purpose, we will collect data that allows creating profiles: Where the clients come from (and more precisely if they are tourists or residents of the city, and what city or neighbourhood they come from), age, gender, economic level.

Question 2: How does my client behave? We will collect activity data to know the behaviour of the client in the Commercial Gallery: Where you access the gallery, what transport modes you use to move, how much time you spend in the gallery, do you repeat visits, do you come frequently, how often?. Additionally, we will study the correlation to some parameters (day of the week, time of day, atmospheric weather, events in the cities)

During the project, we are considering the following data sources:

- Self-acquired data: The galleries will capture data via three methods:

- Sensors deployed on the street (presence detectors, cameras, Wi-Fi smartphone detection/tracking, others.)
- through the use of a planned loyalty card,
- and through a customer interaction app that we will also deploy as part of the project.
- Telco data: obtained either directly from mobile telecommunications operators or consultancy companies acting as data brokers gathering data from telecom operators and other tech companies such as Google, Facebook, etc. They provide valuable information on:
- Origin of the client: allowing marketing campaigns segmented by zones
- Socioeconomic profile: This gives additional information about the expected success of products and services.
- Time of stay in the commercial gallery, which allows to size the services.

This data has two components: historical data, which is available from the beginning of the project, and data in real-time, which the operator will provide as it appears.

- Data shared by commercial establishments: Obtained from their internal information systems.
- Financial data: Payment data comes from the use of credit cards and POS terminals.
- Mobility operators' data: Data coming from the operational services of tram, buses, on-street parking, private underground parking lots of public access.
- Other significant data: Data comes from other entities located in the city. Datasets include meteorological data, traffic status, calendar of holidays in Zaragoza, agreements for the opening of trade on public holidays and festivities of localities in its area of influence, etc.

All the data acquisition process complies strictly with the Law on the Protection of Personal Data and Guarantee of Digital Rights (LOPDGDD).

From this data, the project will calculate the following relevant information:

Occupancy in commercial areas: The goal is to know the number of people in selected areas. Figures are available in real-time and with great precision. Segmentation in visitors (locals and tourists), as well as residents and employees, is also an important feature. Occupancy values can be displayed and managed as numeric figures, graphs, or occupancy levels (heat maps), etc.

Time to destination: It allows to characterise the behaviour of the visitor while in the controlled area. The objective is to automatically propose reactive actions to attract customers, accelerating or pausing the rhythms.

Translating it into a series of interesting KPIs for commercial management.

Project governance

To carry out these tasks, we propose to create the following management profiles:

- **Data manager of commercial interest:** will perform the tasks of data collection, relationship with data from different sources for sharing and merging, analysis of the same, and generation and publication of commercial KPIs.
- **Content manager:** it will carry out the tasks of generating content to feed the various sources of interaction with customers: publications on the street, marketing campaigns, loyalty programs, gamification, etc. This figure must be in continuous relationship with the Data Manager of commercial interest and with the Commercial Managers of each one of the urban galleries. It requires a high level of training in digital content. It can be proposed jointly to the data manager.
- **Commercial manager:** it will coordinate the physical and digital actions in the different galleries, marketing and dynamization activities between shops and the citizens/customers.

Temporary project scheduling

The objective of the project is to transform this raw data into useful information at the commercial level. To achieve it is necessary to generate a model, calibrate it and adjust it until obtaining the correct KPI. Then, the model will generate different dashboards for the different types of users (City Council, Commercial Galleries, Individual retailers)

Explained by an example: sensors on the street will tell us the number of people at a given crossing or the time it takes to travel the distance between two points at any time. But those are not the expected results: the system has to infer the expected volume of activity and how it affects the need for labour or the expected sales volume according to the indicators shown above.

Derived from the experience in the implementation of similar applications in commercial environments (Shopping Centers), we suggest the following 3-year calendar:

- **Phase 1**: 4 months of installation and commissioning of the equipment and the different software components (management, app, etc.) At the end of this period, we will obtain quality raw data.
- **Phase 2**: 1 year of data calibration. At the end of this period, our goal is to obtain quality KPIs describing the ongoing commercial activity in the galleries.
- **Phase 3**: 1.5 years of improvements in the analysis and machine learning of the system. At the end of this period, we expect to predict KPIs with a sufficient degree of approximation.

The project is currently at the launch of Phase 1.

Results

One of the most significant results expected of the project is the development of a methodology that allows replicating the implementation of the project in the remaining ten urban galleries in a standardised way.

Thus, commercial data management will coordinate among all of them in the future, bringing synergies.

As partial results for each of the phases, we expect the following ones:

- During Phase 1 of the project, we will adjust the number and location of field elements and their relationship with data obtained from other sources (telco mainly, but also the rest) to deliver meaningful data.
- During Phase 2 of the project, we will adjust the calibration procedures to obtain the commercial KPIs pursued.
- During Phase 3, we will implement the prediction algorithms developed throughout the project.

Blockchain and Cultural heritage: a systematic literature review

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Problem/Goal

Digitization has started a process of formalization of cultural heritage as an exchangeable good. Furthermore, the role of the consumer has changed because he not only has acquired knowledge about new technologies and is autonomous in acquiring digital content but, as some scholars suggest (e.g.Vargo & Lusch, 2008; Buhalis & Sinarta, 2019), he has become an active participant in the cultural experience. Cultural heritage has a sentimental existence and value (Krutilla, 1967), a value system that appeals to the bond that a community of individuals has for a particular relic, attributable to the social, aesthetic aspect of the object or its historical value (Bedate et al., 2004). The artifacts also have a legacy value, that is, a value associated with the satisfaction obtained knowing that the object is preserved for the future generation. Cultural and creative products play an important role in helping local cultural prosperity and economic development (Jun & Tiejun, 2020). European Commission defines cultural heritage as "cultural and creative resources of a tangible or intangible nature, with a value for society that has been publicly recognized in order to preserve it for future generations (European Commission 2018)". Today the cultural sector presents itself as an elective field of application for the development of new investments in technologies. These investments are also facilitated by recent development programs promoted nationally with the aim of modernizing the sector using the integration between technology and artistic and cultural heritage

In this context of digital transformation of cultural heritage, blockchain technology is part of the driver technology of a new approach that makes possible to offer a guarantee of the provenance and authenticity of works of art (Nowiński & Kozma, 2017; Kimani et al., 2020). Although researchers have investigated the influence of blockchain in cultural heritage, extant studies are fragmented and disconnected. Our study provides an inventory of the work to date and identify key research and development patterns. In detail, objectives of this paper are: to shed light on the role of the blockchain; to evaluate systematically the theoretical and empirical development of the influence of blockchain on cultural heritage; to propose a comprehensive insight into the influence of blockchain on cultural heritage so as to identify the specific areas in critical need of further development; and to provide recommendations for future research aimed at developing a more integrated research agenda on the influence of blockchain on cultural heritage.

The speed of technological changes and market needs and the unpredictability of their times and directions, implies a continuous orientation and an increasingly precise and rapid decision-making capacity that allows to protect the high value of cultural heritage. Today, cultural institutions draw on new technologies to meet a variety of purposes, from communication to heritage conservation and enhancement (All this is signaled by the growing academic, practical and managerial attention to the adoption of a digital cultural strategy (Johnson et al. 2016)

Methodology

We carried out a systematic literature review of peer-reviewed articles in the last 29 years (1992-2021) to probe into existing scholarly articles on blockchain and cultural heritage. The systematic literature review has been widely used in the business management field (e.g., Macpherson and Holt, 2007; Deng, 2012) because it facilitates the assessment of the field of studies relevant to a specific research topic. We have chosen this timeframe because it deemed appropriate due to the sporadic and patchy evidence of relevant articles prior to 1992.

Secondly, we selected only the articles in English present in the most used databases in the management field, Web of Science, Scopus and Science Direct (Tian et al., 2018). Further, we added Google Scholar articles and sector reports. Thirdly, we analyze inn depth the articles (title, abstract, conclusion) and we chose only the most relevant sources related to the field of Blockchain in cultural heritage. During this stage, we identify and eliminate 61 duplicate studies.

After this process, we exported the remaining 675 retrieved studies to Excel documents. Then, we conducted a deep analysis of these articles following the categorization criteria from Macpherson and Holt (2007), where the retrieved articles are further reviewed against the inclusion (e.g., sector, age, empirical studies, theoretical papers) and exclusion criteria (e.g., pre 1922 articles, all field that is not refer to business management) in an iterative process using keyword searches and title and abstract analysis. We have decided to adopt these categorization criteria because in this way we identify only the relevant references that improve the identification of the relevant literature in relation to the topic of interest. Through such an iterative process involving keyword searches, title and abstract analysis, we got 15 primary articles, and the full text of these articles was found for further analysis. The selected articles were independently analyzed by the researchers and categories of themes were identified. Following a phase of individual analysis, the researchers discussed the results that emerged and discussed the final categorization of the themes and the relationships among them.

Results

After reporting the findings of the systematic literature review, we discuss how blockchain technology characteristics combine to facilitate innovation cultural services. Results show core trends and patterns related to application of blockchain technology in cultural heritage. Based on systematic analysis of sample articles, we have classified the use cases of the blockchain: tokenization, digital scarcity, provenance and rights management. In all, almost half of the studies in our sample concern the application of technology for the certification of the provenance and authenticity of cultural works. The lowest percentage concerns the issue of right management, with only 2 articles in our sample. Our results confirm that blockchain technology is primarily applied as a guarantee of the authenticity of works of art, manuscripts and intellectual property in the cultural heritage industry (Whitaker et al., 2021). Our study confirms that the introduction of the blockchain provides an immutable timeline of cultural heritage that allows to salve all documents relating to works of art in order to salve their value especially for future generations, as suggested by the scholar Anagnostakis (2018).

The development of competencies on artificial intelligence (AI) for small and medium-sized enterprises (SMEs) of the skilled crafts: Empirical study and conception of a low-threshold qualification

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Problem/Goal

Although small and medium-sized enterprises (SMEs) of the skilled crafts are usually aware of the potential benefits and opportunities of digital technologies including artificial intelligence (AI), there is often uncertainty regarding its operational implementation. While the use of AI in large companies or industries is accompanied by specialized staff units or laboratories, day-to-day operations and no specialist departments usually dominate in SMEs. In fact, numerous studies show that the use of AI decreases as the size of the company decreases.

However, SMEs of the skilled crafts are of great economic and social importance in Germany, with around 1 million businesses, 5.5 million employees and 370,000 apprentices. This makes it an important target group for an increased use of AI. To open the diverse possibilities for these SMEs, competencies about AI are considered valuable. However, a qualification specific to this target group does not yet exists and needs to be suitable to the specific learning context which predominate in these enterprises: Research shows that SMEs of the skilled crafts compensate the lack of formal research and development through interactive and informal learning processes, as well as knowledge transfer (learning-by-doing, -using and -interacting). The ability and mode of innovation is therefore primarily based on application-oriented, practical experiential knowledge and innovative problem-solving skills – dependent on the requirements of the customer´s specific needs. In the context of innovation, craft enterprises often have to overcome competence-related obstacles, such as building up the necessary technological know-how or adapting processes and planning aspects in the face of technological change.

Therefore, the research-project »KomKI« wants to develop and test a hybrid qualification in learning and experimentation spaces, which helps the company management, the employees as well as the work councils to build competence of AI. With the result, that SMEs of the skilled crafts are enabled to do what they are usually denied due to the small company structure: Joint experimentation in a moderated, protected environment to overcome the obstacles for the use of AI and to form a learning mindset for further innovative business development.

Methodology

To fulfil this task, the presented study is based on three pillars: First, this article presents findings of the state of the art in work science. The research landscape was explored regarding to the required competencies as well as barriers to the use of AI for SMEs of the skilled crafts and the requirements for professional, methodological, and social competencies. Since the use of AI cannot be considered in isolation from digital transformation, the field of investigation was broadly defined to make possible deductions.

Second, this empirical study is based on 32 qualitative interviews with SMEs, consultants, and other experts of skilled crafts. The interviews took place in the period from January to April 2021 and were evaluated by content analysis and clustered thematically. The focus was on the use of AI (How is AI used and deployed in companies?), the effects of AI (What is changing in the work context and in the company? How does business models (have to) change due to volatility of environment and competition?), the competencies required to use AI (What new competencies do entrepreneurs, employees and consultants need? How can they acquire these competencies?), the qualification needs (What needs do companies and consultants have?) and the qualification opportunities (What offers do companies and consultants already use and on what topics?).

The last-mentioned was also corroborated quantitatively and forms the third pillar. The task was to explore the existing training landscape to see for which target groups and for which contents offers of training and/or qualification already exist and how these are accessible and usable in each case for the target group of SMEs of the skilled crafts.

Results

The results reveal that the use of AI increases with the size of the company. In the long term, SMEs could be displaced by (larger) companies that are already addressing the issue and profiting from AI, e. g. in the form of optimized processes, more efficient workflows or (digital) business models that open new markets. So that SMEs of skilled crafts can also benefit from the advantages of the use of AI, the analysis has shown 5 clusters where knowledge building is important: (1) basic understanding of AI, (2) leadership and AI, (3) organization and AI, (4) safety and AI and (5) health and AI:

First fundamental knowledge and awareness about AI is necessary (e. g. practical examples, legal basics, ethics). There is both a knowledge gap and a transfer gap: On the one hand, there is a need for knowledge of what AI is and where it is already used. On the other hand, it also requires know-how on how existing applications can be used or adapted for operational processes in the context of SMEs. The current situation, with full order books and long lead times, also tends to promote the conservation of the status quo rather than focusing on the (business) future with innovation management activities. In addition, the coronavirus pandemic puts the focus more on securing the existence and less on promoting the future through innovation. As a conclusion, the company´s managers are in the need of outer counsel and expertise to bring AI actively into their businesses. Furthermore, many SMEs are already using AI applications without even realizing it. The next step requires leadership skills: The executives decides whether AI is to be used or not. Therefore, the advantages of using AI must be communicated and how the added value can be communicated to the employees. In addition, participation is essential, because without the co-determination of all involved, any change is difficult. The introduction of AI in companies also transform the fundamentals of the company organization itself: new areas of responsibilities arise, processes have to be questioned and redesigned, and communication structures could change. At the same time, employees might work more autonomously due to the availability of data. But to do so, data competencies are needed. Since the greatest obstacles to the use of AI lie in data security and data protection, knowledge is needed about how operational processes can be mapped in an AI, what data is relevant (data literacy), and how data can be protected and secured. In addition, AI must be considered in the context of change management, (digital) business models and customer journey issues. By a changing risk and stress situation due to the use of AI, health and safety topics must be also adjusted adequately. New forms of health prevention and safe ergonomic work with AI are needed. Therefore, the question must be addressed under which conditions the use of AI can lead to relief or to new stress factors.

Furthermore, methodological and personnel skills are also required, e. g. by promoting the willingness for lifelong learning, the acceptance of the technology and openness for new things within the environment of the specific structure of SMEs. Particularly in the areas of leadership, organization, safety and health, hardly any further training opportunities for SMEs exist. Therefore, the »KomKI«-project will translate these into a concrete low-threshold qualification offer based on learning nuggets developed specifically for the target group.

Robot design: What's Ahead for Services?

Doris Schartinger (AIT Austrian Institute of Technology, Austria)

Introduction

With the increasing of robotics in industry 4.0 expectations arise that social robots will also more and more become part of our physical and social environments. Generally, market expectations for social robotic markets are high, although technology and the design of robots still lag behind these expectations. Artificial intelligence and robotics are high on the agenda of the European Commission and many countries. The Proposal for a Preparatory Action for a FET Flagship on Robotics states "The issue is not if robots will enter our life, but who will design and deploy them first, who will set the science and technology agenda, and who will ensure they will benefit society." Furthermore, the expectation is that a new generation of robots and intelligent machines will significantly help addressing European challenges. "Future robots will have to understand, communicate, and safely blend with humans in unprecedented ways."

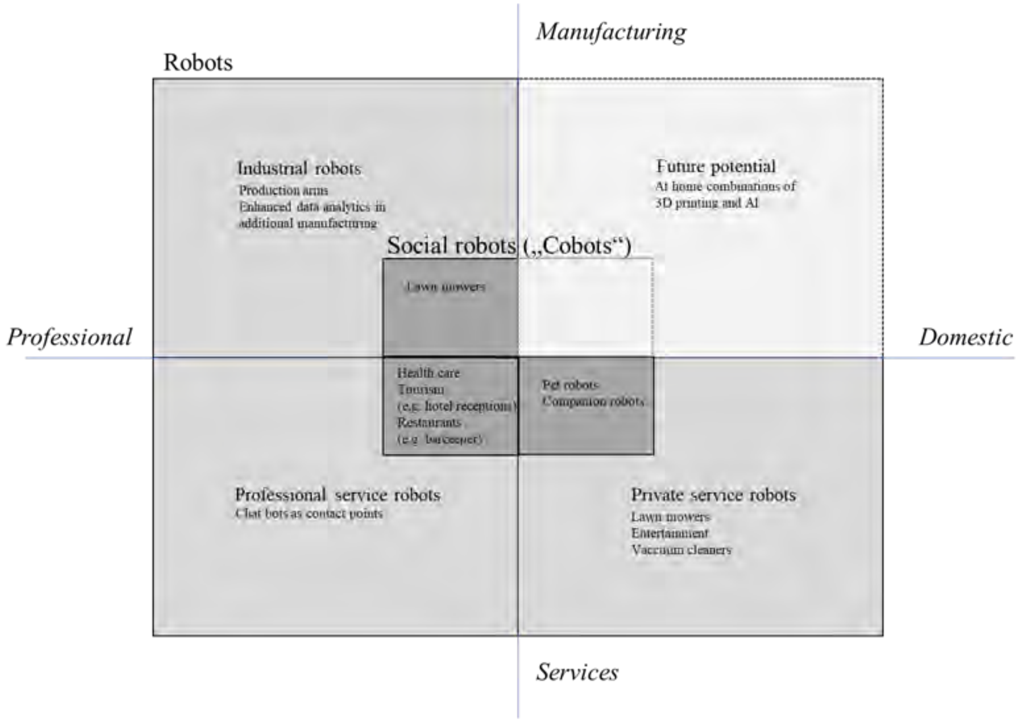
Importantly, for services there is a current understanding that Europe shows particular strengths in service robotics, especially professional service robotics (Cséfalvay 2021). There seems little systematic knowledge about the spread of social robots in the market. The International Federation of Robotics (IFR) provides accounts of the flow (installations, shipments) and stock of robots (robots in operation assuming an average service life of 12 years) on basis of their own market observations and cooperation with national robotics associations. They estimate the operational stock of industrial robots to be at 2,722,077 units (+12%) for 2019. After years of growth from 2014 to 2018, where annual installations increased by 11% on average each year (CAGR), there was a drop already in 2019. However, with the COVID-19 pandemic, IFR expects that after a major contraction in the short run, in the medium term, the crisis will create growth opportunities for the robotics industry worldwide. Compared to this, the market for professional service robots grew in 2019 by 32% to 173.000 units, strongest in the area of medical robotics. (International Federation of Robotics (IFR) 2020). Every 5th service robot supplier is a start-up. Data is scarcest on robots for private use. However, robots for vacuuming and cleaning seem to diffuse progressively. According to (Cséfalvay and Gkotsis 2020; Cséfalvay 2021), Europe is on top of service robot manufacturers in terms of numbers. There seems a widening scope of application areas, but still low diffusion and actual use.

On the research and innovation level, technological opportunities seem to vastly shape the debate in the area, but also a social science and economic perspective should contribute to the discourse on artificial intelligence (AI) and robotics. In sociology AI may be conceived as a social phenomenon and a non-human social actor (Mlynář, Alavi et al. 2018: 2; 8) which helps framing issues of steering the new technology in its processes of emerging and taking shape. In 2019, the European Commission has issued guidelines on trustworthy AI to guide the debate further.

Artificial intelligence can, but need not, be embedded in hardware devices like robots. "Artificial intelligence (AI) is understood broadly as systems and applications that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals" . A variety of definitions exists for the term "robot". The term origins from Czech language, "robota" which means "forced labour". It was first used in Karel Čapek's play 'Rossum's Universal Robots' (1920). A robot is "the physical manifestation of a system in our physical and social space" (as opposed to virtual characters or avatar-based interfaces) (Duffy 2003: 177). "A robot is typically a machine controlled by a computer that is used to act and perform jobs automatically. […] In our context, a robot is always designed to interact with the environment in a physical way."

Social robots are a sub-type of robots. Based on Floridi and Sanders (2004) and Dignum, Dignum et al. (2018) social robots are characterized by interactivity meaning they respond to a stimulus by a change of state, autonomy meaning they are able to change their state without stimulus, and adaptability meaning they are able to change the 'transition rules' by which their state is changed. Social robots start to diffuse more widely, in the industrial sphere, as well as in professional services and the domestic sphere (see Figure 1 below)

Figure 1: Types of robots. (Source: Author)



Design in general is inextricably bound to a product and market perspective, as the design of products decides on the customer experience, on his/her decision to purchase a product and on its use in everyday life. For domestic robots, the need for interactivity is the base line along which robots have to be developed and shaped. The aim of this paper is to provide a literature review on the current lines of debate in the design of social robots, the design rationales that exist in the literature and how these relate to an innovation economic perspective, i.e. to what we know about launching novel products in the market place.

The objectives of this paper are to first, identify the design rationales for social robots that underly the academic research around human-robot interaction, and second, to analyse what these design rationales imply for the market diffusion of social robots. The theoretical basis for this analysis is the perspective on diffusion of innovation put forward by Rogers (Rogers 1962; 2003). This is a conceptual paper based on a literature review.

The paper starts with a section on the design rationales behind robot designs (2). Then I will discuss these design rationales in the light of the concepts on co-production and co-creation in services, and (3) conclude with issues that seem to be critical for the diffusion of social robots in markets but need further research and attention.

Methodology

The analysis of design rationales is a meta-perspective on social robot design. It aims at uncarving the arguments and established research results behind social robot design. This requires several approaches for identifying relevant literature:

First, a systematic search in Scopus using the search strings "social robots"; "collaborative robots", "cobots" AND "design", "features", "interface" yields around 60 review articles. We separated those that rather focused on technicalities (e.g. types of sensors) and not on design features that are perceivable to customers and users of the product. Screening those that focus on the look and feel of social robots we explicity searched for multiply overlapping references, yielding early seminal articles like (DiSalvo, Gemperle et al. 2002; Duffy 2003; Fong, Nourbakhsh et al. 2003).

Second, some social robots have acquired fame. Pepper, Aibo, Paro, Sophia, Care-o-Bot, Kaspar etc have been designed with care and yield articles explaining and arguing their design features. Mostly, these articles use the names of these robots in relevant research articles, hence can be missed with the above search strings. This required individual search processes to identify related articles and add arguments.

Third, specific application areas, notably the Henn an hotel in Japan, specific health conditions (dementia, autism etc) analyse the implementation of social robots for specific tasks. Here the term "social" tends to be omitted because it is made obvious by the context of robot implementation. Again this requires individual search processes to add them to the literature review.

Robot design and design rationales

In terms of a clear-cut definition it is difficult to capture what design actually is. Bruce and Bessant (2002, cited from Moultrie and Livesey, 2014: 573) define design as "the purposive application of creativity to all activities necessary to bring ideas into use as a product (service) or process innovation." D'Ippolito (2014) argues that design is part of a problem-solving activity, starting with the perception of a gap in a user experience, developing a plan for a new artefact which results in the production of a better artefact. Charles Eames (1972, cited in Auger (2014: 21)) defines design as "*a plan to arrange elements to accomplish a particular purpose*".

Design refers to the physical appearance of a product, not to its function or operation. Design is concerned with how a product looks, whereas patents are concerned with how it works. However, functional design, as opposed to aesthetic design, means that the user should be able to use a product easily and mainly with intuition without necessarily understanding the operational architecture behind (Utterback, Vedin et al. 2006). So functional design is most relevant for robot design, even more so as robots are highly complex artefacts.

Understanding how the human-robot interface should be designed for what purposes is an important part of the discourse on human robot interaction (HRI), machine learning and artificial intelligence. Empirical methods applied are artefact analysis, which is a method in design processes that allows to think systematically about design features of technologically complex products. In a technologically complex product different features interact with each other, so designers study how the different features are used in practice to develop an optimal design for interaction (Lee, Šabanović et al. 2016). Further methods are laboratory experiments (Goetz, Kiesler et al. 2003), exploratory observation, in order to reveal new perspectives and user-centered research design (Lee, Šabanović et al. 2016).

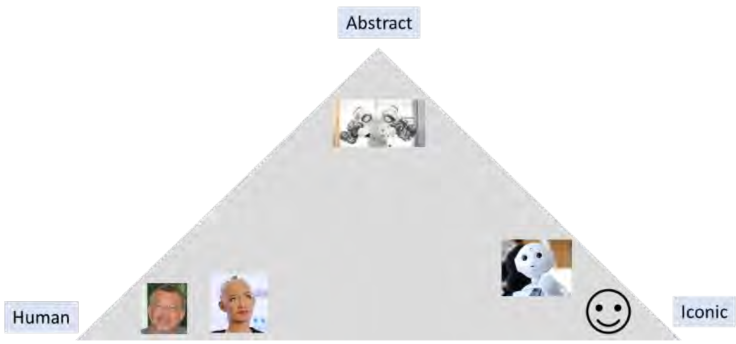
With respect to social robot design, *anthropomorphism*[1] plays a huge role. In line with Fong, Nourbakhsh et al. (2003) and Lee, Šabanović et al. (2016) this means designing inanimate objects with a tendency to add human characteristics to their appearance, thereby strengthening the interpretation on part of the user that the object/robot be a *rational agent who governs its "choice" of "action" by a "consideration" of its "beliefs" and desires"* (Duffy 2003: 180). In the literature anthropomorphism is defined along with *humanlikeness*, i.e. as having "*a structure similar to that of a human body*" (Lee, Šabanović et al. 2016: 136). Some go even further arguing anthropomorphism is reflected in the robot's shapes (*appearance*), behavior (*facial expressions*, *gestures, motions*) and interaction (e.g. *modality*) (Fink 2012).

There is a plethora of typologies of social robot designs, particularly to define the morphological impression of the robots. Fong, Nourbakhsh et al. (2003) define four categories of social robots: 1. Anthropomorphic

[1] From Greek: Anthropos (man, human), morphe (form, shape)

robots are viewed as close to human form and are more likely to be perceived as having humanlike characteristics (e.g. Kaspar). However, an additional distinction can be made within this category between *android* robots (highly resembling a human being, e.g. Sophia) and *humanoid* form (rough human resemblance) (Lee, Šabanović et al. 2016) 2. Zoomorphic robots resemble living creatures other than humans (animals, e.g. seals). 3. Caricatured robots show simplified or exaggerated traits, in a similar way as animated characters do. 4. Functional robots are of highly variable form designed for the tasks they are supposed to carry out. In social robotics these robots can e.g. have a tray instead of arms for service robots. Goetz, Kiesler et al. (2003) distinguish between human, midstage and machine, very much in line with Bartneck and Forlizzi (2004) who apply the categories of abstract, biomorphic and anthropomorphic.

Figure 1: Design space of anthropomorphic features. ***Based on McCloud (1993). Sources for images: Shutterstock, private.***



Design rationales are frameworks to categorize the design features idiosyncratic to artefacts, here robots. Smooth human-robot-interaction (HRI) is not taken for granted. There is a vast stream of research that dedicates resources to matching robot appearance (i.e. *design*) to the tasks the robot is supposed to carry out in order to enhance human-robot-interaction. Social robots can be used as personal service robots (Goetz, Kiesler et al. 2003), robots in the art scene, on stage (Oh and Park 2014), or for learning therapies (Vélez, Gallegos et al. 2013) and elderly care (Parlitz, Hägele et al. 2008).

It is a stylized fact in the area that "*a robot's appearance and behavior provide cues to the robot's abilities and propensities*" (Goetz, Kiesler et al. 2003: 55) *Humanlikeness* is at the centre of much debate on robot design, on the one hand a certain degree of humanlikeness is seen as a crucial feature to make robots user-friendly (Lee, Šabanović et al. 2016), on the other hand researchers have different ideas about the optimal degree of humanlikeness.

Similarity rationale

Fink (2012), based on Kiesler and Goetz (2002) observes that findings suggest that people tend to apply richer mental models to robots with anthropomorphic design as opposed to more abstract ones. Earlier, Sears (1983) proposed a "person-positivity bias" which means that *[attitude] objects* are judged the better if they resemble human beings. Perceived similarity has an impact on sympathy and liking, whereas impersonal versions of the [attitude] objects were evaluated less favorably.

Partial humanlikeness rationale

Partial humanlikeness is a notion opposed to total humanlikeness. Lee, Šabanović et al. (2016) found in their research based on user-centered exploration that participants did not so much focus on the humanlikeness of the robot as a whole, but were focused on particular features of the robot. "Participants identified humanlike features in various parts of the robots, […but these] were different for each robot." (ibid. 137) Humanlikeness was attached to the body shape, clothes, a single eye, hands, fingers, gestures. Particular attention is generally paid to robots' faces, and within the face to the robots' eyes. Earlier research on robots' eyes (DiSalvo, Gemperle et al. 2002) is confirmed in that the width between eyes is of particular importance for the perceived humanlikeness of robots.

This is of importance in combination with another stream of research that studies the influence of certain features on the perception of persons in social interaction. In order to perceive a person as intelligent, attractiveness is an important feature as long as visual appearance dominates the impression. As soon as acoustics are added to the perception of a person, the voice/wording becomes dominant (Alicke, Smith et al. 1986; Borkenau and Liebler 1993 in: Duffy (2003)). This research was repeated for robots by Kiesler and Goetz (2002). This impacts on the design of robots because it shows what features govern the perception of robots in social interaction and how this can be successfully exploited (Duffy 2003).

Context dependent design rationale

Users' perception of humanlike appearance is closely connected to social meanings of the robots' tasks. Gender, race and the related role of robots do influence users' interpretation and acceptance. "It was not important how similar the robot is to human, but what the meaning of its humanlike appearance implies to users." (Lee, Šabanović et al. 2016: 139) Participants project their social models on to the robot and term them accordingly as "scientist", "housemaid", "butler" or "astronaut". These social models have been formed through past experiences, learning, reflection which in turn has resulted in contextual meaning of robots' design features. This is illustrated by participants' comments in a laboratory experiment:

"To me, if he were selling cosmetics, "she" would be better. But, if he is selling all kinds of things like mechanics, then I think the male would be better. The reason is because we are just used to that." (*Lee, Šabanović et al. 2016: p139*)

The uncanny valley

One of the earliest and most widely cited articles on robot design is Mashiro Mori's theory of The Uncanny Valley (Mori 1970). He proposes that human acceptance of robots does not increase in a linear way with humanlikeness. As a robot's appearance comes close to humanlikeness, acceptance and familiarity of the robot at first increases in a linear way. But once it has passed a point where it comes already very close to humanlikeness but is still not 100% similar to humans, acceptance drops dramatically and people feel uncomfortable (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). The explanation for this lies in the increased expectation that goes along with rising humanlikeness. The surprise about the non-humanness is then sudden and results in non-acceptance.

Projection rationale

Projection is a well-known concept from social psychology. In its simplest form, it refers to seeing one's own emotions, affections, desires and impulses in other people. Based on Freud, projection is seen as a mechanism of self-defense. However, in a more popular meaning it may be regarded more as a cognitive bias than a defense mechanism (Baumeister, Dale et al. 1998). In applying degrees of anthropomorphism in robots, it will be more likely that users project their traits or their interpretations of reality on robots, in a similar way as this happens with pets. Thellman, Silvervarg et al. (2017) show in their study that people rely on folk-psychological interpretations and judge humans and robots similarly in terms of ascribing intentionality, and in explaining and arguing behavior.

Projection plays a particular role for robots that simulate human intelligence. Simulation of human intelligence is opposed to duplication of human brain activities with all its functions, emotions and consciousness in merely giving an illusion of all these brain activities. This means the robot is designed in a way and provides signals that are normally connoted with being the outcome of brain activities (i.e. with being intelligent), and the perception of intelligence is fundamentally a projection on part of the user (see also Duffy 2003).

For robot design this implies there are design aspects relevant because they help mimicking intelligence where there is actually a lack of understanding (see also on perception biases). But also the reverse is true, a different set of cues might support the projection of mental inferiority, indeed covering up augmented functionality on part of the robot that the user is unaware of.

Functional design and interface rationale (interaction)

Human-robot interaction is seen as the fundamental reason why anthropomorphism is employed in robots. Human-like qualities manifest in form or behavior, or in both (Duffy 2003). Robot appearance is an interface, people should remain largely unconscious of the technology underneath, but steer the technology through (social) behavior. With this there is less learning effort is necessary on part of the user (Goetz, Kiesler et al. 2003; Fink 2012), indeed the user is induced to not realise the existence of an interface and to just act as in human-human interaction. Especially non-technical users (Blow, Dautenhahn et al. 2006) do not engage in mental processing but simply apply stereotypes and heuristics to it (Fink 2012). With humanlike appearance and qualities, robots fit more easily into social expectations and past social experiences of users. People make sense of robots in the same or similar way as they make sense of other humans (Vélez, Gallegos et al. 2013) they even "mindlessly respond to computers according to social rules and expectations" (Nass and Moon 2000).

Environmental rationale

If integrated into our physical and social environments, it is often assumed that the humanoid form for robots is best able to technically cope with these physical and social environments, i.e. using our tools like stairs, cars, etc. Here, the human shape is popularly assumed to be of general-purpose functionality. Degrees of humanlikeness take advantage of the physical infrastructure available and hence facilitate assisting humans (Duffy 2003). However, as it is still extremely difficult to design robots capable of e.g. grasping a cup with the current form of handle, we may think in the future of rather designing the environment to fit for robots, than robots to imitate humanlikeness to fit for human environment (e.g. magnetic cup handles) (Auger 2014). Although this may sound weird now, it has of course happened in the past with other technologies, most notably with road infrastructure for cars.

Product-ness rationale

DiSalvo, Gemperle et al. (2002) suggest for social robots to retain a certain amount of product-ness in their design, so that users still feel comfortable with them. In order to get an understanding what is meant by this we could complement it with the observation by Auger (2014) of "neediness": A needy robot is extremely smart, but trapped in an underdeveloped body and hence needs its user to move it around. Although this may be extreme, it makes sense to design a certain amount of neediness into very smart objects in order to evoke a sense of control on part of the user.

Augmented functionality rationale

With the technological opportunities to implement augmented functions in robots, they are also bound to take other shapes beyond humanlikeness and human asthetics, i.e. those shapes and forms that best serve added functions. Examples are Geiger counters, infra-red cameras, a robot handshake that measures blood pressure through sensors, radar, sonar or bio-sensors (Duffy 2003).

Upending the uncanny valley rationale

For the various reasons mentioned above "the role of anthropomorphism in robotics in general should not be to build a synthetic human." (Duffy 2003: 181). Still, Hanson Robotics Ltd presented the robot Sophia in 2015. It has a very realistic face with over 50 facial expressions (Weller 2017). According to an article "Upending the uncanny valley" which the CEO of Hanson Robotics Ltd published in 2005 the rationale for realistic robots is that these are an underexplored topic in robotics and they could be an art form.

Design of robots and the concept of co-production

What do these design rationales mean for service co-production?

Co-production is an essential feature of services and reflects the involvement of customers in the service provision process. The parallel production and consumption of services is one of its hallmark features.(Lovelock and Young 1979; Mills and Morris 1986) Voorberg, Bekkers et al. (2015) distinguish co-production from co-creation in placing co-production at the implantation stages of services, whereas co-creation is placed at the more strategic levels of co-initiating or co-designing a new service. (Brandsen and Honingh 2018; Lember, Brandsen et al. 2019)

Co-production is a term that has always been reserved to human-to-human interaction, so a first area of debate will be if it should also be applied to human-machine interaction. Lember, Brandsen et al. (2019) argue that "it can be, if people perceive it as such." (p1673) Co-producing with robots can on the positive side mean more personalized and/or more entertaining solution, or the opposite, in being less personal and pre-structured by an engineering mentality that leaves little room for users and becomes boring in repeated interaction. (Lember 2018). Co-production is the service theory perspective, the robot developer community uses the term human-robot-interaction (HRI).

Co- production and relative advantage. First, a clear relative advantage of innovative products helps their diffusion compared to their competing products or existing ways of doing things. At present, relative advantages of robots for services are still unclear – which also relates to their design: In order for robots to diffuse as e.g. personal service robots they have to be affordable (in purchase as well as in use) and comfortable to use. On top of the white goods (washing machines et) that households have already to save labour, robots need a mechanically complex design. The environmental rationale suggests that in order to cope with our physical surroundings and do difficult tasks like emptying the dishwasher or climbing stairs robots need a certain degree of humanlikeness which may be hardly compatible with cost-effectiveness or affordability. Apparently, this is still a long way for research (Auger 2014). When this is achieved, energy intensity will most probably be an issue too. At the current state-of-the-art, robotics is intrinsically energy intensive. (Pellicciari, Avotins et al. 2015). All this points to robots as personal assistants - once they will be available - will first be affordable only for the rather affluent parts of society.

Co-production and compatibility with values. Study participants often expect robots to be adapted to "current social and cultural norms of gendered roles" (Lee, Šabanović et al. 2016: p139). Hairdressers have to be female, technicians male etc. Hence, the context-dependent design rationale indicates that users' perception of humanlike appearance is closely connected to social meanings of the robots' tasks. Associated gender, race, shape of corpus, etc and the related role of robots do influence users' interpretation and acceptance, and are thus likely to influence co-production. However, obeying users' expectations here would mean to prolong these current social and cultural norms where the societal debate often goes in the direction of becoming aware of boundaries and opening them up. Seamless integration into some contexts then means prolonging stereotypes as dissociation from these contexts may result in non-acceptance of robots.

The current literature seems vague on how to handle the balance of succumbing to stereotypes in exchange for social acceptability of robots. Lee et al. (2016: 140) conclude that enlarging the role of expected users in robot design is a fruitful pathway of robot research. They suggest "[t]he starting point of social robot design should therefore be understanding the contextual meaning of design."

Co-production and complexity. Robots are certainly complex products in terms of the numbers of their components, the number of design variants, the elaborateness of system architectures, the range, and depth of knowledge and skill inputs required to develop and produce them, and the variety of materials (Hobday 2000). On the other hand, the interface rationale suggests that exactly this complexity shall be invisible to the lay user through designing a humanlike interface. This can have several effects on co-production:

First, the interface rationale related to a complex product may induce customers to over-trust or under-reliance of robots in critical situations with serious consequences. Both are errors; over-trust occurs when autonomous machines are allowed to operate too freely (self-directed) in situations that surmount their capabilities

(Bradshaw, Hoffman et al. 2013). This was already discussed early in the robot literature (see e.g Foner 1993). Duffy (2003: 178) states that "people's expectations based on strong anthropomorphic paradigms in HCI overly increase a user's expectations of the system's performance." This implies that a flawed design concept of social robots can have serious consequences because it results in overly optimistic expectations regarding its actual capabilities on part of the user (Ullrich and Diefenbach 2017). In turn, under-reliance occurs when machines are prevented from realizing a task or handling a situation although they are sufficiently equipped and competent. For both, over-trust and under-reliance it needs more insights on the effects of properties of robots on HCI in order to derive specific design solutions (Bradshaw, Hoffman et al. 2013; Ullrich and Diefenbach 2017).

Second, complexity is also associated with privacy issues. How a robot is designed influences our way to interact (see interface rationale, projection rationale, similarity rationale etc) and it also influences what we disclose about our self in the course of the interaction. The Johari window is a model of self-disclosure by Luft and Ingham (1961) that argues that there are parts of ourselves that are either not known by us, but known to others as well as parts that are known to us, but that we want to hide from others. The Johari- window is dynamic in nature (Nair and Naik 2010), which means what we disclose or hide consciously or unconsciously changes according to our communication partners. This has of course serious implications, especially if the robot is part of a wider system architecture. Ethics and privacy issues in the area will always be very strong arguments for public funded research and government regulation in the area of social robotics.

Third, another aspect comes from the implementation of complex technologies in healthcare services: we know from wider technological solutions (Peek, Luijkx et al. 2016; Tsertsidis, Kolkowska et al. 2019) that fear of technical problems, false alarms etc associated with complex products of course cause resistance in the pre-implementation phase of a technology. This can potentially remain even if product complexity is disguised by a human-like appearance.

Co-production and repetition. What will be extremely important is to try HRI (human robot interaction) not only in shortterm laboratory settings, but in real-time, real world, longterm and repeated HRI contexts. The length of interaction in HRI design studies seems a weakness. Research introducing users to evaluate robot design features are often vague about the length of time the users actually do interact with the robot. However, this is of course a crucial point. Design features that are new and acceptable for a short time need not be so in a lengthy period of interaction or in repeated interaction in a real context. Already Fink (2012: 204) observe that it is still a challenge to design human social characteristics in robots and "most systems can only be operated in shorttime interaction […] ". Tsertsidis, Kolkowska et al. (2019) still find longitudinal studies amiss that study the acceptance of the same technology over time.

Conclusions

This paper explores social robotics as an emerging technology that has not developed a dominant design yet but is in the process of orientation between a number of design rationales, user/societal expectations and newly upcoming ethical and legal questions of robots entering markets.

From a service theoretical point of view the whole debate around robots and services follows a good-dominant logic. It is unclear until present how much choice will and can be given to customers to adapt bundles of services to their needs and actually define elements of services themselves.

Although some of the design rationales provide concrete suggestions, for many questions there are no uniform answers. The UK Engineering and Physical Sciences Research Council (EPSRC) states that robots should never be designed in a deceptive way to exploit vulnerable users; instead their machine nature should be always obvious (Bryson 2017). Many issues of importance in finding design solutions for robots need further research. Some issues of importance should intrinsically be part of robot research:

Ethical design. Robotics is a field that has to build axes across scientific disciplines and a variety of competences and across various organisations, also for the design of robots. Programmers, engineers, material scientists, lawyers, social scientists, designers, and philosophers , are needed to design robots, additionally people that are supposed to co-work with robots like doctors and nurses in healthcare, psychologists, private persons in their domestic contexts, and of course firms as they will be the suppliers.

What causes additional difficulty is that the above described interdisciplinarity will not suffice for ethical design. As Bradshaw, Hoffman et al. (2013) observe, a robot might perform excellently and without supervision in situations and contexts within its designated space of performance. This designated space of performance, however, is in itself an echo of the designers' mental map/ construction and embedded assumptions/ goals, capabilities, resource constraints etc. The aim is therefore to build design not only on a handful responsibles' mental maps and resource constraints, but socially acceptable results for autonomous systems and their associated appearance should be based on even more inclusive processes, i.e. larger groups that develop shared views or tap the wisdom of crowds on ethical questions and moral acceptability of more complex issues (Dignum, Dignum et al. 2018).

Many countries at the moment state they intend to be a frontrunner in AI and robotics and devise AI strategies for their countries. Europe follows a responsible research and innovation approach (RRI) and initiates inclusive research, spurs public debate and consultation of experts and devises Ethics Guidelines for Trustworthy Artificial Intelligence (AI) . Europe has the twofold ambition of shaping the debate ethically and being on the very edge of the research frontier.

Ecological questions of design: The durability or longevity of robots as goods will be crucial, once they enter markets and private homes. Considering the size of many robots, waste from electrical and electronic equipment (WEEE) is likely to rise remarkably. Considering that WEEE is one of the fastest growing waste streams in the EU anyway, growing at 3-5 % per year , this would be even more of a problem with robots becoming a widely used product. Design for durability, easy repair and reuse will be of extreme importance. Furthermore, the recycling of robots should offer substantial opportunities in terms of making secondary raw materials available on the market.

The focus of robot design is now on autonomy and how to design the HRI works effectively. There does not seem to be awareness that robots should be designed to have a long life (durability) and to need a low amount of consumables and energy. In the technology and utility driven perspective, only obvious elements of design are considered like form, function, ergonomics and materials. What designers consider as well, idiosyncrasies of the intended users, and the fluctuations of fashions and trends (Auger 2014) is less reflected until now, but may play a huge role in the acceptance of robots in the future and on the length of their life cycle.

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Inclusion on delivery: Development of a digital assistance system for delivery drivers with handicap

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Objective

Route planning systems deployed in the logistics industry rarely take into account the drivers' individual needs and requirements. Instead of that, the efficient determination of the shortest or fastest route in complex road networks is in the focus of efforts (cf. Geisberger et al. 2012; Grünert & Irnich 2005). The mathematical models developed for route planning tasks consider various framework requirements, e. g. which vehicles, products, and repositories exist, how time frames for delivery are assigned and if delivery goods are only distributed or collected after usage as well (Golden, Raghavan & Wasil 2008; Toth & Vigo 2014).

In contrast, the research project InkluServ develops an assistance system for delivery drivers with mental handicap, which takes into account the employees' individual abilities and special needs (cf. Engels 2016). The delivery drivers deliver goods from a supermarket and a café, both operated by the sheltered workshop WEK Werkstätten Esslingen-Kirchheim at Plochingen/Stuttgart, Germany. For delivery in the surrounding urban districts, the drivers use a cargo e-bike (Figure 1).

Figure 1: Digital assistance system to support delivery of goods from an inclusive supermarket and café by drivers with mental handicap.

As the delivery drivers are not in the field of care of their sheltered workshop during delivery, four modules of the assistance systems provide for their safety during the delivery tour:

1) The route planning module not only calculates the shortest route for delivery to one or more customer addresses, but takes into account drivers' characteristics like physical fitness, mental capacity and social interaction skills.
2) The navigation module offers an accessible surface and directs the drivers on predefined, safe ways.

3) The support module contains an accessible visualization of the delivery stations, offers a help menu for standard and brakedown situations, and allows for an instant video call with a supervisor at the sheltered workshop.
4) The accessible webshop module provides order data (e. g., weight of goods, details for delivery at the customer's site relevant for handicapped people) to be processed for route planning, and allows for taking follow-up orders at the door of the customer.

The first three modules listed above are based upon the tour planning system "transIT" provided by the project partner GTS Systems and Consulting. The pad with the implemented assistance system can be mounted either at the cargo e-bike,

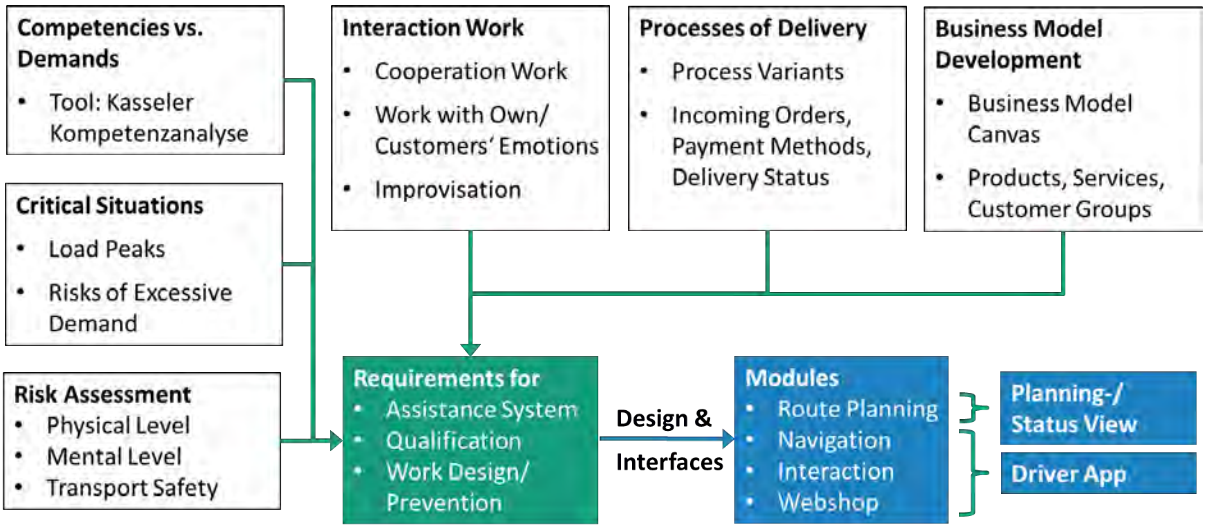
at a delivery car (for those handicapped drivers owning a driver's licence), or at a handcart (for those employees who are not able to perform delivery by e-bike yet, but can deliver over short-distance by foot).

Methodology

Requirements Analysis

As the delivery of goods is a new business model for the sheltered workshop WEK, it is necessary to integrate the requirements for the assistance system from multiple perspectives (cf. Ebke & Däuble 2015; Fisseler & Bühler 2018) (Figure 2).

Figure 2; Sources for requirements analysis and levels of implementation for the assistance system.



Starting point of the Requirements Analysis is the evaluation of present and additionally required competences, which has been conducted by means of the Kasseler Kompetenz-Analyse (Klammer & Alberding 2011). This instrument is used by WEK to assign new employees with handicap to those jobs most appropriate to their abilities. In the InkluServ project, the competencies most relevant for the delivery process were used to deduce critical incidents, resulting from situations of the delivery process where the requirements of the delivery exceed a persons' competencies. Aiming at the critical incidents identified, preventive measures were formulated and integrated in the delivery-related risk assessment.

At the sub-levels of interaction work, certain requirements from a) cooperation work, b) work with own emotions, c) work with customer's emotions and d) improvisation (Böhle, Stöger & Weihrich 2015; Nerdinger 2012) have been identified as success factors for delivery drivers with disabilities. For example, some employees with mental disabilities tend to show their emotions more openly and intensely to customers, which can lead to a positive perception of authenticity on behalf of the customer, but also to a negative reaction due to emotional overload. Besides, the professional handling of varying customers' moods may be limited, although some employees with mental disabilities possess a high degree of empathy. Moreover, this group of employees tends to rather *stick to rules* than *improvise* in unknown situations, which are both typical requirements for interaction work. This leads to possible advantages for handicapped delivery drivers in terms of process quality, but also to possible disadvantages in uncertain situations, e. g. when the expectations of the customer are not clear.

The last two areas of the requirements analysis apply to details from the process modelling at the one hand, including process variants for different channels of ordering (webshop, phone, on-site in the supermarket/café, at the customer's door) and payment methods (cash, online payment, payment before/after delivery). At the other hand, methods of business modelling were conducted, including the analysis of most appropriate customer groups, products and services, marketing channels, competitors and unique selling propositions related to delivery.

Results

Below, the planned project results are depicted. The final implementation is planned until July 2022.

Individualized Route Planning

In order to ensure safety for the handicapped drivers during delivery, route planning parameters are used as constraints to prevent overload for the drivers (Table 1).

Table 1 Restrictive parameters of the assistance system in relation to drivers' individual characteristics.

Drivers' Individual Characteristics	Restrictive Parameters of Assistance System
Physical Fitness • Biking fitness • Lifting and carrying capacity	• Range of delivery route (kilometers) • Degree of inclination or decline • Weight of goods • Distance for carrying goods from bike to customers' door • Floors in buildings without lift
Mental Capacity • Multitasking-capacity in traffic • Alignment of navigation display and real environment • Ability to cope with excessive (traffic) noise • Ability to conduct interaction work	• Main road/ side road/ bicycle track/ field path • Number of crossroads per street • Number of supplied customers per tour/ day
Roadworthiness • Knowledge/application of traffic regulations • Comprehension of traffic situations • Anticipatory driving • Mastering of cargo e-bike	• Authorization for vehicle: Cargo e-Bike/ motorcar/ hand cart • Authorization for delivery in surrounding neighbourhood/ all urban districts
Mastered Speed with Cargo e-Bike	• Warning signal for driver, e. g. from 5/ 10/ 15 km/hour
Escort necessary	• Availability of second/ higher/ lower performing co-driver
Interaction Work Skills • Resilience to social stress • Problem solving capability	• Authorization for delivery to new customers
Incompatibility between driver and customer	• Communication problems, pets, rooms, other

General constraints aim at avoiding possibly dangerous routes, such as passages which exhibit a high intensity of traffic or construction sites. Relative constraints lower the chance for the delivery driver to ride along difficult ways, e. g. those exceeding a certain degree of inclination or decline: The greater the inclination or decline, the lower is the chance that the relevant route section is recommended by the system. These functions are based on publicly available route data from OpenStreetMap. Moreover, warning notices are displayed to driver and scheduler in case the driver leaves a predefined delivery radius or does not move during a tour for a time much longer as planned.

Additionally, individualized restrictions of tour planning parameters take into account the specific characteristics of drivers with disabilities and result in tailored tour designs. E. g. certain drivers will receive only tours with a single customer address (instead of several addresses), in order to reduce the physical and mental impact and allow for the supervisors to check the drivers' well-being after each tour. In other cases, drivers who need attendance when conducting deliveries will only get tours assigned when a second co-driver is available. Depending on the customer's address, driver's will get only those tours matching with their personal authorization of delivery area, e. g. only the surrounding urban district, elsewise additional districts located more distant.

Accessible Navigation

To guide the drivers with mental disabilities towards their customers, a specialized navigation view for handicapped drivers is developed (Figure 3). It shows a minimized range of information to prevent mental overload while navigating in road traffic, and follows the guidelines for accessible software design, such as for suitable colours, contrasts, and simple language.

Figure 3: Accessible navigation display included in driver app (example from test layouts).

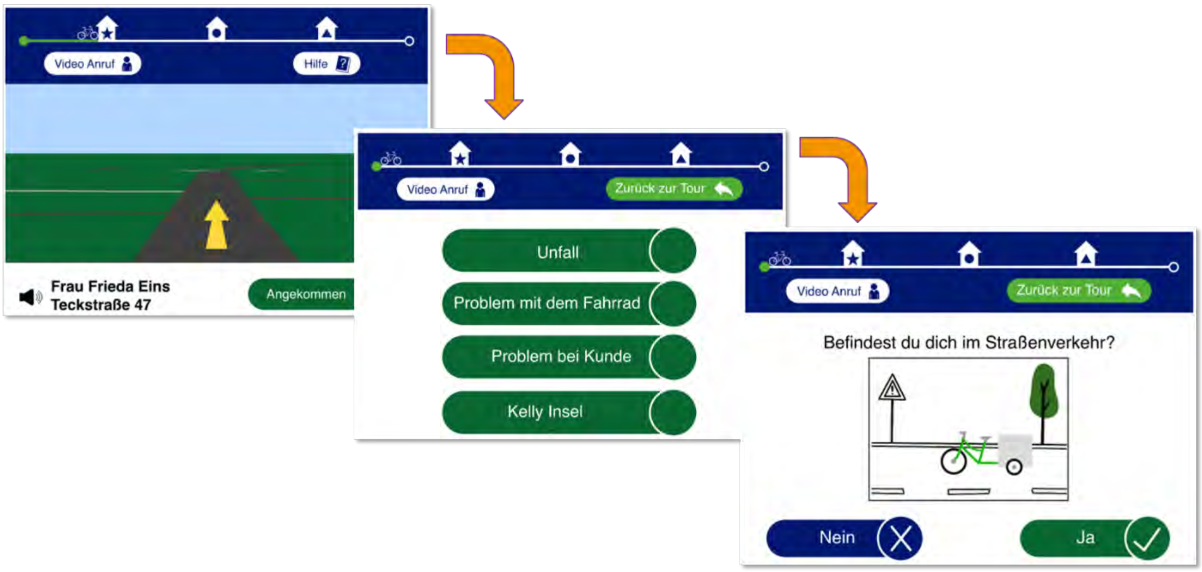
The navigation view and the other views of the assistance system are tested iteratively with the future delivery drivers, in order to ensure that the special needs of employees with mental handicap are served.

Delivery Guidance

The driver app menu guides the driver through the delivery process. At the top of the view, building icons are displayed representing the customers to be supplied. After having reached a customer, the view changes from navigation to on-site mode and offers information about how to find the customer's door (point of transfer) and where to find alternative repositories in case the customer is not present. The driver then enters the new delivery status (delivered, placed in repository, customer complaint, or not delivered for other reasons).

Additionally, a help menu offers support for particular situations (Figure 4). In case of accident, breakdown, problems with the customer and distress, information is displayed and the option to initiate a video call with a supervisor is provided. The displayed text can be read aloud by voice output, optionally.

Figure 4: Help menu included in driver app (example from test layouts).



To support the drivers' interaction with the customer, standard sentences for greeting, asking, explanation and problem solving can be displayed or read aloud, respectively. Also, the nearest safe place (Kelly Inseln or WEK sites placed throughout the delivery area) can be chosen as new destination.

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Defusing Psychosocial Risks: Development of a Detection System

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Introduction

In Europe, psychosocial risks (PSR) at work have been the subject of several important policy initiatives in recent years. These risks are significant for the service company as they directly impact employees with consequences in terms of demotivation, poor performance or turnover, for example, and ultimately increase customer dissatisfaction and thus affect service quality. Numerous research studies have proposed different scales to measure different manifestations of PSR, such as stress or job dissatisfaction. Taking all these measures into account is an insurmountable task for a company. In order to manage these risks with a simplified process, we identified and listed the items of the main questionnaires for the assessment of stress, burnout, turnover, job satisfaction and commitment. We first eliminated redundant items, and then identified and validated the dimensions to be retained. We propose here a four-dimensional model obtained through statistical modelling on a sample of 831 people.

Purpose of Research

According to Enterprise Risk Management (ERM), risk is that which prevents the achievement of an economic objective. In business, people-related risk should be considered as a risk related to the management of organizations and not only as a medical problem related to the individual. Stress, presenteeism, burnout, conflict and turnover are examples of risks affecting organizations and individuals. They are often referred as psychosocial risks (PSR), defined as "risks to mental, physical and social health, generated by employment conditions, organizational and relational factors likely to interact with the mental functioning of individuals" (Gollac & Bodier, 2011).

In other words, working in a stressful environment increases the risk of suffering of physical illness and/or psychological distress (Clarke; Cooper, 2004). In practice, psychosocial risks are described by terms such as: burnout, poor performance, deterioration in the quality of work, negative stress, illness, staff turnover, etc. (INRS, 2006; Brun, 2007; Charini, 2012). In Europe, at the political level, a more restrictive legal framework is invoked to ensure a quality environment for workers. In this extend, the best-known ERM standards are COSO ERM and ISO 31000 and include all kinds of risk categories. However, no category specifically focuses on human-related risk as a business risk. At the same level, companies are not able to effectively fight a toxic environment and its adverse effects if they do not have the right tools. Indeed, strategic decisions are the responsibility of top management (Elbanna, 2006), and human resources must be considered strategic (Noe et al. 2017). In a research conducted in Switzerland (Jenny et al., 2011) involving over 5,000 employees, a human risk management process improved performance, maintained or improved health of workers, reduced absenteeism, and improved economic gains for companies.

The objective of this research is to create a systematic, efficient and ergonomic data collection system to identify the employment conditions and factors, which may interact negatively with the individual, with the aim of preventing and/or mitigating them.

Review of the literature

The workplace has undergone a multitude of changes in recent years, bringing new health risks (European Agency for Safety and Health at Work, 2007). Technology and social developments have influenced the relationship between people and their work, in order that managing psychosocial risks in the workplace has become an increasing challenge (Jain, Leka & Zwetsloot, 2011). Among the numerous researches in the field, we will mention three reference models: the Job Demand Control (JDC) model (Karasek, 1979), the Effort-Reward Imbalance (Siegrist, Siegrist & Weber, 1986) and Maslach's Burnout Inventory (Maslach & Jackson, 1981). All of these models are the basis for questionnaires that are often used to conduct field studies related to work experience.

In Karasek's (1979) model, also known as the demand-autonomy model, it is assumed that a work context characterized by a combination of low decision-making autonomy and high psychological demand increases the risk of developing a physical or mental health problem. More specifically, psychological demand is the amount of work to be done, the time constraints associated with this work and the mental demands. Decision autonomy refers to the ability of the worker to have control over the tasks the employee has to perform but also the possibility to develop his/her skills. Further research added social support as a third component of the model by creating the Job Demands-Control-Support Model (JDCS) (Johnson & Hall, 1988; Karasek & Theorell, 1990). In general, it reflects the interactions experienced at work, with colleagues and hierarchy. Social support thus acts, when present, as a modulator of tension at work. In other words, in case of difficulty, social support can help the person by giving him/her the feeling of being supported, or on the contrary, it can aggravate the situation with a feeling of abandonment from colleagues/leaders.

Siegrist's model (Siegrist, Siegrist, & Weber, 1986), also known as the effort-reward imbalance model, is based on the assumption that a combination of high effort and low reward could lead to the development of pathological reactions, both physiologically and emotionally. The high effort variable can come from two sources: external and internal. The external source includes high demands at work, such as having a lot of responsibility or being interrupted frequently. Alternatively, it may be intrinsic effort that reflects attitudes in motivation for excessive commitment to work. With regard to the latter, one can explain the sense of duty, the need to excel or the self-rewarding experience of meeting challenges or mastering a situation. If low rewards such as unsatisfactory pay, lack of esteem and respect at work and low job security are present in conjunction with high effort, then the person may be facing a risky situation.

Burnout in the Maslach Burnout Inventory (MBI) model (Maslach & Jackson, 1981) is defined as a psychological syndrome of exhaustion, cynicism, and ineffectiveness, experienced in response to chronic stressors. Of the three components of burnout, exhaustion represents the individual and personal experience. It refers to a personal sense of being overwhelmed and exhausted in both emotional and physical resources. The cynicism component represents the interpersonal context of burnout. Refers to responses to various work situations that are insensitive or excessively detached. According to this theory, cynicism develops in response to burnout overload, and is a way of protecting oneself by using an emotional "buffer. The risk of this detachment results in the loss of idealism and dehumanization of others and is in part an immediate reaction to exhaustion. The third component, ineffectiveness, represents the self-evaluation dimension of burnout. It refers to feelings of incompetence and lack of achievement and productivity at work. The MBI attempts to account for the criteria for burnout, but does not allow for the assessment of the multiple work stressors that contribute to burnout. For this reason, Leiter & Maslach (2003) have extended the theory by formulating a model that focuses on the degree of balance between an individual and six domains of their work environment. These six domains are: workload, control, reward, community, fairness and value.

Methodology

Identification of relevant dimensions

On the basis of the three reference questionnaires (see literature review) complemented by other highly cited works (e.g. Morgeson & Humphrey, 2006; Cohen et al. 1983; Diener et al. 1985, Schaufeli, Bakker & Salanova. 2006) we identified and retained 195 relevant items. These items were then synthesized using a Delphi procedure with eight experts. The result consists of sixteen dimensions grouping these items: (1) Organization of work, (2) Decision-making or initiative, (3) Variety of tasks, (4) Material resources, (5) Workload, (6) Matching tasks and skills, (7) Meaning of work, (8) Recognition, (9) Fair treatment, (10) Job security, (11) Separation of private and professional life, (12) Team atmosphere, (13) Support from the hierarchy, (14) External relations, (15) Attention to the employee's well-being from the hierarchy, (16) Cooperation with team members.

We combined these dimensions into a new short questionnaire to ask people about their job satisfaction incorporating these sixteen components.

Construction of the questionnaire

The questionnaire was made of 32 questions which evaluated job conditions, organizational and relational factors at the workplace. We measured employees' general attitude toward their work environment and their overall satisfaction with their job. The core of the questionnaire assessed the sixteen items listed above (i.e. "Currently, in your job, how satisfied are you with the workload?"). Each question was measured by means of a 5-point Likert scale statement ranging from "Strongly disagree" to "Strongly agree".

Participants

The sample consisted of 1129 service employees in the Fribourg region of Switzerland. We retained and processed the responses of 813 people (see 4.1), of whom 417 were women (51.3%) and 396 men (48.7%). The sample is composed of 595 employees (74.4%), 148 managers (18.5%) and 57 senior managers (7.1%).

Results

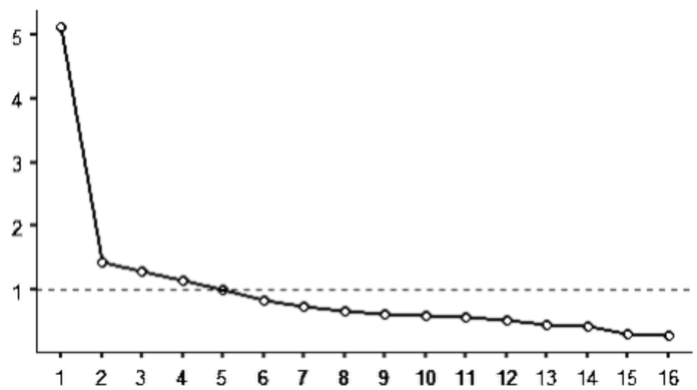
Preliminary analysis

In order to control the quality of our database, it was tested and analyzed in order to delete questionable or incomplete observations. Specifically, we excluded incomplete questionnaires (less than 70% completed), questionnaires completed too quickly (less than 90 seconds) or too slowly (ten hours). Finally, the statistical calculation of the Malhanobis distance was used to highlight the extreme values and therefore exclude them from the database (Tabachnick & Fidell, 2001).

Principal component analysis (PCA)

PCA is a technique that summarizes the information contained in a database into a number of synthetic variables, also known as principal components. Using Kaiser's rule, we retained four principal components explaining 56.6% of the total inertia.

Figure 1. Eigenvalues



Interpretation of the axes

In order to obtain a simpler factorial representation, we proceeded with a Varimax rotation and retained only the variables that saturated adequately (factorial weight greater than .600) and only on one factor.

Table 1. Component matrix after rotation

	Components			
	1	2	3	4
Organisation of work				
Decision-making or initiative				
Variety of tasks		0.803		
Material resources				
Workload			0.683	
Matching tasks and skills		0.670		
Meaning of work		0.716		
Recognition	0.640			
Fairness of treatment	0.714			
Job security				
Separation of private/professional life			0.790	
Team atmosphere				0.877
Support from the hierarchy	0.815			
External relations				
Hierarchy attentive to well-being	0.798			
Cooperation between team members				0.868

The first factor associates elements related to the relationship between the organization at all levels and the employee and is composed of recognition, fair treatment, support from the hierarchy and the interest of the hierarchy in the well-being of the employees.

The second factor relates aspects of the self to the work and is composed of the variety of tasks, the adequacy between the tasks allocated and the skills of the person and the meaning of the work. The third factor relates to work-specific constraints and includes workload and the separation between private and professional life.

Finally, the fourth factor is related to relational aspects with co-workers and includes the variables of team atmosphere and cooperation between team members.

Creation of reduced scales

On the basis of the PCA we selected all items that were well represented on the 4 factors. Then we combined these items into 4 different scales by checking the internal consistency through Cronbach's alpha. This index expresses a degree of homogeneity (internal consistency) that is all the higher the closer its value is to 1.

Table 2. Composition of the scales and internal consistency

Scale	Item	Alpha (α)
Coherence between employee and the work	The meaning you find in your activities Variety of tasks Adequacy between the tasks allocated and your skills	0.7
Interpersonal relationships	Atmosphere in the team Cooperation with team members	0.81
Relationship between employee and organization	Support from the hierarchy Attention of the hierarchy to the well-being of the employees Fairness of treatment Recognition of your work	0.82
Job strain	Workload Separation between work and private life	0.53

To evaluate the internal consistency, we use the proposal of George and Mallery (2003): if α is equal or higher than 0.9 the consistency is excellent, good if higher than 0.8, acceptable if higher than 0.7, debatable if higher than 0.6, poor if higher than 0.5, and unacceptable if lower than 0.5. We observe that only the scale related to work constraints is poor (α = .53). The scale related to the coherence between the employee and his/her work is acceptable (α = .70) and the scales reporting on interpersonal relations and the relationship between the employee and the organization are good (respectively α = .81; α = .82).

Linear regression

Linear regression aims to model a dependent (explained) variable through several independent (explanatory) variables. In this research, the variables to be explained are the level of general satisfaction (Table 3), while the explanatory variables, which model the variation of the explained variables, are the satisfaction scales created. One of the advantages of using a linear regression is to increase the understanding of the phenomenon studied by avoiding collinearity between the explanatory variables, i.e. a multiple linear regression allows the effects of the independent variables on the dependent variable to be considered at the same time and in a single analysis allowing the respective weights of the predictors to be measured.

Table 3. Linear regression between job satisfaction and scales assessing job conditions, and organizational and relational factors

R	R²	F	df1	df2	p
0.675	0.456	169	4	808	<.001

Predictor variables	B	SD	t	p
Constant	0.209	0.169	1.235	0.217
Coherence between employee and the work	0.409	0.035	11.813	<.001
Relationship between employee and organization	0.313	0.029	10.814	<.001
Job strain	0.134	0.028	4.764	<.001
Interpersonal relationships	0.098	0.032	3.116	0.002

Our model indicates that 46% of the variance in job satisfaction is explained by these four elements. All factors contribute to the explanation of job satisfaction. The most important factors (see Table 3) are the coherence between the employee and the work (B = 0.409; p < 0.001) and the relationship between the employee and the organization at all levels (B = 0.313; p < 0.001). Job strain (B = 0.134; p < 0.001) and interpersonal relationships (B = 0.098; p = 0.002) were less important in explaining satisfaction.

Based on the results of the PCA, we constructed scales that summarize the job conditions and the organizational and relational factors. The internal consistency of these scales is high, except for the work stress scale (α = .53). Further studies could complete this scale, modifying or adding relevant items to increase its internal consistency. All the scales constructed are important in explaining job satisfaction and account for 46% (R2 = 0.46) of the variation in job satisfaction. It seems that a good fit between the characteristics of the individual and the components of the job and its organization (support from the hierarchy, fair treatment) are important characteristics leading to better employee satisfaction.

Conclusion

Final discussion

Based on these results, we will be able to create a very short questionnaire used for a psychosocial risk data collection system. Indeed, we believe that we have isolated the main elements necessary to evaluate what Gollac & Bodier (2011) call "the organizational and relational factors likely to interact with the mental functioning of individuals". In the process, we have simplified the information to be collected while maintaining a good quality of risk analysis.

Our PSR management system will use the scales identified in this research through items drawn from the existing literature and adapted to reflect the one of the four dimensions. This new system will serve as the basis for the design of a digital tool for collecting data on organizational and individual factors. Its aim is to detect a toxic environment at an early stage and thus prevent its harmful effects before they can become manifest in the workplace with their devastating power.

Future studies

Our study has many limitations, which raises the possibilities of further studies. The first thing to improve is the internal consistency of the scales composing our model. Secondly, the validity of our model should be tested with other more specific statistical methods and on other samples. Our model should also be tested in different working environments. Finally, comparison with existing tests will allow us to test concurrent validity.

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The potential of Telehealth in the Co-creation of value in University Hospital services

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Introduction

Digital Transformation (DT) refers to "a process that aims to improve an entity, triggering significant changes in its properties through combinations of information, computing, communication and connectivity technologies" (Vial, 2019, p. 118). When applied to the healthcare sector, DT can improve the delivery of healthcare services, enabling new ways to interact with patients and provide extra work resources for healthcare professionals. In this research, we are going to use the perspective of telehealth as an instrument for digital transformation in health services. Telemedicine is "the provision of health services, where distance is a critical factor, by all health professionals who use information and communication technologies to exchange valid information for the diagnosis, treatment and prevention of diseases and injuries" (World Health Organization, 2010, p. 9). This study considered telehealth and telemedicine synonymous terms.

Telehealth allows for several benefits such as reducing stay and rehospitalization rate, avoiding the unnecessary displacement of patients or health professionals, creating opportunities for collaborative learning among health professionals. Faster and better oriented services improves access to care in rural areas and enhances medical follow-up (Lockamy & Smith, 2009; Mold et al., 2019; Oliveira et al., 2015; Speyer et al., 2018). Telemedicine allows for many possibilities and shows itself as a global market that is expanding rapidly and should continue to see high growth rates in the coming years (Zenteno et al., 2016). Telemedicine services are allowing more access to health care and are expanding service possibilities. Portugal was one of the first countries to adopt telemedicine to overcome geological barriers and the shortage of health care professionals (Maia et al., 2019). With the coronavirus pandemic, telehealth opened new horizons by allowing safe care without the physical presence of the patient or caregivers, particularly for chronic pathologies or in the early diagnosis of COVID-19 (Khodadad-Saryazdi, 2021).

Telehealth makes it possible to go beyond its conventional limits, both geographically and conceptually, as it allows consumers to easily obtain online healthcare services from global providers. Examples from Portugal and the USA clearly show this perspective. In Portugal, telemedicine services are an opportunity to connect Portuguese-speaking countries and promote better health services. The increase in the number of telemedicine consultations shows the central role of this innovation in providing more access to populations in distant regions (Maia et al., 2019). In a study carried out in the USA, we have another important example of telehealth, in which a case was discussed about a real-time teleultrasound consultation between a doctor and a patient with pericarditis in Antarctica and a team of cardiology consultants in Texas. This experience demonstrated that real-time teleultrasound can serve as an important diagnostic resource in providing healthcare to isolated populations in remote environments (Otto et al., 2012).

Therefore, we understand that telehealth is an important instrument to create value in the provision of health services. In value co-creation, suppliers and customers work together and collaboratively to create value. This occurs through meetings and application of the resources of the actors involved in the services. This point is central as value co-creation involves the collaborative activities of actors in exchanging services, which is linked to the capabilities and resources available to the supplier such as the technology provided and the consumers who will act with their knowledge and experiences (Osei-Frimpong, Wilson and Owusu-Frimpong, 2015; Osei-Frimpong, Wilson and Lemkec, 2018). Here we see the central role of an experience in the value co-creation process for users that can occur at the cognitive and subconscious level, which will generate knowledge through interactive processes. We highlight that some publications in the area, especially the older ones, use the concept of co-production as a synonym for co-creation, given the perceived involvement, engagement, and participation in the provision of services (Oertzen et al, 2018). So, when the term co-production is mentioned we are referring to the concept of co-creation.

Purpose of Research

Therefore, this research aims to identify how telehealth can enhance the co-creation of value in University Hospitals (UH). These hospitals are references in the construction of scientific knowledge and demonstrate increasing relevance in practices capable of being extended to the health system (Strauss & Leta, 2009). To answer this broader question, we raise three more specific questions:

1. Is value co-creation perceived when the patient is able to use their knowledge and skills in the context of telehealth?
2. Does telehealth allow interaction between the actors involved so that there is a more efficient, precise, agile, and/or equitable service provision?
3. Is telehealth capable of creating rupture and triggering strategic responses to co-create value while managing organizational barriers that affect the results of this process?

In this study, enhancing co-creation is linked to users being able to gain more control over their well-being and interact more quickly and effectively in data sharing, search for information, interaction with other users, medical care, in addition to the interoperability that occurs when there is the adequate use of the technological tool. To verify the potential of telehealth in the co-creation of value in the services of university hospitals, a systematic literature review was carried out to raise studies that could answer the questions of this research. To identify the aspects related to value co-creation in the articles of the systematic review, we used the Service-Dominant Logic (SDL) theory and the Integrative Approach of the theory of innovation in services in the discussion and analysis of the results.

The Service-Dominant Logic shows the use value and role of knowledge and skills as essential resources in interactions between providers and users. SDL logic allows for the integration of resources so that value is co-created, as value is co-created when there are combined efforts of companies, employees, customers, government, and other related entities. Thus, it is important to think about the fundamental role of value created in using collaboratively interactive mutual exchange configurations when discussing the service perspective. Participants and resources interact to create value in service systems by allowing value and value creation to be at the heart of the service (Vargo, Maglio e Akaka, 2008). However, these experiences are not always easy as they are influenced by the social context in which the encounter takes place. There may be distortions in the use of exchange motivated by their beliefs and perceptions that lead to emotional appeal and the level of trust and guarantees that impact the co-creation process. This can compromise the co-creation of value and generate possibilities of co-destruction of value (Plé and Caceres, 2010; Echeverri and Skalen, 2011).

Plé and Caceres (2010) critically analyzed value co-creation in SDL logic to think about the implications of value co-destruction as a new concept that should be analyzed within the SDL logic framework. Value can be co-destroyed through stakeholder interactions, resulting in value destruction through misuse. It can happen that a service system, accidentally or intentionally, misuses resources and acts inappropriately, thus allowing the co-destruction of the service's value. The authors have therefore pointed out that value co-destruction is a process of interaction between service systems that results in the instability of at least one of the welfare systems of those involved, which can be individual or organizational, and in this case the available resources applied operant/operand can be misused.

Therefore, value co-destruction results from resource misuse during interactions between different service systems in which there may be misuse of their own resources that results in value co-destruction for at least one of the two service systems. Plé and Caceres (2010) pointed to accidental misuse when there are discrepancies in the way resources should be integrated and applied by service systems during their interactions. This occurs when users are unable to use their resources or company resources as the company expected due to limitations, thus misusing available resources without intending to do so. There is also intentional misuse when there is an interest in misuse of resources, which occurs when a system seeks to increase its own well-being and does not consider the others involved.

The integrative approach seeks to unite goods and services by developing a common conceptual framework capable of accounting for an expanded vision of innovation applicable to any tangible or intangible product (Gallouj and Savona, 2008). According to the integrative approach, the analysis of innovation in services must assume a very broad concept of innovation in which innovation can be identified in situations such as the following: introducing a new service or new quality of service; introducing a new service provision method such as a new form of service delivery (Vargas and Zawislak, 2006). These examples of innovation activities can be understood as activities incorporated into a problem solving process. “These processes, in turn, are contextualized under a certain technical, cultural, social and economic structure, in short, under a certain institutional environment” (Vargas and Zawislak, 2006, p. 144; Dosi, 1982). As Zawislak (1996) clarified, “The problem solving process and, consequently, the innovation process are a characteristic that will prove to be different from one firm to another and will generate different individual behaviors and histories” (p. 329 -330).

According to Sundbo and Gallouj (1998b), external and internal forces can drive this process. External forces involve institutional, technological, managerial, social, and professional trajectories that influence services. Relationships established with competitors, suppliers, the public sector, and above all customers are also linked. With regard to internal forces, it is clear that they are established by the existence or not of formal structures dedicated to innovation by the involvement of workers in the change process and by the integration of the innovation process into the organization's strategic planning. Combining the different ways these forces interact in each situation will guide the innovation pattern. It is not without reason that according to Vargas and Zawislak (2006), innovation in services can lead to an endogenous decision process of organizations that make up the sector, reflecting the specific components resulting from the very nature of services. Sundbo and Gallouj (1998b) present some types of service innovation of which only Process Innovations will be discussed as they help shed light on the research question raised here. Process innovations are related to modifying prescribed procedures for the elaboration/production of a service (back office) or in the user/customer service and service delivery procedures (front office) (Vargas and Zawislak, 2006).

From this perspective, the user (or client) must be considered an important source of skills formation. Service innovation should be considered “a process of generalization of capabilities obtained in specific customer relationships” (Hauknes, 1998, p. 30). Sundbo and Gallouj (1998a) pointed in the same direction when they said that the service innovation process is essentially an interactive process in which the service provider maintains internal and external links that lead to innovation. It is on this path that a new type of innovation stands out called ad hoc (or “adocratic”) innovation, which is the result of a process of solving user problems through the co-production of the service. In this sense, ad hoc innovation is understood as “the interactive (social) construction of a solution (strategic, organizational, social, legal) to a particular problem posed by the customer. This type of innovation is co-produced by the customer and the service provider” (Sundbo and Gallouj, 1998b, p. 5). This leads us to understand that "in every service provision activity there will be room for this type of innovation to a greater or lesser extent, depending on the intensity of the user-producer relationship and the specificity of the problem to be solved" (Vargas and Zawislak, 2006, p. 146).

Methodology

We searched five databases in June 2021: Virtual Health Library (BVS), Ebsco, Pubmed, Scopus, and Web of Science. The search terms were related to two dimensions of descriptors with their respective variations: telehealth and university hospital. Eligibility criteria included empirical academic articles written in English, Portuguese, and Spanish that verified the implications of using telehealth in teaching hospitals to create value. Exclusion criteria were articles that were not peer-reviewed, articles from conferences, systematic reviews, articles that did not have empirical data analyzed, letters to the reader, book chapters, and research that did not show telehealth as a process that could show changes and improvement in the delivery of health services.

For data analysis, we articulated the Service-Dominant Logic (SDL) theory and the Integrating Approach of the theory of innovation in services. According to the Integrative Approach, telehealth is an innovation in services, occasionally a process of innovation that will deal with a new method for providing services as it presents a new form of delivery (Gallouj & Savona, 2008). SDL presents an important perspective in the relationships established when providing services as it allows the integration of resources and the application of skills of those involved in the relationship so that there is co-creation of value (Vargo, Maglio & Akaka, 2008). Thus, the articulation of these two theories in the analysis can shed light on the contributions of telehealth in the context that observes the co-creation of value based on innovation in services in the healthcare environment.

The review was carried out in five phases that occurred as follows: identification of the problem, literature selection, data evaluation, analysis of studies, and presentation of the review. The strategy to retrieve the information needed to search the databases involved using Medical Subject Headings (MeSH) related to vocabulary synonyms used to index articles for PubMed (BVS, 2020), which presented the synonyms related to telehealth (telemedicine, telemonitoring, telepractice, and telecare) linked to a university hospital (academic hospitals and teaching hospitals).

Once the descriptors were identified, the strategy based on the methodology synthesized by the acronym PICo (P = problem; I = phenomenon of interest; and Co = context) was used to help systematize the non-clinical research question (HUCFF, 2020). With this, groups of words were established that could translate the problem question and return searches that would contribute to answering it. The descriptors were established in sets of synonymous terms limited by parentheses. Inside the parentheses, the Boolean operator "or" was used so that synonymous terms were added to the search. Outside the parentheses and between sets of descriptors, the Boolean operator "and" was used, considering the need for intersection between each set of descriptors.

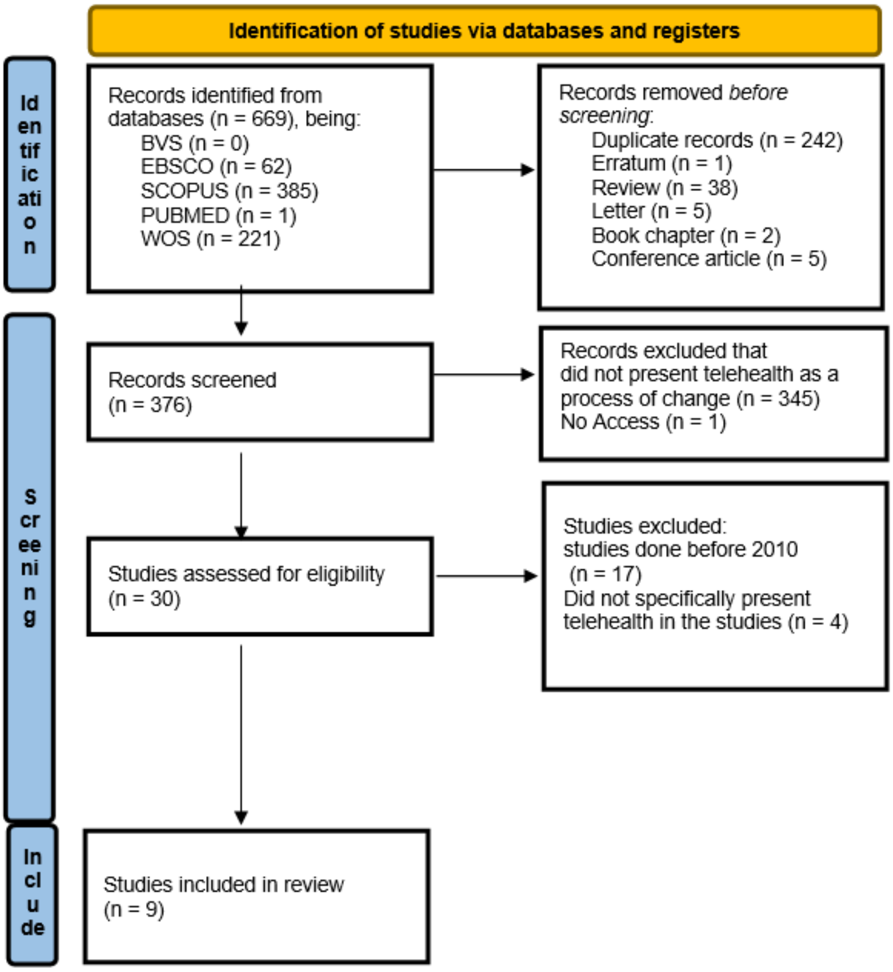
Thus, there was a division into three sets in which the terms with their respective variations were linked to telehealth and university hospitals. The search fields in each set involved the title (TI) and abstract (AB). Quotation marks were used in certain descriptors to indicate compound terms in the search. The idea was to rescue studies that could show the use of telehealth in university hospitals and its contribution to co-creating value in providing services so that the experiences could be analyzed in the light of the Service-Dominant Logic and the Integrative Approach of the theory of innovation in services.

The strategy used in the combination of descriptors in the search was as follows: TITLE-ABS (telehealth OR telemedicine OR telemonitoring OR telepractice OR telecare) AND TITLE-ABS ("university hospital" OR "teaching hospital" OR "academic hospital"). After selecting the articles based on the inclusion and exclusion criteria, the studies were analyzed based on the theoretical discussion mentioned above.

Result and Data Analysis

The search resulted in 1 article in Pubmed, 62 in EBSCO, 385 in SCOPUS, 221 in Web Of Science (WOS), and no article in VHL, totaling 669 articles. Of these 669 articles, 242 were duplicates, 1 was an errata, 38 were reviews that did not constitute empirical articles, 5 were letters to the reader, 2 were book chapters, and 5 were studies resulting from presentations at conferences, leaving 376 articles, but 345 did not present telehealth as a process of change, so were also disregarded, and 1 study was not possible to access. Of these, 30 articles were evaluated for eligibility, but it was noticed that 17 were studies carried out before the year 2010, so they were excluded from the analysis as their contributions have already been surpassed given the elapsed time and the speed with which new technologies advance. In addition, 4 did not specifically present telehealth in the studies. Thus, there were 9 articles that fit within the inclusion and exclusion criteria for analysis, as shown in the PRISMA selection and evaluation diagram observed in Figure 1.

Figure 1 : PRISMA article selection diagram



The information of the 9 studies selected in this review was extracted in a Microsoft Excel spreadsheet and grouped into the following categories: author, year, country, objective, and telehealth contributions.

Table 1: Contributions of studies resulting from the systematic review

Author/ Year/ Country	Objective	Telehealth Contributions
Khodadad-Saryazdi 2021 France	Understand telemedicine implementation issues from the perspective of process change.	The findings indicate that implementation requires context adaptation at the level of technology, culture, and strategy. Telemedicine benefits: Patient – Easier access to care Medical follow-up Faster medical appointment Faster and more relevant orientation; Healthcare system – Better care quality Continuity and accessibility to care Cost reduction (in hospitalization, transportation, consultations and treatment), Efficient use of resources, Fewer referrals to hospitals/specialists; Healthcare professionals – Cooperation with other professionals, Knowledger and experience improvement.
Maia et al., 2019 Portugal	Explore the evolution of the Pediatric Telecardiology Service through a comprehensive assessment of the development, evolution, and impact of PCS on public health to better understand the critical factors for the implementation and sustainability of telemedicine in the context of the digitization of health services.	The Pediatric Telecardiology Service allows real-time communication and sharing of clinical information, overcoming many barriers (from geographic to the shortage of health professionals), improving access to specialized care both in Portugal and in Africa. Motivation, teamwork, and perseverance were fundamental for the Pediatric Telecardiology Service to overcome the window of opportunity that created the conditions for sustainability.

Author/ Year/ Country	Objective	Telehealth Contributions
De-Carlo et al. 2018 Brazil	Describe the activities developed by the Special Interest Group in Occupational Therapy in hospital contexts and palliative care and discuss the importance of videoconferencing in the continuing education process of Occupational Therapy students and health professionals in the area.	Videoconferencing through GIS on occupational therapy in hospital contexts and palliative care allowed the progressive creation of a collaborative network composed of occupational therapists working in general hospitals, specialized units, and similar institutions, which has allowed the active interaction and participation of professionals from various institutions and services located in different parts of Brazil. This tool also made it possible to improve clinical practices and stimulate social actors involved in teaching, care, and research in occupational therapy.
Sadoughi et al., 2017 Iran	Investigate the opinions of radiologists through teleradiology, as well as assess the executive possibility of teleradiology in these hospitals through the opinions of the executive director and build a comparison between these two views.	Teleradiology has widely changed the methods by which radiologists work. By this technology, radiologists are able to monitor the cases of emergency from their houses. Such benefits lead to increase in the professional activities of radiologists. Most radiologists who participated in this study agreed that teleradiology increases the probability of their professional activity and, at the same time, can lead to increase in job opportunities, whereas most of the research community agreed on the opinion. Telecommunication, teleradiology, Hospital Information System/Radiology Information System, and Picture Archiving and Communication System are such mechanisms that increase the quality of patient care. Most of the participants also believed that teleradiology provides the probability of access to specialized diagnostic services. Access to such specialized services is very useful both for patients and for staff toward educational objectives. Continuation of education through teleradiology is a key component of this technology, which can lead to improved knowledge and experience of radiology staff.
Zenteno et al., 2016 Spain	Present the technological solution for a tele-assistance process for patients with acute-phase stroke in the metropolitan area of Seville.	The main objective of this process was to reduce the time from the onset of symptoms to the treatment of patients with acute-phase stroke through telemedicine with regard to mobility between an intensive care unit ambulance and a specialized center and activation of the pre-hospital care phase. The technological platform that covered the process was defined following an interoperability model based on standards and focused on a service-oriented architecture.
Ho et al., 2015 Taiwan	Describe a proposed telesurveillance system designed to monitor and classify electrocardiogram (ECG) signals and evaluate the performance of ECG classification.	Through connected telehealth devices, the telesurveillance system and the automatic ECG interpretation system, this mechanism is intentionally designed to support continuous decision making and is reliable enough to reduce the need for face-to-face diagnosis. With this value-added service, the system can broadly assist physicians and other healthcare professionals in decision-making in clinical practice. The system will be very useful for the patient who suffers from heart disease but who is inconvenient to go to the hospital too often.
Alonistiotis et al., 2014 Greece	Analyze glaucoma patient monitoring with video communication using high definition imaging.	Monitoring glaucoma patients with video communication using high definition imaging is an innovative approach. Several imaging exams exist in the daily practice of Ophthalmology and are used as the bases of ophthalmologic diagnosis. Glaucoma patients, in addition to being suitable for tele-examination with video and high-definition imaging, also have a history of dropping out of therapy. Telemonitoring is expected to improve training, reminding, correct instillation of drops, and therefore adherence to therapy. Project LiveCity developed a user-friendly software plugin that can be easily used in scale to connect the community with the reference Hospital in smart citie.
Blomstrand et al., 2012 Sweden	Analyze the introduction of telemedicine in clinical practice.	Under the European Union project "Health Optimum", telemedicine consultations with specialists from the Department of Maxillofacial Surgery at Uppsala University Hospital (Uppsala, Sweden) were offered to dentists from the public oral health service. An additional benefit of using telemedicine is a possibility to reduce waiting time for consultations. The GDP or GP has rapid access to specialist opinions, and doctor's delay is minimized. Furthermore, follow-up during treatment could be accomplished by fixed and scheduled rounds. The most effective healthcare level, or the right type of patient/diagnosis at the right place in the health service, is a costeffective way to organize healthcare. Telemedicine is a means to fulfill this goal.
Andersen at al., 2011 Denmark	Investigate why clinicians have problems interpreting implantable cardioverter-defibrillator (ICD) data when the patient is absent and to explore how to reintroduce patients into the sociotechnical configuration of telemonitored interpretation practices.	The interpretation of ICD data is a collaborative practice involving physicians and patients and involving three separate collaborative processes: interpretation of numbers, interpretation of the general condition, and the patient's interpretation of their own condition and ICD data. In a collocated configuration, these three interpretation processes are entangled and perfectly interrelated. However, in the current telemonitoring setup, only the number interpretation process is fully supported,

Author/ Year/ Country	Objective	Telehealth Contributions
		neglecting the other two processes and, in particular, the role of the patient. By reintroducing patients into the sociotechnical configuration of telemonitoring through myRecord, this design recognizes the collaborative nature of the interpretation process. However, the reintroduction of patients transforms their role and leads to new transformed telemonitoring practices, different from both the current telemonitoring setup and the current setup.

The articles analyzed in this study were able to present the context and the important role of telehealth in the UHs. From the perspective of SDL theory, the use value and the role of knowledge and skills was perceived as an essential resource in the interactions between suppliers and users. The integration of resources so that there is co-creation of value was clearly perceived in many examples pointed out in the table, such as the research carried out in Portugal when verifying that motivation, teamwork, and perseverance were fundamental for the Pediatric Telecardiology Service to overcome the window of opportunity that created conditions for sustainability. In addition to the perceived co-creation, telemedicine service brought significant savings in resources, around 1.1 million euros for the health system in administrative and logistical costs and around 419 euros per patient when considering an average of 1777 patients per year (Maia et al., 2019).

Research carried out in France and Brazil also showed the role of telehealth in allowing the progressive creation of collaboration networks with active interaction and participation of professionals from various institutions and services (De-Carlo et al., 2018). In France, it is clear that the implementation of telemedicine requires the alignment of processes with the organizational strategy so that this medical practice continues to be beneficial to all interested parties. If telemedicine does not bring added economic or health value, not only will it not attract the intention of the medical and administrative staff, but it will also generate director dissatisfaction (in a bottom-up initiative) and health personnel reluctance (in a top-down shift) (Khodadad-Saryazdi, 2021).

The study in France also presented the perspective of co-destruction observed in SDL theory when it presented the challenges arising from the implementation of telemedicine. The author points out that health is generally known as a complex system due to the interdependencies that exist between its components resulting from political, regulatory, and financial interactions. Thus, the introduction of a particular innovation will impact several aspects of the system. Telemedicine is not exempt from this reality, and its interaction with the different stakeholders of the system will entail unequal costs, risks, and benefits. In addition, there is also the cultural change that is also part of adapting the implementation context to promote responsiveness to innovation. The organizational culture is decisive in adapting to process innovation. If the change runs counter to the current organizational culture, members may disentangle and move away from the suggested strategy. Culture change management includes all activities that facilitate the introduction of new processes, targeting members involved or affected by the process change (Khodadad-Saryazdi, 2021). Here, we can also verify the perspective of the integrative approach when observing telemedicine as an innovation activity and, in this case, understood as an activity incorporated in a problem-solving process. It shows these processes contextualized under a specific technical, cultural, social, and economic structure.

We found that from the articles analyzed in this systematic review, telemedicine, in addition to being considered a process innovation, can also be understood as an ad hoc (or "adocratic") innovation, as it presents the interactive character in the process of innovation in services that it is vital to the effective use of innovation (Sundbo and Gallouj, 1998b). In addition, in the context of telehealth, there is a need for a process of solving user problems through the co-creation of the service. In all articles, the authors drew attention to the collaborative process in relation to the use of telehealth and the co-creation of value in the UHs so that innovation could effectively occur, as shown in table 2.

Table 2: Perspectives showing telehelth as ad hoc innovation

Articles (Country)	Perspectives that show telehelth as ad hoc innovation
France	"Adapting to the implementation context also requires strategic and cultural alignment. Strategic adaptation incorporates the accordance of innovation with organizational interests and perspectives and vice versa. Most collapses of telemedicine projects emanate from the failure of technology integration into the strategy and business model of the healthcare organization. Although the present findings reveal that the main objective of telemedicine implementation concerns the general interest in favor of patients, we should not ignore the contradictory strategic effects" (Khodadad-Saryazdi, 2021, p. 14).
Portugal	"The "secret" of success identified was mainly a professional and motivated team, which had at their disposal a simple, but effective technology. Additionally, the creation of a network of partnerships with district hospitals and the active collaboration of ICT teams were paramount. Last, but not the least, the inclusion of TC reimbursements (and foreseen in the business plan) from NHS and the required time to improve and adapt to each client Hospital's needs" (Maia et al., 2019, p.14).
Brazil	"Videoconferencing through the SIG on occupational therapy in hospital contexts and palliative care allowed the progressive creation of a collaboration network made of occupational therapists working in general hospitals, specialized units and similar institutions, which has made possible the active interaction and participation between professionals from several institutions and services located in different parts of Brazil. In addition, this tool enabled enhancing clinical practices and stimulating social actors involved in teaching, care, and research in occupational therapy" (De-Carlo et al., 2018, p. 12).
Iran	"The success of telemedicine programs not only depends on the technical aspects but also relies on organizational and human factors. A telemedicine system that considers only technological cases will fail. Organizational aspects are equally important and must be considered. According to this issue and the importance of chief executive officer views in the organization for supporting and successfully implementing these systems, the views of chief executive officers of hospitals through the executive probability of teleradiology were evaluated" (Sadoughi et al., 2017, p. 306).
Spain	"Once at the patient's location the corresponding diagnostic tests are performed by tele-assistance devices and a videoconference session starts from the patient's home or inside the ambulance with the Neurology specialist in the Reference Hospital to direct the diagnosis. All the medical data are electronically sent from the device by means of a cross-consultation report. At the same time the patient may be transferred to the hospital. Once the ambulance arrives at the hospital the patient suspected of stroke can be directly requested for a computerized tomography (CT) without Trial" (Zenteno et al., 2016, p. 3).
Taiwan	"By providing long-term informative interaction and long-term health monitoring, the presented telehealth care system is more than a health monitoring system—it is also helpful for clinical decision making. The service provided must be able to take care of routines and subroutines and act as a health information center to share the data among heterogeneous platforms, such as hospital information systems and health information systems. Hence, our system successfully provides a continuous, real-time, secure, Web-based telehealth care service for both patients and medical staff" (Ho et al., 2015, p. 7)
Greece	"LiveCity e-Health is a European research program, which aims to provide better treatment and follow up of glaucoma patients at their home, through telemonitoring with high definition video-to-video (v2v) communication from the University Hospital. It aims to reduce the cost of health and improve the city environment by decreasing the number of visits to the Hospital. For this purpose, a software application has been developed; the latter is easy to use for elderly people at home, and capable of keeping the medical history and digital records of every patient in the Glaucoma Department" (Alonistiotis et al., 2014, p. 48).
Sweden	"With the telemedicine solution that is now being introduced on a broad scale, we are convinced the result will be maintenance of quality, increased availability, and a faster, simplified, and costeffective way to improve primary care. Patient care will be delivered at the correct and most effective level, providing that participating therapists are well trained and organized" (Blomstrand et al., 2012, p.).
Denmark	"Earlier studies show that including the patient in telemonitoring practices is vital; however, the patient needs time and effort to become a skilled, active, and responsible participant able to engage in the interpretation process. When the patient is reduced to representations such as images and graphs, the essential cooperative potential between the healthcare practitioner and patient when interpreting the ICD data collocated disappears. The invisible work of the patient involved in interpreting practices is missing. While the reduced representation might be adequate in some situations, it seriously "disables" the data interpretation process in situations of uncertainty. Here the patient's active role as diagnostic agent is needed so that the representation becomes adequate "to speak" for the patient [19]. We designed myRecord to re-introduce the patient in the interpretation process by providing the patient the opportunity to add contextual information to the partial representations captured and measured by the ICD-monitoring system" (Andersen at al., 2011, p. 124).

The study carried out in Denmark shows that patient cooperation is essential in the process (Andersen et al., 2011), which was also noticed in the study carried out in France when the author mentions that a poor understanding of the user's needs can lead to difficulties in accept telemedicine (Khodadad-Saryazdi, 2021).

Regarding innovation being identified from the introduction of a new service or new form of service delivery, all the studies analyzed highlighted the importance of innovation to improve processes and allow for problem-solving. As seen in theory, these processes are determined by contexts linked to the institutional environment, that is, technical, cultural, social, and economic structure. This was pointed out in the research carried out in France when they showed that telemedicine as a process innovation represents a new form of medical work that requires technical, cultural, and strategic changes. The process actors and their beliefs, technologies and information systems, promoting activities, as well as restrictive limits and rules can play a decisive role in these changes. Technical adaptation is not independent of cultural adaptation (Khodadad-Saryazdi, 2021).

It was possible to see the importance of co-creation of value in all articles raised in the systematic review even when it was not directly addressed in the text, but when they spoke of the co-created value in the combined efforts of the institution, staff, and patients or the absence of these attitudes of collaborative support. For example, in the study carried out in France, the author pointed out that the conformity of technical telemedicine tools with the user's needs promotes their adoption. Furthermore, he pointed out that telemedicine is not a simple tool or technology already developed and ready to install that can be imposed on medical personnel. On the contrary, interest is needed on the part of health professionals, the institution, and agents so that there is a network of actors interested in identifying the strategic needs of the organization in terms of telemedicine. This is critical to creating an organizational culture that relies on teamwork and individual responsibility to facilitate process change. It also highlights that the early involvement of various actors in developing the process can contribute to its implementation (Khodadad-Saryazdi, 2021).

The study carried out in Portugal also followed this path by showing that the Pediatric Telecardiology service connects the Hospital Center of the University of Coimbra to 13 other Portuguese national hospitals every day and regularly to Portuguese-speaking African countries through a teleconsultation platform. The Pediatric Telecardiology Service allows real-time communication and sharing of clinical information, overcoming many barriers (from geographic to the shortage of health professionals), improving access to specialized care both in Portugal and in Africa (Maia et al. , 2019).

Conclusion

We observed that in the services provided through telehealth in university hospitals, it is possible to verify the fundamental role of the value created since the participants and resources interact in a collaborative way and in interactive configurations of mutual exchange so that the creation of value is in the center of the service in addition to cost reduction as observed in the study carried out in Portugal. The results show that telehealth is a key part of the digital transformation of university hospitals as it contributes to and enhances the co-creation of value in health services. It was noticed in the data analysis that through telehealth it was possible to observe a more efficient, accurate, agile, and equitable service provision, as it allowed the inclusion of geographically distant patients with health limitations. In Portugal, it was also possible to verify potentials and opportunities through the promotion of privileged relationships between the Coimbra University Hospital Centre (CHUC) with other health entities.

Regarding the specific questions raised in this study, it was possible to observe the co-creation of value when the patient used their knowledge and skills in providing services from telehealth. The study carried out in Denmark showed that patient collaboration cannot be neglected and when telehealth is attentive to this aspect, it can contribute to value co-creation. All articles analyzed showed that telehealth allows interaction between the actors involved so that there is a more efficient, precise, agile, and/or equitable service provision. However, many studies highlighted the importance of monitoring, training, and attention to the needs of the actors involved so that there is no co-destruction of value in the process. We see many examples in which the creation of an advantage for an individual in the context of telehealth can result in disadvantages for others involved and, therefore, the importance of the context in which telehealth is being used.

Considering that telehealth is an ad hoc innovation, it was possible to see that this innovation is capable of creating rupture and triggering strategic responses to co-create value while managing organizational barriers that can affect the results of the process. In many of the examples already described in table 2, it is possible to see that telehealth allowed cooperation between actors in the co-creation of value and introduced a new form of service delivery, configuring in many cases a new quality of service provided.

Reflection and discussion on the possibilities of telehealth are essential for providing health services, especially in a pandemic/post-pandemic context with all the limitations and implications of the Covid-19 virus in providing services and in the way of relating and thinking about health.

Finally, we highlight as a limitation of this research the number of articles analyzed in this systematic review, which was reduced, which may have been due to the inclusion and exclusion criteria that guided the selection of articles. However, there is also the possibility that important articles have not been retrieved by the databases used here. It is suggested as future research the verification of the potential of telehealth in other health institutions to broaden the understanding of the contributions of this innovation.

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- Table 2: Perspectives showing telehelth as ad hoc innovation

List of Sources

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6
Topic »AI in Frontstage Service Interactions«

6.1
List of papers

- **Artificial Intelligence in the Customer Journey: A Systematic Overview of the Most Popular Use Cases Through the Creation of AI Archetypes**
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- **Human-centered work and technology design with AI – insights into the project »humAIn work lab«**
  Ines Roth (INPUT Consulting, Germany), Dominik Grafenhofer (Deutsche Telekom, Germany), Markus Hoppe (INPUT Consulting, Germany)

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Artificial Intelligence in the Customer Journey: A Systematic Overview of the Most Popular Use Cases Through the Creation of AI Archetypes

Richard Sander, Christoph Peters (University of St. Gallen - School of Management, Law, Social Sciences, and International Affairs (HSG), Switzerland)

Introduction

The attention Artificial Intelligence (AI) has received in academia and public news often feels unprecedented. A disruptive technology with humble beginnings transformed into an omnipresent buzzword. Considering the research of Davenport and Bean (2019), the hype regarding the technology seems justified when measured by companies' adoption of it. The authors have interviewed 65 Fortune 1000 companies and made the following findings: 80% call AI the most disruptive emerging technology and 96.4% have already invested in AI (p. 10). McKinsey (2019, para. 3) made similar findings in their 2019 Global AI survey, where 58% of all respondents answered to have at least one AI capability implemented in their business already. Considering that AI is expected to add almost $16 trillion to the global economy until 2030 (PWC, 2017), these numbers are not surprising. In fact, the potential that comes with AI is unprecedented. In a survey conducted by Chui et al. (2018, p. 13), the authors discovered that in almost 70% of the investigated use cases, AI can enhance performance beyond the capabilities of any other analytic technique. In 16% of these use cases value could be created through AI only.

However, Davenport and Bean (2019, p. 11) also identified that 77.1% of all the companies they have interviewed consider the business adoption of AI a challenge. Ransbotham et al. (2017, p. 6) collected insights from more than 3'000 executives, managers, and analysts, identifying that 47% of all companies have no or very little understanding of AI and only 19% actually understand the technology and truly capture its value. In short, a disruptive technology is establishing throughout the business world but only a minority of companies are able to leverage its potential.

The interesting finding is that a significant part of the faced challenges is not of a technical nature. According to Davenport and Bean (2019, p. 7) 95% of these challenges originate from people and processes. Other researchers came to similar conclusions. Many executives struggle to understand the applications and benefits of AI (Bean, 2019). Often business problems that need to be solved aren't defined (Thomas, 2019, p. 11), business cases aren't available or unclear (Pettey, 2018; Ransbotham et al., 2017, p. 6), the company is lacking a clear AI strategy (McKinsey, 2018), executives don't understand the topic sufficiently (Ransbotham et al., 2017, p. 11) or there is a lack of existing, practical knowledge like integrating AI into Customer Journeys (CJ) (Peters & Zaki, 2018, p. 1).Tim O'Reilly, founder and head of O'Reilly publications, sums up the current situation as follows: "Everyone is talking about AI these days, but most companies have no real idea of how to put it to use in their own business" (Thomas, 2019, p. v).

To resolve this situation Ransbotham et al. (2017, p. 11) articulate the need for management to develop an intuitive understanding of AI. Such an understanding is founded on a fundamental knowledge of AI, which is not too technical but allows for comprehension of its capabilities and potential use cases. To build the described knowledge, the authors suggest simple courses and introductions that are in line with the needs of managers and decision makers (Ransbotham et al., 2017, p. 11).

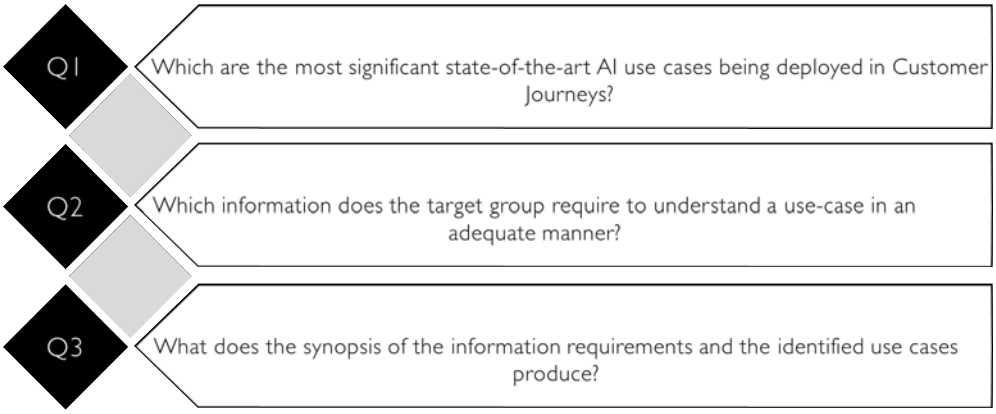
Purpose of Research

Following the suggestions of Ransbotham et al., the goal of this paper is to contribute to solving the knowledge gap for managers and decision makers. The vastness of the application potential of AI dictates the need to focus the research on one field specifically. Accordingly, the authors chose AI in the customer journey (CJ) as a focal point. Not only are CJs in line with the authors' backgrounds but also show one of the biggest potentials in general. Chui et al. (2018, p. 19) were able to identify marketing as one of the greatest value opportunities for AI, highlighting tasks such as pricing, promotion, and customer service management; all components of the customer journey. Additionally, an initial desk research revealed that there are several tools and tutorials for managers regarding AI in general, but no such support exists when it comes to a focus on CJs.

Therefore, to fill this gap, this paper develops an information model of the most significant state-of-the-art AI use cases in the CJ providing all necessary information for decision makers and managers to leverage the technology. To do so, firstly the most significant state-of-the-art[2] AI use cases in the CJ need to be identified. Secondly, the information need of the target group needs to be derived. And thirdly, a synopsis of the two prior dimensions creates the final information model. These tasks are summed up as the three central research questions of this paper in the figure below.

All things considered the expected value of this work is to facilitate an individual's understanding regarding AI use cases in the CJ. It does so by giving an easy entry to the related topics and being an approachable orientation and overview tool. Through this approach, the scientific objective of gaining knowledge is closely connected with practical usefulness.

Figure 1: The three research questions underlying the paper (Source: Own figure)



Methodology

Neither the use cases nor the information need of managers and decision makers have been investigated in the outlined context before. Accordingly, both dimensions need to be identified to be then overlapped, creating the intended information model.

- **Identification of Use Cases**
  The use case identification follows a quantitative approach by conducting a descriptive, cross-sectional survey based on extensive desk research. The idea is to identify sources which show a company deploying an AI use case in their CJ. Through collecting these sources an extensive registry of use cases currently deployed in the CJ is created. From this registry the distribution of use case types and thus their popularity is derived allowing to focus the information model on the most significant ones. This method was chosen, as it offers the most objective and systematic way to gather a meaningful amount of use cases while regarding the scope of this paper. The information captured includes the deploying company, the type of use case, a description of deployment and respective sources. To the authors' knowledge such a registry has not been created in this context before and is therefore a novelty. To assign a use case to a CJ phase, the interpretation of Kotler and Keller (2016, pp. 195-201) named the 'Buying Decision Process' is applied. It is one of the most commonly used variations and represents a five-phase interpretation of a CJ which allows for an optimal allocation of each use case.

[2] State-of-the-art in this context is understood as the level of development of currently and widely deployed use cases.

Additionally, both academic and online sources were considered to depict the current state of AI use cases as accurately as possible. This approach follows Smith's (2006, p. 179) criticism of peer reviewed publications who stresses that the time intensive reviewing process can lead to significant gaps between presented information and current developments and thus an inaccurate representation of the status quo.

The non-academic research was conducted via Google. The search-engine was chosen as it is not only the most popular and accustomed one with a worldwide market share of ca. 87% (StatCounter, 2020), Google also has a significant higher precision and relative recall than other search engines as e.g. Yahoo (Sabha & Sumeer, 2016 pp. 524-525). However, Google results, while still related to the topic, will gradually become vaguer (Sahu et al., 2016, p. 215). Therefore, during the research, each result on each Google page was examined. If three consecutive pages of Google results (~30 separate web pages) did not yield one use case, it was assumed that the results lost relevance and the Google search was therefore abandoned. Additionally, non-academic sources were investigated for content correctness, publication by recognized institutions and appropriate audience to guarantee the quality of adapted information.

All academic research was conducted via the meta-search provided by the library of the University of St. Gallen (HSG). The HSG Metasearch was chosen as it conducts the search in several renowned databases at once, including but not limited to: Business Source Ultimate, Scopus, Science Direct or the university's own catalogue. Furthermore, all research was conducted between 24.04.2020 and 22.05.2020 and through the HSG VPN, thus setting the location to Switzerland.

The applied search terms, restrictions, total results, results including inclusion and exclusion criteria, the derived sources, and the total amount of use cases obtained from each search can be seen in the following table:

Table 1: Summary of the desk research regarding AI use cases in the customer journey

Search Engine	Search Terms	Restrictions	Results	Inclusion/ Exclusion Criteria	Derived Sources	Amount of Use Cases
Google	artificial intelligence + use cases	English	408M	X[1]	102	**214**
	artificial intelligence + customer journey	English	48.8M	X[1]	19	**55**
	artificial intelligence + user journey	English	35.6M	X[1]	4	**9**
	artificial intelligence + customer experience	English	203M	X[1]	2	**5**
	artificial intelligence + best practices + marketing	English	193M	X[1]	8	**21**
HSG Metasearch	artificial intelligence AND customer journey	2017-2020; full text available; academic journals, journals, books, e-books; English	43	18	5	**25**
	artificial intelligence AND marketing AND use cases	2017-2020; full text available; academic journals, journals, books, e-books; English	54	12	6	**22**
	artificial intelligence AND marketing AND overview	2017-2020; full text available; academic journals, journals, books, e-books; English	33	6	0	**0**
					Sub-Total	**351**
			After Consolidation		Total	**327**

M=million [1] Instead of inclusion/exclusion criteria, at this step the quality standards set in chapter 1.2 for online ressources were applied

The research resulted in a sub-total of 351 use cases from 146 sources. All identified use cases were then reviewed and duplicates either removed or merged, reducing the number of use cases to a total of 327 after consolidation. The complete list of all consolidated use cases is available from the authors upon request.

For illustration purposes, two examples of such use cases are shown below.

Table 2: Exemplary presentation of two captured use cases

Google	Chatbots	Google's Duplex is a virtual assistant that can book appointments or respond to calls in a human like way	(Johari, 2020)
Shoepassion	Recommender	Through their existing data and segmentation, Shoepassion can differentiate between customers and recommend them the most relevant products	(Ganatra, 2018)

- Identification of Target Group Needs

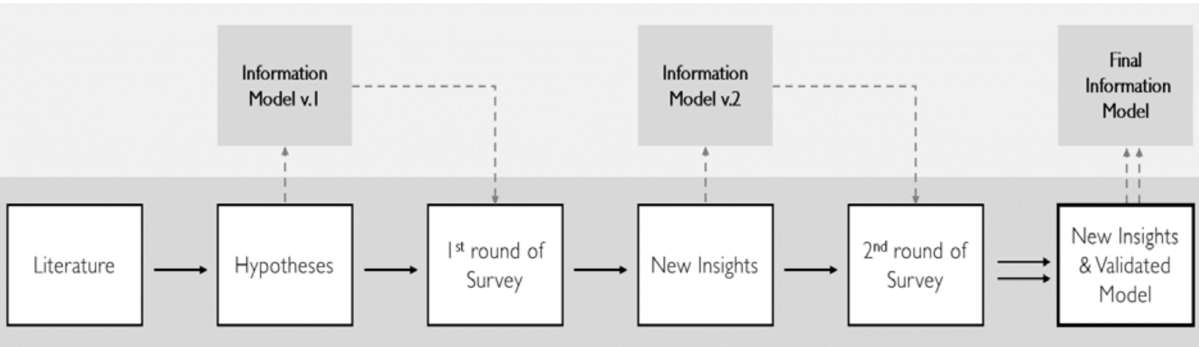
The second part of the methodology had the goal to identify, what kind of information the target group of this paper requires, to purposefully grasp the use cases identified earlier. The applied mixed methods approach was based on two different steps.

The first one being the desk-research for the use cases. Throughout the research for the use cases, information that could provide valuable input for the need identification, was additionally captured. On this basis, initial hypotheses were derived from existing literature regarding the kind of information the target group needs, to sufficiently grasp a use case. These hypotheses were then aggregated and visualized in a prototype information model. The idea of this model is to act as a stencil to capture use cases in a uniform way and present necessary information concisely and uniformly.

The second step was to validate and adapt this information model from a prototype to a final version through an explanative online survey. Two consecutive iterations of the survey were held with representatives of the target group. The prototype was presented in a first survey round, meant to gather insights regarding the informative value for and the assessment from the target group. Based on the gathered feedback the prototype was adapted and improved. In a second survey the refined prototype was presented to a new crowd, to enhance the model once more and to derive a final and validated information model. The described approach was chosen, as insights could be gathered from a significant cross-section of the target group, thus enabling a purposeful development of the information model. Furthermore, the direct input from the target group enhanced the validity of the model, rendering unnecessary the need for a separate ex-post validation.

The approach is summed up in the following graphic, visualizing each step of the method:

Figure 2: Visualization of the need identification approach (Source: Own figure)



Both survey iterations were conducted through a renowned online tool. The questions were standardized and could either be answered through multiple-choice or through ratings. In addition, the questions had the optional possibility to provide feedback to allow for individual input.

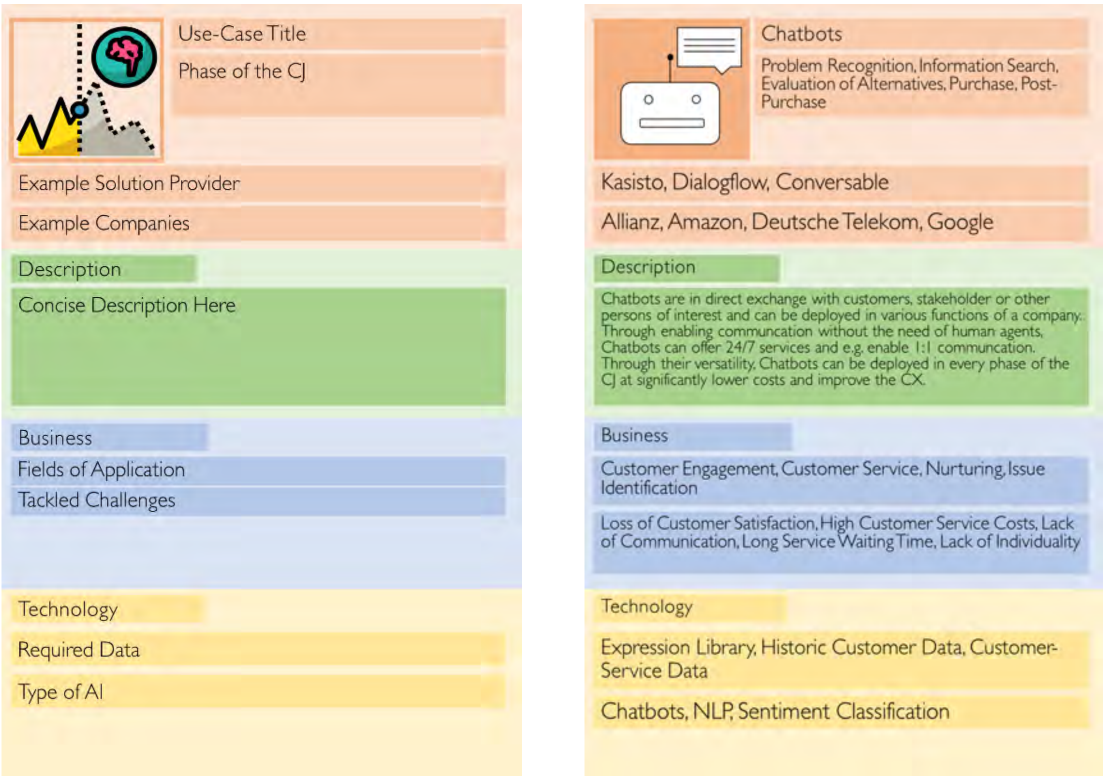
The surveys were based on the quality criteria set out by Berger-Grabner (2016). Emphasize was put on universal comprehensibility (Berger-Grabner, 2016, p. 191), so that the ability to understand the given information and to answer the questions is mostly independent from an individual's background. The questions were also aligned in form of a funnel (Berger-Grabner, 2016, p. 192), progressing from general to more specific ones. Furthermore, the survey iterations were designed to be answered within 15 minutes, to prevent fatigue among the participants (Berger-Grabner, 2016, p. 193).

As this paper's target group is defined as managers or decision makers with a topical focus on customer journeys, the representatives are commonly found in the marketing or innovation team. However, depending on the company size, also founders, CEOs, CTOs or CXOs can be relevant. Therefore, company size was not a differentiation factor. Interview candidates were selected primarily based on their affiliation with the topic and not their position.

Contact to these individuals was made through LinkedIn and the authors' personal network. A search based on keywords like 'Customer Experience', 'Customer Journey', 'Marketing' or 'Innovation' and combinations thereof returned profiles of fitting representatives. Through LinkedIn's in-mail feature these persons were contacted and asked to participate in the survey. Additionally, the authors' personal networks were scanned for appropriate candidates, which were then invited to share their insights. The chosen approach is therefore based on randomized cluster samples as the two sources of participants each represent a cluster (Berger-Grabner, 2016 p. 205). During the process it became apparent, that the personal networks were yielding a superior response rate and thus have been concentrated on. The invitations to the survey were sent directly to individuals only and not made available publicly. In total 84 individuals were contact throughout both rounds, 53 for the first and 31 for the second. 43 surveys were completed, 22 in the first and 21 in the second iteration.

Seven hypotheses regarding the information need were derived from literature. The topics covered thereby include a description of the use case, the fields of application, the tackled challenges, the data required, the type of AI applied, an example of an application as well as companies providing the solution.

Figure 3: First prototype, raw and applied to the Chatbot use case (Source: Own figure)Based on the mentioned hypotheses, the illustrations shown below were created.



The concept was inspired by quartet cards and aimed at visualizing and summarising each hypotheses' core messages. It was the first iteration of the information model and therefore the prototype. The stencil nature is made visible through only describing the separate fields of the model through a generic description. When applied, the generic descriptions are replaced through the information of the respective use case. These illustrations were also the central part of the survey, illustrating the concept to the participants.

In addition to the hypotheses introduced above, the phases of the CJ and a visualization were added. The visualization was added for aesthetic reasons, improving the design and recognisability of a use case. The hypotheses were separated into four different thematic groups, visualized through the different colour schemes. To illustrate how the information-model can look like when filled with data, an exemplary mock-up is added as well. It is based on the Chatbot use case and rudimentary information, meant only for illustration. Both illustrations were presented in the survey, to give the recipients an accurate understanding of the concept. The final results of the survey and the refined information model are expounded in chapter 2.2.

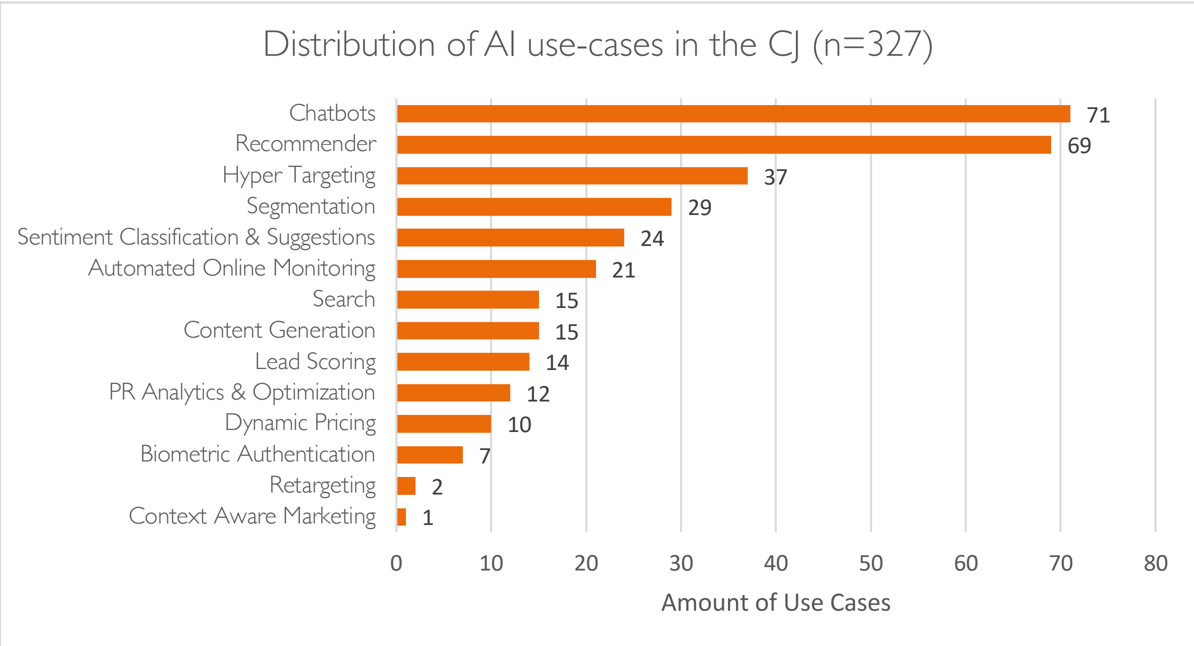
Findings

The following chapter presents the results of the research. Therefore, the identified use cases are elaborated on at first. And secondly, the final information model is presented.

The State-Of-the-Art AI Use Cases in the Customer Journey

This chapter shows the distribution of the different use case types and allocates each use case type to the phases of the CJ they are being deployed in. Based on the registry, the following distribution of use case types becomes apparent:

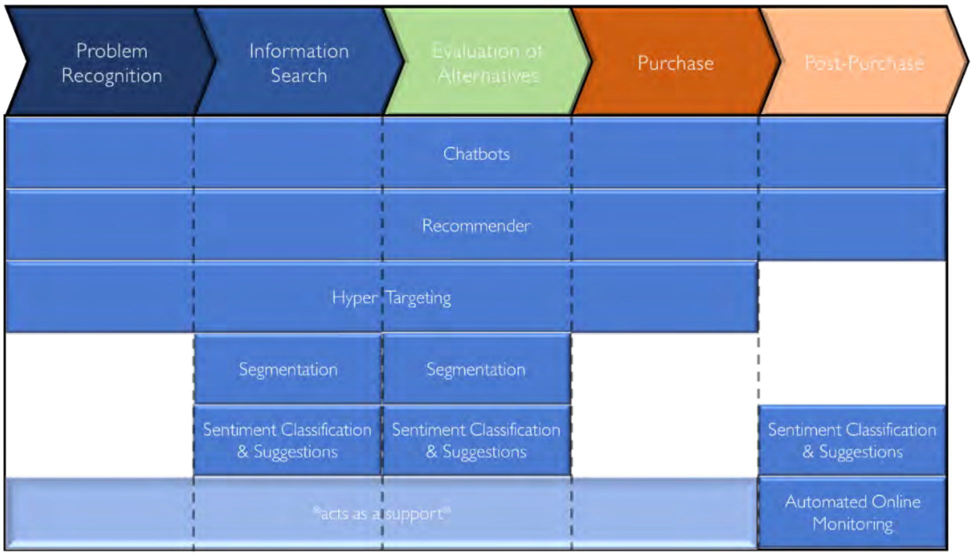
Figure 4: Distribution of AI use cases in the customer journey (Source: Own figure)



Chatbots (~21.6%) and Recommender (~21%) are the two most dominant applications, together representing more than 40% of all identified use cases. Following are Hyper Targeting (~11.3%), Segmentation (~8.8%), Sentiment Classification and Suggestions (~7.3%), and Automated Online Monitoring (~6.4%). All other use cases scored below 5%. Accordingly, the focus of this paper is put on these six use case types due to their relative popularity.

Furthermore, the graphic below visualizes in which CJ phase each use case occurs:

Figure 5: The use cases mapped to their deployment in the customer journey (Source: Own figure)



While all shown use cases were found to be applied in various phases of the CJ just with varying extent, Automated Online Monitoring is applied only in the Post-Purchase phase. However, the use case's impact can be found in every phase of the CJ when accounting for its support functionalities. When applied in general, the data gathered by the use case is able to enable several other applications. Therefore, its supportive role is highlighted in the graphic above.

The Use Case Information Model

Through the two survey iterations several insights were deduced, and the final information model iteratively developed. The information model is applied in full-length in chapter 2.3-2.4. This chapter presents the outcome of the research. The central findings that were made are the following:

All seven initial hypotheses regarding the information need were verified

The survey participants were asked to rate the importance of each hypothesis on a scale from 0 equalling useless to 4 equalling essential. The results are particularly clear regarding the first four hypotheses, with each one having the following score: Description of a use case ~3.59, fields of application ~3.41, tackled challenges 3.5 and type of needed data ~3.09. These results highlight the importance of the mentioned information. A little less distinctive, but still positive on average, are the results of hypotheses five to seven. Type of AI needed scored ~2.73, real-life examples ~2.95, and potential solution providers ~2.55. While scoring lower than the first four, the average sentiment is still positive, showing that all of the seven fields of information, represented by the hypotheses, have proven as relevant and thus will be covered by the information model. (see appendix 1).

A single quartet card only is not able to cover the information need

The surveys made apparent that even though the initial concept of a quartet card is appealing and appreciated by the target group, it is in conflict with the information need of the recipients in regard to the amount of information it can cover. The participants either asked for more types of information, like risk exposure or implementation costs, to be covered. Or provided comments asking for a more holistic view or labelling the provided information as too generic. One participant specifically asked for "[…] additional documents, which include some supplementary comments". Therefore, an additional free text was added to the model. The idea being that the quartet card serves as an informative wrap up for each use case and the additional text provides in-depth explanations. This description encompasses each field of information of the card and explains it more comprehensively. Through this approach, it is possible to identify the key points of a use case based on the quartet card and get more in-depth information through the free text when needed. (see appendix 1)

The information model is capable of increasing the reader's knowledge

The second survey iteration showed the model applied to the Chatbot use case and asked the recipients to rate their own knowledge regarding Chatbots in the CJ on a scale from 0 equalling useless, 3 equalling satisfactory, and 5 equalling excellent. On average the participants gave a score of 2.24. After being presented with the model, the participants were asked to answer the same question again, which resulted in an average score of 3.85 and thus an increase of 1.61. Before being presented with the model's insights, only 14.29% of all participants rated their knowledge as good or excellent which increased to 80% of all participants after being introduced to the model. (see appendix 2)

The information model sparks positive reception throughout the target group

Both survey iterations asked the participants to rate the model's capability of satisfying their information need on a scale of 0 equalling useless, 3 equalling satisfactory and 5 equalling excellent. In the second iteration the corresponding question resulted in an average rating of 3.95, up from 3.59 in the first iteration. 80% of all participants rated the model as good (55%) or excellent (25%). Not only does this increase demonstrate the value of the added free text. But this very positive outcome clearly demonstrates the approval of the target group and thus validates the model, showing that the promised value can be delivered. (see appendix 1 & 2)

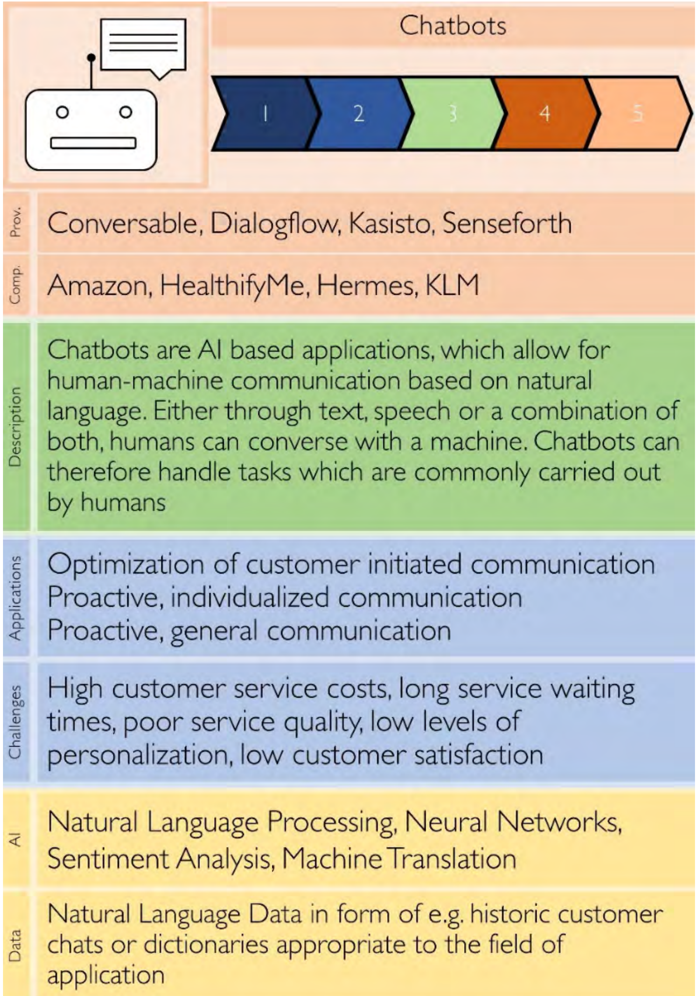
The surveys yield leads for further research

Through the surveys the topics of risk and risk exposure, costs and time of implementation and performance indicators were also raised. While their potential gain in insights is acknowledged, the limited extent of this paper does not allow for the validation of the topics and the gathering of the needed information. The authors assume that to gather the needed data further interviews with solution provider and use case applicants would be needed as none of the existing sources yielded relevant insights. (see appendix 1 & 2)

Exemplary Application based on the Use Case 'Chatbots'

While the full research output includes the information model applied to the six use cases mentioned before, the model will be shown in full for the Chatbots and Hyper Targeting use case only. All other use cases can be requested from the authors.

Figure 6: The Chatbots quartet card (Source: Own figure)



Chatbots are AI applications which enable human-machine communication through natural language input (Social presence and e-commerce B2B chat functions, 2020 p. 1220). These machines can autonomously communicate with humans and hence handle tasks, commonly taken care of by human agents. Generally, Chatbots are either text-based dialog systems or language-based dialog systems (Kreutzer & Sirrenberg, 2020, p. 30). Kreutzer and Sirrenberg (2020, p. 28) explain, that historically Chatbots evolved from pure text in- and output. In such a case, users can input text in a dedicated interface area and receive textual output in another area, thus enabling communication based on natural, written language. More advanced are language-based systems that can process speech as an input source and generate a speech output. Famous examples are personal assistants like Siri or Alexa, which the user can converse with. But generally, all variants of text or speech in- and outputs (text-to-text, text-to-speech, speech-to-text or speech-to-speech) are possible and can even vary in one system (Kreutzer et al., 2020, p. 28). Chatbots that are merely rule-based and e.g. deployed to answer frequently asked questions through predefined answers, are not based on AI and therefore not regarded in this context.

Chatbots are one of the most versatile applications of AI in the CJ. As the conducted research shows, the use case can be found in every stage of the CJ and a single application can span more than one phase of the journey at a time. On the contrary, the use case's touchpoints are straight forward. According to Woodford (2020 p. 3), 48% of chatbot interactions are through messenger applications and 43% through websites.

Kreutzer and Sirrenberg (2020, pp. 111-113) show that Chatbots can be applied for essentially three different tasks: to optimize customer-initiated communication, for proactive, individualized communication, and proactive, general communication. The first task focuses on helping users solve ordinary inquiries like searching for the right product or resolving questions (Kreutzer, et al., 2020 p. 111). These Chatbots are very popular in the Post-Purchase phase to take care of customer service needs, such as Hermes' Holly Chatbot (Thong,

2020) or Deutsche Telekom's Tinka (O'Boyle, 2018 p. 13). Proactive, individualized communication tasks are often automated marketing use cases (Kreutzer, et al., 2020 p. 112). The authors explain that in defined boundaries, Chatbots take over a predefined task. Such tasks can be follow-up messages after a processed complaint or come-back messages for idle customers. Generally, they are based on certain triggers, which are monitored for each customer and acted upon on occurrence. In such cases, Chatbots often overlap with the use case of Hyper Targeting. An illustrative example is KLM's Blue Bot, through which customers can book tickets but also receive booking or check-in confirmations or updates regarding their flight's status. The Chatbot proactively delivers important information to the customer and thus enhances the experience and decreases the amount of cost-intensive, customer-initiated inquiries (Kreutzer et al., 2020, p. 112). Proactive, general communication applications target the complete customer base or individual customer segments and provide a more general kind of information. These Chatbots are most often used to deliver information to a high number of customers at once (Kreutzer et al., 2020, pp. 112-113).

Chatbots offer a wide variety of benefits. On the business side, cost savings and efficiency are most significant. Through the 24/7 availability and lack of fatigue, Chatbots can handle many tasks cheaper and more consistent than a human agent can (Kreutzer et al., 2020, p. 115). Additionally, through abandoning the restrictions of limited available manpower, the use case allows for simple scalability, proactive communication, and personalization at the same time (Kreutzer, et al., 2020 pp. 115, 120). This has benefits for employees and customers alike. Existing human agents can be relieved of monotone and mundane tasks and their capabilities leveraged for more complicated and delicate encounters. Customers on the other hand can receive a faster and more personalized experience, encounters become more convenient and thus increase the overall customer experience (Kreutzer et al., 2020, p. 117). The described upsides can also result in better consumer engagement, customer retention or brand loyalty (Woodford, 2020 p. 4). Through combining Chatbots with other use cases such as Recommender or Sentiment Classification & Suggestions, the benefits of several applications can be combined in one feature for the customer.

Companies struggling with a high amount of simple customer-service requests can deploy chatbots to take over such tasks and significantly decrease waiting time for customers and the time needed to respond to enquiries (Kreutzer, et al., 2020 p. 115). Swift customer service is essential as a study by Forrester shows (Leggett, 2016): 53% of individuals interviewed are likely to abandon their purchase when answers to their questions are not provided fast enough. And 73% even claim that the most essential factor to a good customer service is valuing a customer's time. Thus, Chatbots can be an important asset for companies struggling with high cart-abandonment rates or low customer service satisfaction.

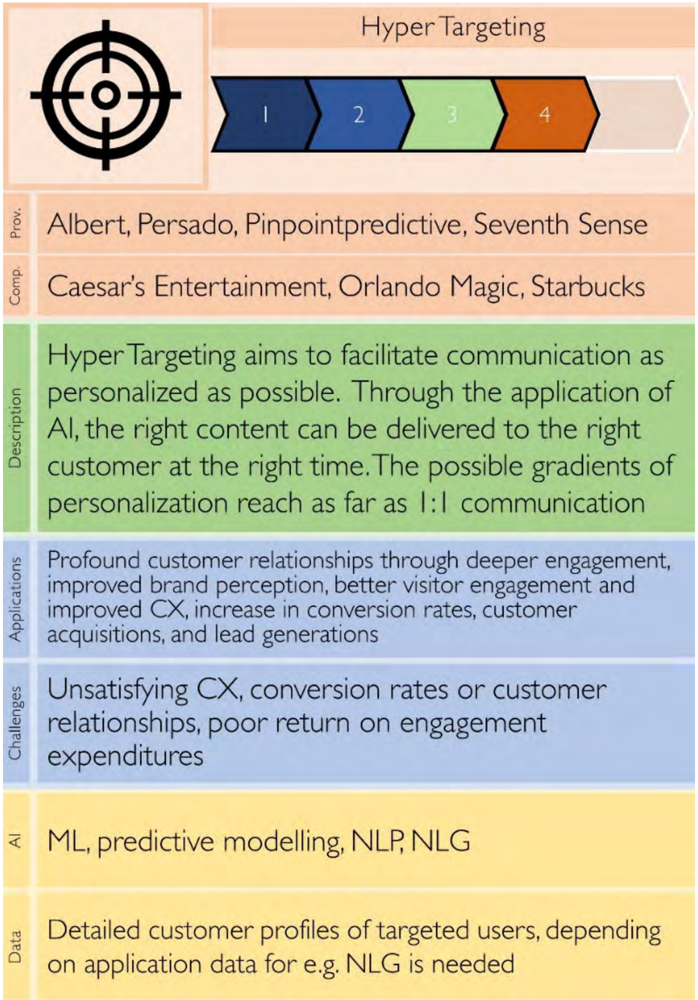
Technologically, Chatbots are based on various forms of AI, though the very basis is natural language processing (NLP) and in the case of voice conversations also neural networks (Kumar et al., 2019, p. 138). NLP is an AI subfield, dedicated to enabling human-machine conversation through making machines comprehend natural language (Akerkar, 2019 p. 54). This field incorporates subtypes like natural language understanding, natural language generation (NLG), sentiment analysis, or machine translation (Kreutzer et al., 2020, p. 27-28). Depending on the Chatbot application, varying forms of NLP will find use. Accordingly, natural language data is needed to train the bots. Such data could be historic customer chats or dictionaries. Regarding AI, the right training data is essential in general but in the case of Chatbots it is especially important. As Chatbots communicate directly with customers, poor quality data can lead to a bad experience, which can significantly harm a brand and a customer's experience. Additionally, the data needs to be appropriate for the field of application, as a Chatbot for suggesting sport gear needs to understand different phrases than a customer-service bot for a chemical supplies company.

There are several solution providers for Chatbot applications such as Conversable, Dialogflow or Senseforth. In the field of Chatbots, the identified solution providers often focus on a specific niche. For example, John Paul offers solutions for concierge services and Kasisto's KAI bot is tailored to the context of banking.

Exemplary application based on the use case 'Hyper Targeting'

Hyper Targeting in the context of this paper, describes the application of AI for (hyper-) personalized communication.

Figure 7: The Hyper Targeting quartet card (Source: Own figure)



Kumar et al. (2020) describe it as delivering "[…] the right content to the right customer at the right time" (p. 7). Simply said, the use case aims at enabling communication as personalized and tailored to an individual as possible. Though the described approach is a prevalent goal, as companies continuously strive to personalize their communication, AI allows for unprecedented levels in doing so.

As shown before through the mentioned Accenture survey, customer expectations regarding personalized experiences have been rising significantly. 91% of consumers are more likely to shop with a brand that offers a personalized experience (Accenture, 2018, p. 7). Similar findings were made by Evergage (2018 p. 2) through interviewing 300 marketing experts, which agreed by 88% that their customers expect a personalized experience. Hyper Targeting fittingly tackles these expectations as it can satisfy a customer's need for meaningful engagements throughout the entire CJ. When taken far enough, AI in the form of Hyper Targeting even makes one on one communication feasible at scale (Brutman & Isaacson, 2019, para. 1).

A notable example for Hyper Targeting in practice is Starbucks. Through leveraging the data Starbucks receives through its rewards program in combination with a real-time AI personalization engine, the company can automatically create 400'000 personalized e-mail variants each week. Additionally, it provides real-time offers, based on customer's current and anticipated behaviour, which are completely unique and tailored to the individual customer. Through these advances, Starbucks was able to improve their response rate by 200%. (Richman, 2016, para. 2)

Another successful application of the use case is by the basketball team Orlando Magic. The sports club uses Wordsmith, which allows them to tailor in-app messages and e-mails to each of their members. One of the challenges they face is that season ticket holders regularly have to resell their tickets as they cannot visit every game. Reselling can be difficult and lead to frustration or membership cancellations. Therefore, the Orlando Magics analyse each customer's data and specifically contact those whose tickets are likely not to be resold. These e-mails are automatically generated, tailored to the customer, and explain their situation in natural language. Additionally, they also contain advice on how to handle the reselling process, by e.g. displaying information if the asked price is too high, how many more tickets are on sale or the opportunity to trade in their tickets for membership rewards. The approach was received very well by Orlando Magic's customers, with over 80% responding positively. (Automated Insights, n.d.a)

While these examples show some possible levers of personalization, there are in fact much more. Sterne (2017, p. 192) presents a very elaborate list of factors that can be used for personalization, with the following topics representing only an excerpt: time of day, day of week, from line, subject line & length, header, headline, content text, content images, layout, colour scheme, language tone, offer, embedded links or a call to action. As one can see the possibilities are vast and vividly illustrate why AI plays a crucial role for personalization.

When it comes to the underlying AI, Hyper Targeting is quite versatile. Many AI fields can be used and combined. At the basis of the use case though lies machine learning, predictive modelling, and natural language generation (Kumar et al., 2019, p. 138). To enable highly individualized communication, detailed information is needed about the conversation partner. That is why the use case Segmentation complements Hyper Targeting very well. Based on attributes like age, gender, interests, spending habits, devices being used or various real-time information, communication can be tailored to the individual (Akerkar, 2019, p. 27; Kumar et al., 2020, p. 7). When it comes to executing the communication, the needed data varies based on the chosen approach. For e.g. tailored e-mails, NLP and the according data outlined in the chapter of Chatbots is needed whereas individualized website banners rely on a set of graphics and themes to choose from.

Based on the identified use cases, it became apparent that Hyper Targeting is applied in the CJ phases of Need Recognition, Information Search, Evaluation of Alternatives and Purchase. According to a survey by Evergage (2018, p. 7), the most popular touchpoints are e-mails (77%), websites (52%), mobile apps (31%) and web applications (24%). Some of the most chosen formats for these touchpoints are banners (45%), call-out messages (40%) or pop-ups (29%) (Evergage, 2018, p. 14).

According to Evergage (2018, p. 21) the five most common benefits that are being realized through Hyper Targeting are increased visitor engagement, improved CX, increased conversion rates, improved customer acquisition and lead generation as well as improved brand perception. Similar findings were made by Brutman and Isaacson (2019, para. 1), who highlight the potential of deeper engagement, stronger customer relationships and better ROI. Accordingly, Hyper Targeting is a great use case for companies, which struggle with their customer experience in general, their conversion rates and customer relationships, and unsatisfying returns on engagement expenditures.

Worth mentioning is that when the use cases of Hyper Targeting, Segmentation and Recommender are combined in a seamless way, a company can offer their customers personalized engagement marketing. The customer experience can then be personalized to a point, where products, prices, website content, and communication messages are tailored to the individual user's preferences and needs (Kumar et al., 2019, p. 138).

There is a variety of solution providers for Hyper Targeting applications. One of the most renowned companies is Albert, which can run highly individualized ad campaigns based on the combination of Segmentation and Hyper Targeting. Other providers include Persado, which can tailor messages to customers, Seventh Sense, which tracks users and engages with them when the contact is most likely to be successful or Pinpointpredective, which tailors communication to customers based on psychological profiles.

Critical Reflection & Closing Remarks

The goal of this paper was to create a support tool for managers and decision makers that are facing the challenges of integrating AI into their companies and business processes. As it was shown, a lack of understanding and capabilities regarding AI is apparent throughout this target group. Therefore, to support the adoption of AI, an information model was created which summarises the most popular AI use cases in the CJ in regard to the information need of managers and decision makers. To do so, at first the most popular applications were identified by systematically scanning available information on the web and in academic literature for examples of AI use cases in the CJ. This process resulted in an extensive registry of application examples, from which a distribution of different use case types was derived, and the most popular ones identified. In a second step, an information model was created by deducing hypotheses from relevant business literature regarding the information need of the target group. Through two consecutive rounds of survey iterations, the hypotheses and the developed information model could be validated and iteratively improved.

The six most popular use cases are Chatbots, Recommender, Hyper Targeting, Segmentation, Sentiment Classifications and Suggestions, and Automated Online Monitoring. On the basis of the surveys, it was possible to show through individual comments and the given ratings, that the target group strongly endorses the introduced concept of an information model regarding AI use cases in the CJ and appreciates its informational value.

Due to the limited scope of this paper, several promising insights that were made during the surveys could not be adopted. These include the consideration of time and costs of implementation, risk factors and exposure as well as ways to evaluate the success of each use case. The reason being for the dismissal of the mentioned factors was the lack of information that could be deduced during the research. It was assumed that in order to generate the needed insights, additional interviews with companies deploying and solution providers developing the respective use cases would be needed. Doing so exceeded the scope of this paper. Furthermore, the undertaken survey rounds were conducted with a modest set of representatives of the target group. Even though extensive insights were gained, a higher number of survey participants could have resulted in additional views or opinions. Furthermore, the approach of randomized cluster samples incorporates the risk of an outcome bias due to the interviewed clusters. Similar restrictions apply to the capturing of the use cases. The chosen approach aimed at identifying a distribution pattern within the use cases. Therefore, it cannot be guaranteed that through more extensive research, incorporating further and more diversified sources, a different distribution or additional use case types would not have emerged.

Nevertheless, the results of this paper are very promising, and the received feedback of the target group vividly demonstrates the relevance of the topic. Therefore, further research should be conducted in order to refine the created information model and the list of deployed use cases. Through interviewing a higher number of representatives of the target group, additional insights regarding potential fields of information can be made and the model tested more profoundly. Additionally, companies deploying and developing use cases need to be involved in further research to access knowledge regarding the topics mentioned earlier and potentially identify hitherto unknown needs, fields of information or deployed use cases. Finally, the authors want to stress the significant value that can be created when academic research is strongly aligned to the needs of a target group. Particularly the field of AI shows great potential when it comes to bridging the gap between the existing knowledge and the need of businesses to understand and apply the technology.

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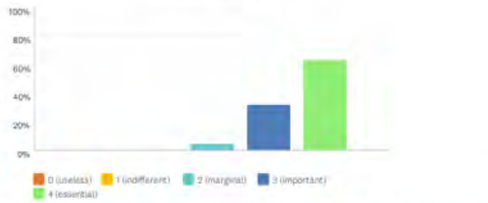
Appendix

Appendix 1 Relevant results of the first survey iteration

Q2 How important do You consider a Description of the use-case, introducing and outlining it?

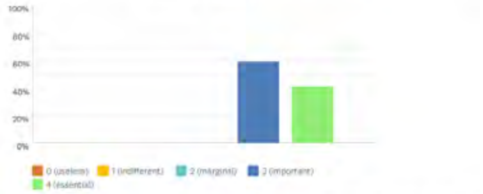
Answered: 22 Skipped: 0



0 (USELESS)	1 (INDIFFERENT)	2 (MARGINAL)	3 (IMPORTANT)	4 (ESSENTIAL)	TOTAL	WEIGHTED AVERAGE
0.00% 0	0.00% 0	4.55% 1	31.82% 7	63.64% 14	22	3.59

Q3 How important do You consider learning about the Fields of Application of the use-case, meaning their purpose and in which way they generate value?

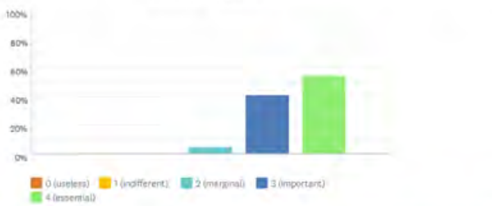
Answered: 22 Skipped: 0



0 (USELESS)	1 (INDIFFERENT)	2 (MARGINAL)	3 (IMPORTANT)	4 (ESSENTIAL)	TOTAL	WEIGHTED AVERAGE
0.00% 0	0.00% 0	0.00% 0	59.09% 13	40.91% 9	22	3.41

Q4 How important do You consider to know about the Challenges a use-case can tackle, e.g. reducing churn or falling customer satisfaction?

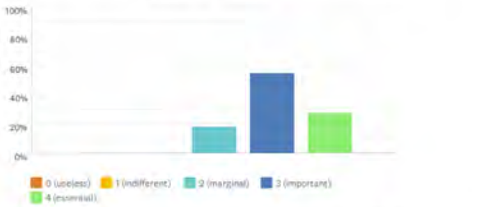
Answered: 22 Skipped: 0



0 (USELESS)	1 (INDIFFERENT)	2 (MARGINAL)	3 (IMPORTANT)	4 (ESSENTIAL)	TOTAL	WEIGHTED AVERAGE
0.00% 0	0.00% 0	4.55% 1	40.91% 9	54.55% 12	22	3.50

Q5 How important do You consider to know about the Type of Data, e.g. historic purchase data, that is needed for a use-case?

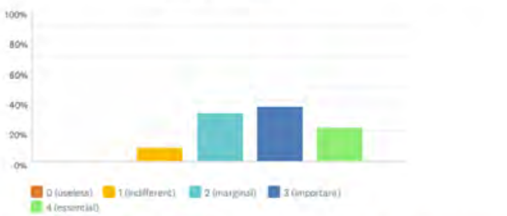
Answered: 22 Skipped: 0



0 (USELESS)	1 (INDIFFERENT)	2 (MARGINAL)	3 (IMPORTANT)	4 (ESSENTIAL)	TOTAL	WEIGHTED AVERAGE
0.00% 0	0.00% 0	18.18% 4	54.55% 12	27.27% 6	22	3.09

Q6 How important do You consider to know about the Type of AI, e.g. natural language understanding, that is needed for a use-case?

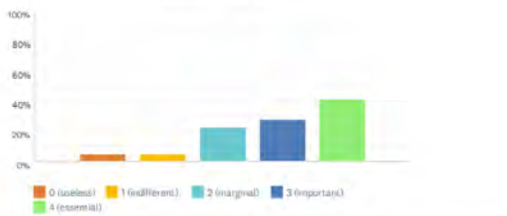
Answered: 22 Skipped: 0



0 (USELESS)	1 (INDIFFERENT)	2 (MARGINAL)	3 (IMPORTANT)	4 (ESSENTIAL)	TOTAL	WEIGHTED AVERAGE
0.00% 0	9.09% 2	31.82% 7	36.36% 8	22.73% 5	22	2.73

Q7 How important do You consider real-life Examples to understand a use-case?

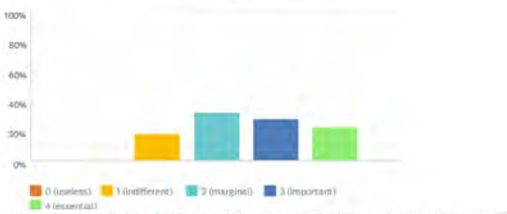
Answered: 22 Skipped: 0



0 (U	1 (INDIFFERENT)	2 (MARGINAL)	3 (IMPORTANT)	4 (ESSENTIAL)	TOTAL	WEIGHTED AVERAGE

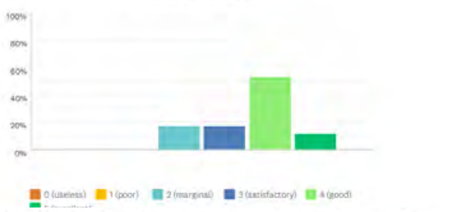
Q8 How important do You consider to know about potential Solution Providers, which offer the use-case?

Answered: 22 Skipped: 0



Q10 How do You rate the current prototype's ability to satisfy Your information need?

Answered: 17 Skipped: 5



Q9 Is there any other field of information You would like to know about?

Answered: 2 Skipped: 20

#	RESPONSES	DATE
1	Scalability & repeatability - how do you evaluate a solution, and pivot or persevere based on how it's working	7/26/2020 7:12 PM
2	Data privacy and other legal constraints to consider, as well as risk exposure as a result of the new solution	7/21/2020 11:45 AM

Q17 Would You like to comment anything else?

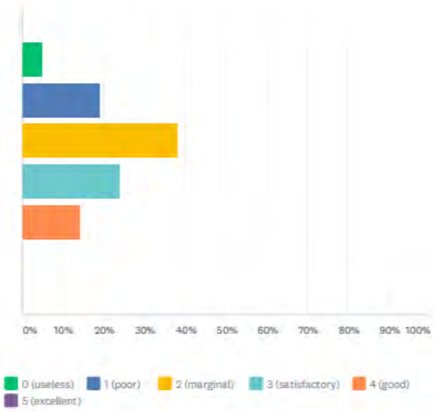
Answered: 4 Skipped: 18

#	RESPONSES	DATE
1	This is a great topic. As an IT manager, I can tell you that tackling the problem of making AI effective and not just a buzzword is a big gap in today's companies, so if you tackle this youll be solving a great problem! Good luck in your studies!!	7/26/2020 7:20 PM
2	The Concept with your Cards is very helpful! Love the Idea behind it and the execution is top notch! But what would help me personally, beside these Cards, are some additional Documents which include some supplementary comments. Anyways, nice work you did there!	7/24/2020 11:00 AM
3	Very useful idea - even more if you have to compare different solutions	7/20/2020 9:39 AM
4	Those use case cards are more for roles in the buying circle which have no clue. It does not really show any benefits of the solutions really - it just tells that it solved a problem. But I can tell a lot of things...	7/10/2020 2:06 PM

Appendix 2 Relevant results of the second survey iteration

Q1 How do You rate Your personal knowledge regarding Chatbots applied in Customer Journeys?

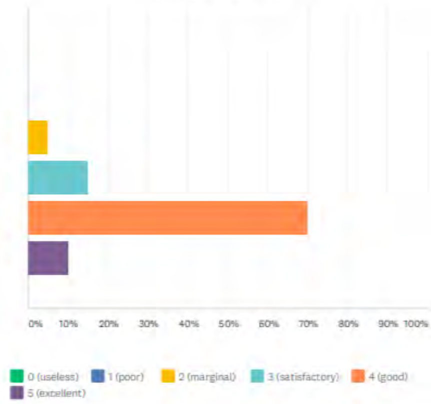
Answered: 21 Skipped: 0



0 (USELESS)	1 (POOR)	2 (MARGINAL)	3 (SATISFACTORY)	4 (GOOD)	5 (EXCELLENT)	TOTAL	WEIGHTED AVERAGE
4.76% 1	19.05% 4	38.10% 8	23.81% 5	14.29% 3	0.00% 0	21	2.24

Q2 How do You rate Your personal knowledge regarding Chatbots applied in Customer Journeys after having read the provided information?

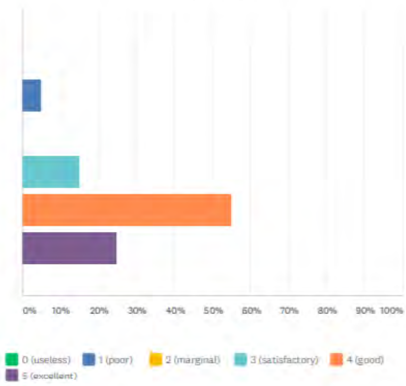
Answered: 20 Skipped: 1



0 (USELESS)	1 (POOR)	2 (MARGINAL)	3 (SATISFACTORY)	4 (GOOD)	5 (EXCELLENT)	TOTAL	WEIGHTED AVERAGE
0.00% 0	0.00% 0	5.00% 1	15.00% 3	70.00% 14	10.00% 2	20	3.85

Q3 How do You rate the introduced model's capability of satisfying your information need?

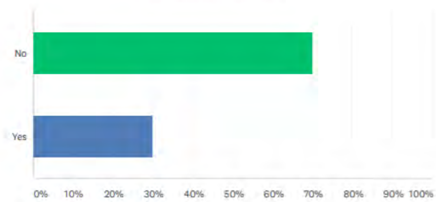
Answered: 20 Skipped: 1



0 (USELESS)	1 (POOR)	2 (MARGINAL)	3 (SATISFACTORY)	4 (GOOD)	5 (EXCELLENT)	TOTAL	WEIGHTED AVERAGE
0.00% 0	5.00% 1	0.00% 0	15.00% 3	55.00% 11	25.00% 5	20	3.95

Q4 Is there any other information You would wish to learn through the model?

Answered: 20 Skipped: 1



ANSWER CHOICES	RESPONSES	
No	70.00%	14
Yes	30.00%	6
TOTAL		20

#	YES	DATE
1	New, potential fields (use cases) in the future in which chatbots can be disruptive to particular industries.	8/12/2020 2:19 PM
2	The model was presented and explained very clearly. Due to the short description in combination with the graphics, the model was basically well understood even without previous knowledge. Nevertheless, from the management's point of view, it would be desirable for the model to be based more on figures and data. For example, it would be interesting to know how long the integration of this model can take on average or how much the implementation can cost. Of course, it is difficult to collect accurate data for such questions.	8/10/2020 9:10 PM
3	Coverage of customers and satisfaction of the interaction	8/2/2020 8:24 PM
4	Might be interesting to have an indicator of the complexity of the underlying AI or the scope of realizing such a project	8/2/2020 5:06 PM
5	It might be nice to have further literature on that topic	8/2/2020 12:04 PM
6	This model is basically close to perfect from my point of view! Great Job! But as a manager and therefore a management perspective i would like to know more about facts and figures.. How much does it cost to implement? How long will the implementation process take? Etc. I know this is really tricky maybe even impossible to say (at least in such a general manner) but it would really appreciate it! Hope i could help you or at least give you some new insides.. Don't hesitate to send me your final results, would love to see where all your work leads to!	8/1/2020 12:56 PM

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Human-centered work and technology design with AI – insights into the project »humAIn work lab«

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Problem/Goal

Artificial intelligence (AI) will have a lasting impact on future working environments and business models. However, the AI transformation of work and companies can only succeed if it is designed around the needs of working people. Our contribution therefore shows the potential benefits of a human-centred AI design in an operational context. The development, implementation and evaluation of AI based on employee participation helps to improve working conditions, eliminate technological vulnerabilities and increase product and service quality.

For research and design projects on the effects of human-centred AI, a participatory research methodology is recommended. In our opinion, there are three reasons why participatory research can be seen as a methodological response to the AI transformation of work. Firstly, based on their specific application and usage experience, employees have the necessary knowledge about the effects of AI in central areas of work regulation. Second, we expect that participatively developed design solutions will bring the greatest benefit in terms of corporate and employee interests. This assumption is derived directly from the model of human-centred technology design. Thirdly, technology development relies on the experience of the operative in the introduction and improvement of AI. The experience and process knowledge available to employees forms a central information for the development of practical solutions for operational AI use.

Methodology

Human-centred AI design is challenging because operational implementation practice must be systematically examined and design knowledge generated at the same time. That's why the learning and experimentation space »humAIn work lab« follows a bipolar approach in that human work and the institutional, organizational and economic framework conditions of the AI use are considered simultaneously. The »humAIn work lab« therefore actively involves operational actors in the research process and uses their expertise and experience in dealing with AI. The project essentially consists of two phases in which the participation of practitioners is weighted differently. The first phase serves the scientific analysis of operational framework conditions for the use of AI and its effects on work. In this phase, operational practitioners are involved insofar as they accompany the scientific analysis work organizationally and share their knowledge with the scientific project participants in the context of preparatory workshops and the case study survey.

However, the analysis serves to identify problems that can be dealt with in the second phase, the operational practice laboratories. This "experimentation and design" phase lives from the active participation of employees in AI design, from their application experience, their feedback on technology development and their ideas on how AI should be used according to their requirements and needs. In practical laboratories they reflect on their handling of AI, identify fields of action and develop design approaches for a human-centred use of AI. The methodology of practical laboratories allows participation in three ways: Firstly, they are organized in an agile manner, which means that lab teams develop and test self-defined design solutions in short-cycle sprints. Second, the lab teams work in a participatory manner, with employees from various company areas working together on innovations for the digital world of work. Thirdly, the practice laboratories are supported on a social partnership basis. This ensures that company and employee interests are balanced in the design solutions and contributes to their acceptance in the company.

Results

Like all automation technologies, AI is blessing and curse at the same time: On the one hand, the efficiency gains through them are what fuel economic growth. On the other hand, they require managing transformation processes. As a result of our analysis, we present below examples of good practise at Deutsche Telekom that show that employee participation contributes positively to AI development and operational use.

The PIA project (Personnel Interactive Assistant) demonstrates many challenges of AI usage in the enterprise: employee participation, customer feedback, reskilling and transformation. At the core PIA offers call centre agents on the fly automatic support for handling customer requests via automation and guidance. Employees are involved in all stages of project implementation going significantly beyond standard employee participation and the active individual decision to use the tool (use is voluntary): First, they play an active role in the ideation process of new use cases and provide feedback on the implementation. Second, a team of call centre agents has been trained in the scripting language of the tool and are developing the use cases themselves. Third, call centre agents take over a significant role in the communication of and training in the new tool. Finally, an interdisciplinary scientific study was carried out to objectively assess the impact on workers, efficiency, and customer experience. The results have been fed back as valuable feedback into the project.

The second example FM (Frag Magenta) touches on fewer and different challenges. The AI based technology offers an individualized natural-language based self-service for customers via text-chat (classical and on new channels like WhatsApp). It is developed with extensive involvement of customers and also employees. FM allows for 24/7 availability and has the immediate reaction time even during peak hours or times with exceptionally high call volume. Based on customer utterances conversations are either routed to the best matching team and agent or are handled automatically if feasible (e.g. answering billing questions, carrying out fault repair procedures). Besides efficiency, there are two key impacts on employees: First, employees benefit from the prequalified handover of customers (routed to the right team, context information about the interaction with FM is provided to the call centre agent). Second, simple tasks are carried out automatically, and reach employees at a much lower frequency. On average, agents are confronted with more complex tasks for which they need to be prepared, e.g., with additional training. Furthermore, there is an impact on workforce composition resulting from a demand for experts for bot training and dialog design, which reskilling can only partially alleviate.

Discussion and outlook

AI, as a frequently formulated demand, should be designed to be human-centric. In our analysis of AI in customer service at Deutsche Telekom, we have learned so far what areas of application there are for AI and what opportunities exist for employees to participate. Above all, it is crucial to involve employees very closely in the design, implementation, rollout and operation of AI. This ensures that the strengths and limitations are recognized and helps to reduce reservations about AI. The key to success lies in offering employees meaningful options and convincing them that these are worth actively pursuing. In the following practical labs, they can work out what these options might be in a participatory manner.

Interaction-sensitive chatbot: Updating customer support in the platform-based ecosystem for business software

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Introduction

In a medium-sized software company establishing a cloud business model, the increase of customer touchpoints leads to growing organizational and technical requirements for high-quality support of numerous and diversifying customers. Following a customer centricity approach, the company whose developments are presented in this paper places great value on intensive customer contact and adequately channeled feedback, aiming to advance not only product improvements, innovations, and customer satisfaction, but also good interaction work on the part of the employees which means that they should be enabled to do “interruption-sensitive” interaction work.

Business customers of the aforementioned provider of corporate software are expecting prompt support at a high level, preferably in an interactive mode. Due to increasing customer frequency on the cloud platform and the challenge of economically feasible personnel capacities, this is becoming increasingly difficult to realize without the establishment of further technical support. To ensure a reasonable and healthy management of requirements for high-quality development and service expected from the employees (especially regarding the management of work interruptions associated with this development), the implementation and use of an AI-based interaction-sensitive chatbot is envisaged. CAS Software AG and the Munich Institute for Social Science Research are jointly exploring how this can be designed and applied in a medium-sized company within the framework of participatory research.

Subsequently, we shall outline the problems of work interruptions and interaction sensitivity of chatbots in more detail. This is followed by a description of the process of our approach: In the context of the project UMDIA – Interruption Management in Digitally Framed Interaction Work, the research and design process includes empirical research and findings, integration and discussion of current literature on interactivity in chatbots, and the development and discussion of social science concepts on interaction work as well as human-machine interaction with AI. Against this backdrop, categories for software requirements will be deducted from literature findings and additional surveys further specifying the concrete chatbot requirements. First indications for a chatbot ‘state of the art’ will be presented, which include requirements for interruption sensitivity and interaction sensitivity in the area of business software solutions.

Purpose of Research

We first provide a practical introduction in order to outline how we understand and define interruption and interaction sensitivity in the context of our study from a software development perspective. This will be followed by a closer look at our UMDIA research program and conceptual solutions.

Interruption sensitivity

A company has many interfaces to communicate and interact with its customers. These can include sales activities, customer support, marketing and hackathons. The challenge here is that customers do not always know how and through which person they should contact the company in order to raise their question or find support for a possible problem they are encountering. A common scenario is, for example, that customer inquiries are submitted through a communication channel which is not designed for their particular request (or its content). Consequently, the inquiry will be sent to an employee who is not in charge of processing this task – he or she then needs to take care of forwarding the inquiry to the responsible colleague, which creates additional effort and is originally not part of his or her respective core activities. In other cases, a customer is struggling to find the necessary information on the company website and therefore tries to contact the company directly (via phone or reaching out directly to employees), hence avoiding the designated customer support communication channel. In order to offer the best possible support to the customer in processing his or her inquiries, a chatbot interface was designed that is able to automatically determine their needs while interacting and engaging in a dialogue with the customer. The chatbot therefore can forward the customer to the responsible department/person or, in some cases, even provide them with information directly. The implementation of this interface is beneficial to the company's employees (e.g., Sales Department), because it decreases the frequency of interruptions they encounter while working on their core responsibilities. Thus, they will be able to improve the focus on their competencies and strengths.

Interaction sensitivity

For interaction to be satisfactory for both customers and companies, the chatbot must have more capabilities than just mastering natural language. Especially complex conversations impose the necessity to incorporate the dialogue context, e. g. the chat history, to capture the current state of the conversation correctly and to be able to continue it in a sensible way. Such a context-sensitive chatbot would be robust towards problems that occur in natural language communication, as ambiguity (i.e., a word can mean different things depending on the situation) and under-specification (i.e., omission of information that can only be recovered through contextual knowledge).

This demand placed on software and AI development is part of the scope of the UMDIA research project (https://www.arbeit-form-zukunft.de/), as well as several other requirements regarding development and design. Subsequently we will focus on the question of the interaction sensitivity of chatbots as an automated customer interface, in the perspective of warranting an interruption-sensitive work design for employees. Initially, we will focus on the aspects of human interaction work that meet the requirements of the service relationship "work on and with people", and we shall discuss in which ways these criteria are relevant for a chatbot and the human-machine interface and how they can be taken into account in this context.

Participatory research – development cooperation

About the context of the investigation

Our presentation of results includes employee expectations regarding interruption management with the help of a chatbot, which were collected and determined through qualitative interviews. Furthermore, the respective employees' interaction work itself was analyzed and questions were asked about the limitations and challenges of chatbots in customer interaction. The criteria for interaction sensitivity are further elaborated by thoroughly discussing the concept of interaction work (e.g., Böhle & Weihrich, 2020). Against this social science background, the UMDIA project provides a constructive discussion of software development (in cooperation with data science, product management and sales) and how it can be geared towards the design of an interaction-sensitive chatbot. The process is designed as participatory research. This implies that the software concepts developed in reference to the empirical findings are cooperatively reflected and discussed by scientific and industrial partners with regard to their contribution to interruption and interaction sensitivity, and the employees are integrated as partners in the evaluation process (Neumer & Porschen-Hueck, 2015; Porschen-Hueck & Maurer, 2014).

Discussion of social science concepts

Can tensions in support and intermediation work be reduced through technical (chatbot) support and is it possible to enhance its quality in the perspective of reduced interruptions? From a critical point of view, it is worth asking whether this effect of minimization of interruptions and workload reduction is actually achieved since, according to other studies (Daum, 2018), self-service and automation techniques seem to only marginally affect the volume of calls. So far, relevant knowledge could be gathered mainly in the context of rationalization of call center work (e.g., Holtgrewe & Kerst, 2002a, b; Holtgrewe, 2003a; Hess & Leittretter, 2004; Gottschall & Voß, 2005). The research on chatbots is more recent and often focuses on their social compatibility as Human Friendly Automation. It is still an open question whether chatbots in empirical reality can achieve the promised results, which will be briefly addressed in the following section. Meanwhile, some chatbot experience has been gathered in practice. For companies, the chatbot experience gained by their customers can either lead to corresponding customer loyalty or momentous dissatisfaction. For employees, chatbots allow for less interruptive and therefore less stressful work, but the establishment of a chatbot may also yield contrary results, i.e., more stressful work: customers that feel provoked or annoyed by the medium will put a strain on service relationships. Considering a more interaction-sensitive design of chatbots, which is necessary from our perspective, what do realistic measures look like for companies that do not operate on the high-end scales of the digital platform giants? In reference to research on interaction work as work on and with people as well as on rationalization, stress, but also relief strategies for good (service) work, we raise the following questions: What does a successful service interaction depend on within the customer–chatbot–service provider triangle? What can be technically mapped and how can this be implemented?

We consider these questions against the backdrop of a concept of interruption management defining interruption as the suspension of a human action or interpersonal interaction that is not self-initiated. (This definition draws on an earlier definition of interruption, extending and improving it: "An interruption is the momentary suspension of a human action caused by an external source", translated from Baethge & Rigotti, 2010: 9). Generally, the UMDIA project differentiates between essential and non-essential interruptions in interaction work. An interruption is essential if it is part of the work, necessary for the execution of a task, or if it contributes to a better execution of the activity or specific task. Furthermore, essential interruptions improve customer orientation. What happens now when a third entity steps in between the customer and the service provider – such as the chatbot, acting as ambassador, representative, digital assistant, informant, digibutler etc.?

To begin with, this depends on whether or not the customer feels that their needs and requests are met, that they are "picked up where they are". Which criteria, again, does this depend on? Which conclusions can be drawn regarding the design of chatbots in the support of business customers in the software sector? We approach the question of interactivity of chatbots drawing on the concept of interaction work developed for the research and design of service work (Böhle & Weihrich, 2020). In our further research, we are focusing on a further criterion: the complementary interaction within the customer–chatbot–service provider triangle. Interaction quality is principally generated as a whole; hence, the possibilities of mutual complementation of humans and technology have to be considered. The focus on the requirements (not restrictions) of human activity leads to new potentials in human-machine interaction (Huchler, 2020).

Chatbots and interactivity – considering the literature

Interactivity in chatbots is not a new topic of development (e.g., Gentsch, 2019; Tombeijl et al., 2020; Waag et al., 2020). However, it also remains a challenge. With concepts, technologies, and best practices for conversational commerce (Gentsch 2019: 29ff), the focus is on optimizing customer interaction (ibid.: 91). Based on the key questions of how customer communication in service and marketing can be optimized and automated to increase customer satisfaction, how bots and digital assistants make communication between companies and consumers more efficient and smarter, and how customer journey optimization can be advanced and automated based on algorithms and AI, Gentsch (2019) indicates the potential of bots: automated and smart customer advisors (personalized and need-oriented) establish the best possible customer proximity and customer satisfaction (especially through services that are tailored to them individually) (ibid.: 120, 132). Time savings achieved through chatbots are beneficial to employees and allow them more time for dedicating themselves to working in depth (ibid. p. 78). They should be able to focus on addressing customers and improving the competitive position of the company (ibid.: 5). According to Gentsch, customer satisfaction is further increased by a more convenient service for customers (ibid.: 93), a reduction of the time between inquiry and response (ibid.: 125), immediate reaction times (ibid.: 160) and 24x7 self-service availability. Thus, increased customer proximity and customer loyalty enable the company to achieve competitive advantages in the long term (ibid.: 68). Additionally, new tasks are created for developers, their scope of action changing from operational tasks to a controlling function (maintenance, escalation) (provided that deep-learning algorithms are used) (ibid.: 100). Notwithstanding the great technological progress, Gentsch (2019) emphasizes that the combination of algorithms and real human interaction remains ideal in customer contact (ibid.: 76). Even if the aim is to implement both comprehensive personalization and actual interaction (and not just a communication system) as the technologies further mature (ibid.: 125), the author points out that the use of chatbots or algorithms is not recommended at any price – it should always be well investigated which touchpoints of the customer journey should be automated or supported (based on benefit-cost aspects).

Waag et al. (2020) also address the opportunities and risks of chatbots in supportive functions in the context of digital transformation. The authors distinguish two perspectives on consultative functions: on one hand knowledge transfer: here, the bot works as an expert within a limited period of time, responding to a request from someone who is in search of advice; on the other hand, co-production of solution competence: those who are in search of advice are the experts of their own needs, the advisors respond with content expertise, methodological knowledge and psychological competencies. Both forms of consultation are (at least in the classical understanding) dependent on the interaction among those who are present. Interaction among those who are absent is possible, for instance, via telephone conversations or written communication. Digitalization has detached interaction from this criterion of the participants' presence (Waag et al., 2020: 181f.). Regarding the interaction with chatbots, they state: Technical features promote the perception of the chatbot as a legitimate interaction partner (e.g., proactivity, communicability of one's own functional limitations, adaptability to the conversation partner); the deficit in double contingency (chatbots are not yet able to avoid logical breaks in dialogue) can be prevented or compensated by the personality design of the chatbot (including visual appearance, name, tonality). This suggests a chatbot that does not appear "too human" will be easier forgiven (e.g., for communicative inappropriateness). According to the authors, especially in the initial phase (e.g., data collection) the chatbot design should promote the forgiveness of mistakes. Appropriately designed, reactions of humans towards chatbots would generally not differ significantly from reactions towards other humans (use of similar courtesy norms and other generally valid interaction rules). Similar to Gentsch's (2019) analysis (making waiting times more pleasant through the bot, e.g., through a FAQ function, clarification of services, closing of knowledge gaps), Waag et al. (2020) detect the potentials of bots in knowledge transfer – through faster access to larger amounts of information, individual combinations and comparisons of individual aspects, accessibility, friendliness. The authors emphasize their suitability in front-office activities related to consultation activities (scheduling appointments, etc.), but also in collection and transfer of data to human advisors in order to facilitate the access to information and give the humans time and resources for in-depth activities. The benefit of bots is especially evident in highly structured dialogues pursuing a definite goal. In addition, gamification measures can be used. However, the authors also name risks: a limitation in the field of consultations (Waag et al., 2020: 186), is the co-production of solution competence. Here, important useful factors in human activity are the additional transmission of nonverbal signals and the presence of contextual information (even though not communicated within the interaction process) as well as the immediate synchronicity of spoken communication. The authors further note the risk of inadequacy (i.e., inadequate reactions of the bot) and hence possible aggravation and solidification of the problem, and they point towards the "overkill" risk: too much technology can lead to excessive demands or discomfort. There is an evident agreement with the notions of other authors that bots should only be used complementary to classic strategies, not substituting them. This is consistent with the results of our empirical surveys.

Lemon & Verhoef (2016) emphasize the necessity to consider multidimensional and multi-layered customer experiences within the framework of a customer journey and touchpoints of (potential) customers, for which they list the following types of experiences: sensory, affective, cognitive, social-identity. These types of experiences may be used to indicate how customers can be 'picked up where they are' and supported accordingly. However, the focus of their considerations regarding Customer Experience/Journey lies on a better understanding of consumer behavior and the increase of marketing performance. Our present article, on the other hand, focuses on the following questions: What do we know about successful customer interaction and good interaction work concerning the perspective of the employees? How can automation at the customer interface contribute to relieving the workload and not further stressing it? Subsequently, we will take a look at the concept of interaction work as a point of reference.

'Good' automated service-work through interruption- and interaction-sensitive chatbots?

Chatbots often seem more "stupid" than truly "artificially intelligent". Context-sensitive and situation-sensitive reactions are meanwhile programmable according to the state of the art, but they cannot be taken for granted. To be sure, these are minimum expectations for competent support, consultation and contact persons in services, which will be claimed also in an automated process. Enabling and establishing a chatbot in this sense is a demanding task, and it is questionable whether and in which way this endeavour is justified from ethical or social points of view. A "human-like" design – or a "delusion" that the customers are dealing with a human interaction partner – is considered critical (on ethics and artificial intelligence see cf. DKE & DIN, 2020). In this article, we focus on the question of interaction-sensitive technology design. What can we deduct from the criteria for interaction work for the design of a chatbot process? At the same time, our question is: to what extent can the requirements for interaction work actually be mapped with explicit knowledge stocks and decision rules of an application? In particular, where are the limits of the explication of knowledge (Porschen, 2008)?

Programmability of service quality as relief for employees? The concept of interaction work

The "production" of successful service relationships is not trivial and has been an issue for service research regarding work on and with people for a long time. A more detailed analysis is possible with the concept of interaction work (Böhle & Weihrich, 2020). This concept deals with the specific features of work in service relationships (Böhle et al., 2015). It focuses on the individual who is not considered as an "object of work" like others, but has his or her own needs and interests and plays his or her own part in the service relationship. Service recipients have their own ideas about how a service should be provided. In order for the service to be successful, however, employees and customers must work together. Work on and with people is therefore always interaction work!

An essential characteristic of interaction work is the demanding task of establishing a cooperative relationship between clients and service providers – this does not happen automatically (see Dunkel & Weihrich, 2012). The necessity to work on one's own feelings (emotional labor) is dependent on the specific type of encounter. As a service provider, for example, it is important to remain polite and neutral in challenging situations. Working on the feelings of the other person (sentimental work) becomes relevant when it is necessary to absorb and channel reactions – e.g., in case of a company's complaint hotline. Furthermore, interaction work is about acquiring and using a special working ability: subjectifying action, which is needed for dealing with situations of uncertainty. Subjectifying action is constituted by a step-by-step approach, perception with all senses, holistic thinking, and an empathic relationship to the "object of work" (Böhle, 2017).

The prevailing perspective in the discourse about technology and interaction work currently is that technical standardization and automation disregard the specifics of interaction work and narrow the scope for action necessary in interaction work (Hielscher et al., 2015). Is this, inevitably, always the case? In the UMDIA project, we assume that interaction work plays an important role also in digitally framed labor and, therefore, deserves special attention.

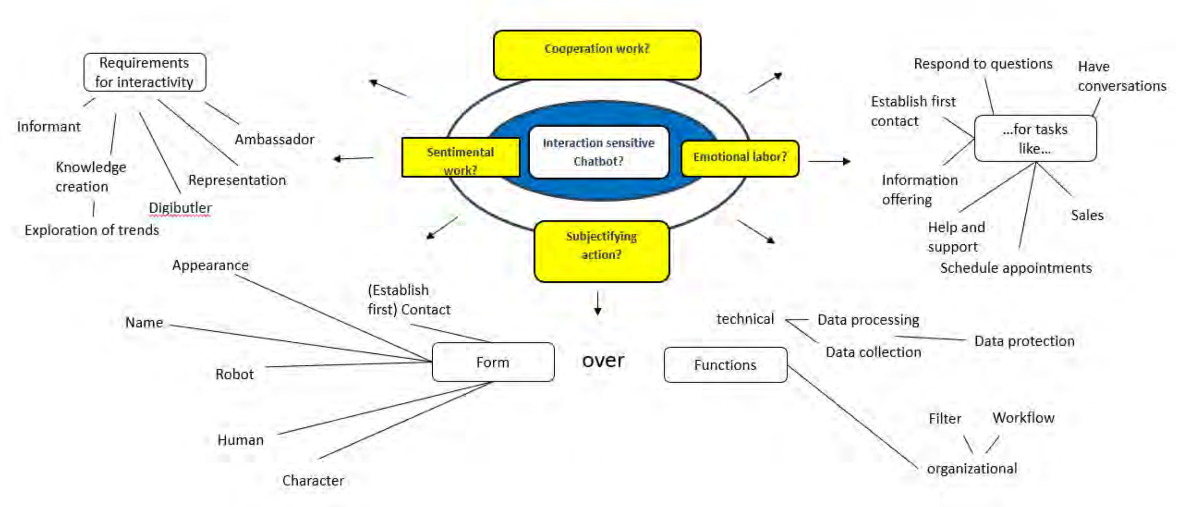
Empirical and conceptual insights into interruption and interaction sensitivity of chatbots

Current customer expectations revolve around service in real time, short response and processing times, flexibility in the contact channels and individualized and personalized notions, This means increasing challenges for customer management in several respects: in terms of data collection; concerning megatrends like differentiation, integration and synchronization of the (digital) communication channels offered; concerning standardization, automation and ultimately outsourcing of services; concerning digitized, networked work systems (Daum, 2018). In the context of these megatrends, chatbots play a key role when it comes to direct contact to customers. A brief definition states that chatbots are dialogue systems capable of natural language in textual or auditory form (Bendel, 2021). The issue of AI is often mentioned with respect to the following background: "AI chatbots use natural language processing (NLP) to help users to interact with web services or apps through text, graphics, or speech. Chatbots can understand natural human language, emulate human conversation, and run simple, automated tasks. In addition, AI chatbots use predictive intelligence and analytics to learn a user's preferences and use this knowledge to provide recommendations and anticipate needs. [...] AI chatbots are a type of chatbot that is used to help humans interact with technology and automate tasks. Improvements in AI, machine learning, data science, and natural language processing have enabled the proliferation of chatbots by making it easier to build conversational bots for a variety of applications that benefit companies, their customers, and their employees." (https://powervirtualagents.microsoft.com/en-us/ai-chatbot/.

Interruption-sensitive chatbot processes have to be interaction-sensitive

There are several starting points for designing an interaction-sensitive chatbot, as indicated in the figure below. The centerpiece is the concept of interaction work. Around this center, we indicated several issues that can be used as starting points for the development and design of a chatbot. It is evident that very diverse issues have to be worked on in order to find solutions for our problem focus on interruption and interaction sensitivity. We shall concentrate on possible areas of tasks/responsibilities and technical functionalities.

Figure 1 Starting points for chatbots and interactivity



The following overview shows the empirical findings of the employee surveys conducted in the form of participatory research. Individuals from development functions as well as support, sales and product management areas provided information on what good customer interaction means to them, where significant interruptions to their work occur and what kind of support they can imagine from a chatbot process regarding the management of interruptions. From this, we derive conclusions for an *interaction-sensitive chatbot*. At the same time, we take note on limitations of the chatbot process regarding interaction work.

Table 1: Empirical insights: Possible relief for employees through chatbots

Interruption caused by …	Contribution of the chatbot for the interruption management	Contribution of the chatbot to the support of interaction work	Limitations of the chatbot with regard to interaction work
Missing assignment/ classification/ information of the request	Comprehensive information offering & correct assignment minimizes interruption (i.e., the "stop"); in the event of problems immediate involvement of human support possible	Connecting the client to the right/actually responsible contact person and producing "informed customers" support the establishment of cooperation	Lack of emotional and content-related involvement; deep understanding is only possible through personal involvement. Deficits: sentimental work, subjectifying action
Chronological processing of requests	Prioritization and classification of requests based on content/atmosphere (mood)/urgency	Pre-sorting and early warnings may support subjectifying action ("going into the case")	Deficits: holistic picture, overall evaluation is missing, sentimental work of great importance for de-escalating situations
Non-sustainable information exchange	Customer access to information independent of time (operating 24/7)	Flexibility and 24/7 accessibility support the establishment of cooperation	Deficits: limited possibilities of explication, information not the same as knowledge (also: data protection aspects), subjectifying action
Individual case consultation	Proposed solutions are prepared and allow faster processing of requests	Supports the establishment of cooperation because customers might be "picked up" better and faster through pre-conceived solutions; may support subjectifying action	Deficit: limitation of chatbot in all four dimensions of interaction work, interaction with customers still important
Communication with interfaces	Automatic initiation of the next steps or workflows	May support subjectifying action by relieving/reducing coordination workload	Deficit: possible restriction of scopes of action
Coordination work	Chat tool intuitively considering availabilities of the responsible worker/person by linking to their day planner	Less coordination efforts may mean more time for content-related tasks	Deficit: Interferences in time management and organization of the individual may be irritating
Frequently asked questions with little need for explanation	I) Standard questions are answered by bot II) Focus on intensive consultation and sales	Supports establishment of cooperation for intensive consultation and sales by relieving and reducing workload	Standard questions are received through all communication channels; in order to deal with the cause of the request, further information is usually required
Communication diversity (multi-channel)	Reduction of work interruptions due to requests in the current chat	Possibly supports establishment of cooperation for intensive consultation and sales	Operation of other communication channels remains – customer knowledge level crucial for success

Based on the previously presented insights, we ask: **<u>what</u>** can a chatbot contribute to *interruption and interaction sensitivity* and **<u>how</u>** is this possible? The project identified the following aspects of the chatbot process that are of added value at the customer interface:

1. Finding information easily (maintaining information, bringing it togeher) and supporting employees by filtering requests;
2. Collecting, preparing and forwarding (relevant) information;
3. Chatbot as an ambassador also acts as a representative of the company. The public image is determined by speech/public address, language, terminology, addressing clients formally, personalization, first impression (look and feel), information preparation etc.;
4. Detection of new trends and information – expansion of the database;
5. Butler for performance records (positive, negative, non-responsive points), which can be used to further learn reactively based on request from external parties – an assistant for employees;
6. Developing competencies of the chatbot in order to enable it to process new use cases (active: learning and including new information...).

Chatbots are evaluated positively as a tool of support with potential for *real* help – not frustration (!) – through clarity and transparence, immediate feedback, reduction of mobility efforts, also for further interaction work between service providers and service recipients. The Items must be designed in compliance with General Data Protection Regulation regulations (DSGVO: no storage of personal data, transparency etc.). The visualization of the process chain, making the process transparent, was also evaluated to be useful further on. Ideally, the chatbot should be able to understand the language of the customer and, if possible, take their individual competence levels into account when presenting the response categories. This makes for an ambitious program given the resources for development in an SME in the software industry. However, if the chatbot works unsatisfactorily for customers, it becomes a liability, creating interruptions or disruptions that complicate or burden the further interaction work between service provider and customer.

Limitations of the chatbot regarding interaction work

Research literature as well as empirical findings address both potentials and limitations of chatbots with respect to their capacity for interactivity. So far, clear statements are: consultation and sales activities require personal exchange to realize customer-orientation and high-quality solution finding (co-production). It is necessary to establish a personal relationship with the customer, comprehending and responding to the customer’s situation, in order to create added value for the customer with new solutions. Although, according to the surveys, chatbots have the potential to provide relief in the volume of inquiries (e.g., through the filter function), a potential deterioration of the company image also has to be considered, since the company is currently seen as particularly *customer-oriented, partner-oriented, interest-oriented* (USP). A simple statement in this regard is: “The chatbot remains a bot.” Comparing it to real humans, it can only less adequately estimate the reaction of the client or customer (sentimental work), but does not have to protect itself the same way as employees have to do sometimes (emotional labor). Considering interruptions by customers who are not very interaction-oriented, the chatbot’s lack of empathy can result in problematic situations. No matter if it concerns missing information or services that are not yet available etc. – a chatbot cannot take over personal assessment and persuading.

In the following section, software-technical perspectives of the company partner developing the chatbot process are introduced according to the above problem descriptions for interruption and interaction sensitivity.

Software engineering perspective of an interruption- and interaction-sensitive chatbot

Especially for small and medium-sized companies, the implementation of interruption- and interaction-sensitive chatbots poses challenges with regard to the resources available. Thus, on the process level as well as on the level of machine learning models, ways have to be found to generate usable results with as little effort as possible. Subsequently, the approach of the developing enterprise partner is described under these general conditions.

Interruption sensitivity

Categorization of chatbot skills

In various interviews with domain experts, the necessary skills of the chatbot were designed. From these concrete skills, more abstract skill categories were developed that serve as the basis for the design of use cases and their technical implementation. The table below shows the designed skills as a pair of expected user interaction and desired behavior of the chatbot.

User interaction	Chatbot behavior
Questions regarding the operating system	Forwarding to FAQ
Questions regarding the device	Forwarding to FAQ
Questions regarding the Outlook integration	Forwarding to video tutorial
Questions regarding archiving rules	Forwarding to video tutorial
Questions regarding user management	Forwarding to video tutorial
Questions regarding webinars	Forwarding to online training
Questions regarding company	Forwarding to about-site
Questions regarding prices	Forwarding to price overview
Questions regarding order processing contracts	Forwarding to download section
Questions regarding product functionalities	Forwarding to online article
Consultation request	Handover to an employee
Questions regarding test versions	Handover to an employee
Questions regarding differences of products	Conversation with chatbot
Cancellation request	Direct answer
Purchase request	Direct answer
Questions regarding data privacy	Direct answer
Appointment request	Conversation with chatbot and email to employee
Without definite purpose, chat, or spam	Say hello, introduction, help, say goodbye

Six skill categories can be derived: (1) FAQ & forwarding, (2) direct answers, (3) consultation with an employee, (4) appointment, (5) product consultation and (6) small talk & spam. Generic use cases are created for these skill categories, which are translated into technical chatbot skills by integrating specific data and using machine learning models. The skill categories derived are based on the employee survey described above in the context of participatory research. It should be noted that the chatbot can be made increasingly complex in further stages; what is described here are first important steps.

The ability of the chatbot to directly answer standard questions eliminates a lot of interruptions for employees. The questions that the chatbot can answer are not only about the area of sales, but will also include support questions and other areas in the future. The chatbot uses the intent classification described below to help assign user queries to the different areas of the company. In further implementation stages, the bot should automatically forward users directly to other systems (e.g., support) and use all the information already collected for a smooth transition. For example, once a support request has been classified, it can be transferred to the support system together with the user information and a new support ticket can be created.

The ability of the chatbot to directly connect users with employees supports the establishment of cooperation in the sense of interaction work. For example, it makes sense for the chatbot to check the calendar of the employee for free slots in order to only contact available persons and thus support the establishment of a fruitful cooperation, at least in further steps. Later on, the chatbot can be integrated into a separate system that dynamically organizes the availability of employees (e.g., traffic light system for availability, preferences for topics, etc.).

Appointment scheduling between users and employees carried out by the chatbot supports coordination work in the sense of interruption management and creates time for employees to execute their work. In the first stage of development, the chatbot records the user data required and sends an email request to employees, who in turn make the appointments (asynchronously). In further stages of development, it will be necessary to automate the appointment-scheduling process. Individual appointment preferences of the employees can be learned and taken into account using machine learning methods.

Use cases, dialogue design, chatbot skills

For each skill category, a use case template was created describing the actors, preconditions, postconditions, and failure cases. In addition, comments can be added and the scenario of potential success (happy path) can be described. As an example, the complex use case for an appointment request will be described in more detail here.

Example: Use Case Appointment Request

Actors: users

Preconditions:

1. User has expressed interest in consultation. There is currently no employee available for live chat
2. User has explicitly expressed to make an appointment with a real person
3. User has the chat client open

Postconditions:

1. The required contact data were saved (name, phone number, email address)
2. The request has been noted
3. Employees have all the information to make contact
4. Employees contact customer on the basis of saved contact data

Happy path:

1. User sends request
2. System recognizes that it is an appointment request and offers that service
3. System asks user if he or she wants to create an appointment with an employee
4. User affirms
5. If not already specified in the dialogue, chatbot will ask the following questions to gather information:
    a. System asks for name
    b. System asks for email address
    c. System asks for phone number
    d. System asks for details on the problem

6. User provides the information
7. System validates the information and asks user for confirmation
8. User confirms
9. System saves the data and forwards the appointment request to the relevant department

Failure cases:

1. Chatbot recognizes the question incorrectly and thus does not provide the correct answer
2. User cancels the request because he or she does not want to provide his or her data
3. Contact details of user are not correct
4. In the event of failure, previously entered data will be deleted and user will have the opportunity to create another appointment or make another request

An interesting aspect can be seen in point 5 of the happy path: certain data is only requested if it is not already known. For example, if the email address has already been requested in the conversation with the chatbot, it is not requested again, which speeds up the entire process and makes it more convenient for users.

For the technical design of this procedure, state-of-the-art techniques from the field of named entity extraction are used (see below).

The structured formulation of the use case above can also be represented as an UML flow diagram, which facilitates discussion about the described processes across team boundaries. It is very easy to establish communication between business experts and software development or data science teams, since a generally understandable description is available.

Data-driven design process

The main tasks of the chatbot are to determine the user's goal (user goal classification) and to conduct goal-oriented dialogues in order to establish a satisfactory state for the user. We have chosen a data-driven process for achieving these goals, as this results in a realistic implementation. The process can be divided into the four phases (1) create data (annotation), (2) dialogue design (stories), (3) model training and (4) system integration.

(1) Create data (annotation)

With annotated data, machine learning models are trained in process step (3). These models make a prediction of the most probable user goal. For this purpose, pairs of data are formed, which on the one hand consist of possible utterances of users and on the other hand define the associated user goal. A pair of this annotated data set could look like the following:

("Ich würde gern einen Termin mit einem Berater vereinbaren", APPOINTMENT)

Possible utterances of the users are partly taken from real chat conversations and were also manually maintained by experts. The labels to be determined by the are often referred to as intents in chatbot systems and the task of determining labels as intent classification. Since it is not possible for a medium-sized company to generate thousands of high-quality training data, models are used that deliver good results even with very little data (see below).

A particular challenge lies in the trustworthy collection of data to improve functionalities of the chatbot. In a first development stage, it is necessary to display a privacy statement to the user when the chatbot is initially opened. In further stages of development, we believe it also makes sense to deal with this issue more openly in the sense of interaction sensitivity, and to create real transparency about the data collection. Ideally, the collection and use of data can be negotiated directly in dialogue with the chatbot. With methods of context sensitivity, as described below, it is possible for the user to ask questions about the data collection when he or she is already in a conversation with the chatbot, e.g., when filling out a contact form, without interrupting the conversation.

(2) Dialogue design

Interactions between the chatbot and users are modeled in dialogues. A dialogue consists of potentially several intents which reflect intention of the user, as well as associated actions. An exemplary dialogue for making an appointment could be modeled as follows:

User intent: Requestion an appointment
Chatbot action: Ask for the name
User intent: User utters name
Chatbot action: Ask for email address
User intent: User utters email address
Chatbot action: Confirmation of receipt of the data
Chatbot action: Chatbot utters that date proposal will be sent

The dialogues were designed together with domain experts and cover the cases described above. The technical implementation of the dialogues was made with stories of the RASA[3] framework. With this framework, sequences of intents and actions, as in the example above, can be easily noted in natural language in a YAML files. In addition, entities (e.g., names, email addresses etc.) can be specified that should be extracted from the conversations.

It is very important to involve domain experts in the creation of dialogues, as they understand the interaction patterns of the company and are able to map them to the dialogues. This is linked to the question of how company culture can be transported by the appearance, behavior and skills of the chatbot. For example, irritations in the customer journey can arise if the chatbot uses more familiar forms of language (e.g., German "Du") and employees in following steps use more formal ways (e.g., German "Sie"). In future work, historical human-human conversations will be analyzed and included in the creation of dialogues.

(3) Model training

With the data created in step (1), models are trained to determine the intents of the users in the dialogues and to extract important entities (e.g., email addresses, names, dates, etc.). As NLP pipeline for natural language processing de_core_news_sm from spaCy[4] was used. The intent classification was implemented using the DIET classifier (Bunk et al., 2020) of the RASA framework. DIET stands for Dual Intent and Entity Transformer and is based on a transformer architecture that simultaneously handles both entity extraction and intent classification tasks. The big advantage for mid-sized companies in using these complex models is that only few training data (about 20 to 100 per intent) are needed to achieve good results.

(4) System integration

The chatbot functionality (intent classification as well as the created dialogs) is provided via standardized REST interfaces, which makes system integration highly flexible. Created user interfaces can be arbitrarily exchanged or designed for different use cases without limiting the functionality. In this way, it is possible to display different interfaces for different target groups.

A typical chat interface was designed, as known from various websites. When designing the interface, the question of how to communicate the culture of the company again plays a role. Is an avatar necessary? Is the avatar a human? Does he or she have a name? These questions must be answered carefully in collaboration with experts in these areas. The answers clearly depend on the use case. As an additional component, an interface was created for company employees that allows them to intervene in ongoing chats and take over communication with users, if desired.

Handing over the conversation to a human

Our chatbot process offers the possibility to recognize when the chatbot-human interaction is no longer useful and a human-human interaction is desired. For this purpose, some dialogues were designed in such a way that users are asked whether a human-human interaction should be established. In this case, employees are notified (currently by email) and can participate in the chat.

The requirement to display the information that has already come about in the chatbot conversation as clear as possible for employees was not pursued further, as all the employees surveyed felt that the conversation itself was clear enough in the current development stage. However, it is important that employees have access to this information in order to make the transition as pleasant as possible for everyone involved. A functionality planned for future development stages attempts to predict in ongoing conversations between

[3] https://rasa.com/docs/rasa/stories, accessed on 01.10.2021

[4] https://spacy.io/, accessed on 01.10.2021

chatbot and human whether and when a handover to employees will be desired. In this case, employees would be notified at the right time so that they can prepare themselves appropriately for the conversation. However, there is a risk of incorrect prediction at this point, which can lead to employees being interrupted even though there was no need.

Evaluation

In order evaluate the intent classification and to answer the question how well the chatbot prevents employees from interruption, the chatbot was made available internally and evaluated on real interaction data. For this purpose, 1153 chat dialogues were collected over a period of two months and subsequently evaluated. A precision of 0.841, a recall of 0.817 and an F1 score of 0.799 were achieved. However, these results should be handled with care. There are intents that performed particularly well in the evaluation. Purchase requests were answered 100% reliably, appointment requests 90%. Intents from the spam category performed worst with an F1 score of 0.44.

In principle, it can be said that the chatbot is capable of answering a large number of queries and thus relieving employees. However, there is a non-negligible risk of losing users due to incorrect classification. In order to improve communication and hopefully increase user satisfaction, context-sensitive strategies are presented below.

Interaction sensitivity

In this section, the integration of context-sensitive behaviors of the chatbot into the dialogues is described, which should increase usability and effectiveness. In the context of this work, context sensitivity is understood as the incorporation of the previous conversation between human and chatbot into the current dialogue and the actions derived from it. Context sensitivity enables a meaningful continuation of the dialogue in the human-machine interaction and is thus an important contribution to the interruption- and interaction-sensitive chatbot process. The notion of context sensitivity is described in more detail by appropriately categorizing it into different use cases. Subsequently, details on the technical implementation are presented.

Use cases

Context sensitivity, which takes into account the conversation that has taken place so far, can be categorized into use cases as follows.

Establish reference to the closer context

Context-related user input such as follow-up questions refer to the immediate context, i.e., to what was said immediately before. They follow on from an initial user input in which a topic was established and refer to this without having to explicitly name it again. The interaction with the chatbot is significantly simplified, since the question does not have to be repeated for contextually similar questions.

Establish reference to the broader context

In addition to references to the immediate context, there may be user input that refers to the broader context. For example, the user may want to correct previously given information, even if it was given at a much earlier point in the conversation. In addition, there are requests from users for which the overall situation of the conversation must be recognized in order to answer them, for example, if the user wants to know whether more data is needed during data collection or if he or she wants to cancel the session completely.

Recognize and resolve ambiguities

Various ambiguities can arise in the course of the conversation. These can be caused by the omission of necessary information by users or by the course of the conversation itself. In the first case, it must first be recognized that information is missing, after which it can be explicitly requested by the chatbot. In other cases, some information may already have been collected, but at an earlier time and possibly in a slightly different context. In this case, it must be decided whether this information is still valid for the current state of the conversation and can simply be adopted. If this is not the case, the information must be requested again.

Responding to deviations

A deviation represents an abrupt departure from the current dialogue path. It occurs when a new topic is introduced even though the current one has not yet ended. This can be followed either by a return to the original topic or by discarding the topic altogether. A distinction is made between the following deviations:

- **Topic changes initiated by the use**r - If the user deviates from the current conversation path, the chatbot must be able to respond to this and also respond meaningfully to further follow-up input from the user relating to the new topic. On occasion, the user can be asked whether a return to the old topic should take place.
- **Topic changes initiated by chatbot** - In addition to topic changes initiated by the user, external events can also redirect the course of the conversation. If such an event occurs, the user receives a message from the chatbot regarding the deviation, regardless of the current course of the conversation. The user can ignore this message and continue to follow the current conversation path or ask follow-up questions regarding the external event and then continue to follow the original conversation path.

Technical implementation

There is already a large body of work on context-sensitive dialogues in chatbots (e.g., Han et al., 2021; Jia et al., 2020; Zhou et al., 2018). All of these studies have characteristics that are unsuitable for implementation in medium-sized enterprises. Many of them are about open-domain chatbots, meaning that the topics on which the chatbot can make utterances are not limited. In enterprises, however, it is important to be able to control the range of topics. Other studies use generative models to generate the output. This has the disadvantage for companies that the chatbot's responses cannot be sufficiently controlled. Other aspects are large amounts of data necessary or insufficient implementations. For these reasons, an implementation is presented here that is suitable for use in medium-sized companies.

For the implementation, following the categorization described above, context-sensitive dialogues are designed, still consisting of user intents and chatbot actions. These defined dialogues are used as training data for a machine learning model, the Transformer Embedding Dialogue (TED) policy (Vlasov et al., 2019). Through this approach, it is possible to learn generic conversational trajectories, which allows unknown dialogues to be appropriately context-sensitive. It follows that for each known use case, it is sufficient to design a finite set of such dialogues to enable context-sensitive actions by the chatbot.

These dialogues are technically created within the RASA framework in YAML files as stories. The following notation shows an example of the modeling of a topic change initiated by the user, followed by a return to the previous conversation.

- story: create with topic switch in between
  steps:
    - intent: create
    - action: generic form
    - active_loop: generic form
    - intent: show
      entities:
    - data_type: a_data_type
    - action: action_show_list
    - action: utter_continue_create
    - intent: affirm
    - action: generic form
    - active_loop: generic form

At the beginning the user goal is to create any data record. This could be, for example, an appointment with the sales department. Via the active_loop: generic_form all relevant data is continuously queried (name, email address, etc.). The actual implementation of this data query is called in the background as a Python script. During this loop users have the possibility to ask questions (intent: show). This could be, for example, the question of why an email address must be provided (purpose of use of data). The chatbot then asks whether the data recording should be continued (action: utter_continue_create). After affirmation by the user (intent: affirm), this is carried out (action: generic_form in the penultimate line).

In this example, the generic implementation of the dialogue can be seen. It is a general loop for recording information and general queries. The specific queries are stored as data in their own use case-specific intents.

Evaluation

Context-sensitive dialogues can be implemented relatively easily by designing context-sensitive dialogue examples and offer real added value for users. One example of feedback on this: "It feels like a real assistant." Through the intuitive description in a flow of user-intents and chatbot actions, even medium-sized companies are able to integrate context sensitivity into their chatbots. A challenge that still needs to be solved is that users are used to chatbots without context and do not resort to context-sensitive interactions on their own. Consequently, the potentials only unfold through learning the possible context-sensitive interactions.

Conclusion

In the article, we presented possibilities towards a more interaction-sensitive chatbot that is supposed to improve or facilitate the task of grasping the customer's needs as well as the process of handover and collaboration with coworkers. Considering the capabilities for working on and with people, which we outlined as interaction work, interactivity in chatbots appears to be an approximation at best. In that case, chatbots can provide constructive support for employees, if they are, at the same time, able to convey, inform, and guide customers appropriately and enable personal contact: In this way, they can contribute to minimizing interruptions and to high-quality service and consulting work through their function as an interaction touchpoint. For this to succeed in the interests of the affected employees, it is crucial that the employees are themselves involved in the development process. From a software development point of view, challenges especially arise from the creation of high-quality data and dialogues that portray real conversations. The quality of the conversation further depends on the respective ability of the chatbot to comprehend both natural language and the underlying user goal and follow up with adequate action. Therefore, incorporated state-of-the-art models have the benefit of already existing comprehensive abilities of speech and language. In this case, the remaining focus for the company lies on the creation of domain-specific data only. Chatbots will become more intelligent and approach human interaction patterns. Of course, the design remains linked to a number of issues, not least the desired division of labour between humans and machines. But also users need to be trained to use context sensitive interactions in order to gain a real added value from the chatbot process.

The field test of the outlined measures in the innovative software SME described above, where further customer touchpoint development is mandatory for a platform-based business model, is still pending. In this context, there remains a need for further research and design – both considering social science and software development perspectives. Furthermore, the connection to the *HAI-MMI: Humanizing AI Men-Machine Interaction* concept (Huchler 2020) that relies on complementary relationships between human work and machine work appears to be appropriate and promising. It takes into account the importance of organizational embedding and division of labor across different levels of society, organization, work environment, human-AI interaction and human-AI system. Moreover, this concept also introduces quality levels of human-machine interaction, referring to coordination, division of labor, adaptivity, learning, and empowerment. Additionally, the inclusion of design criteria such as protection of the individual, trustworthiness, conducive working conditions and adequate division of labor is necessary. In the end, it is about nothing less than the integration of humans and AI in an overall spectrum (Andrè et al. 2021). This is without question also relevant for AI-based chatbot processes.

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7
Topic »From Industry 4.0 to Service 5.0 – Servitization of Specific Industries«

7.1
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- **Context Sensitive Field Service Assistance Based on Digital Twins**
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Context Sensitive Field Service Assistance Based on Digital Twins

Eckart Uhlmann, Julian Polte, Claudio Geisert (Fraunhofer-Institut für Produktionsanlagen und Konstruktionstechnik IPK, Germany)

Problem/Goal

Despite increasing automation, the use of (mobile) robots and artificial intelligence, humans are indispensable in industrial production due to their numerous abilities. Therefore, assistance systems are becoming essential due to the growing complexity of processes and the increasing range of tasks for employees. Especially in maintenance, repair and overhaul (MRO) of capital goods such as production machinery, professional competences in the disciplines of mechanics, electronics and informatics are becoming mandatory. Globally operating production networks and supply chains as well as the lack of skilled workers confront technical customer service with major challenges. Static instructions are still frequently used today to support technical service personnel in the field. These make it difficult to react to complex tasks in a way that is appropriate to the situation, as the necessary up-to-date information is lacking. The time-consuming gathering of information leads to inefficient service calls, as the time spent on the actual value-adding activity decreases in relation to the total duration of the call. The resulting mental stress for the service technician also increases the likelihood of errors and poorer qualitative results.

With the ever-increasing availability of up-to-date data and information in the age of digitalisation and Industry 4.0, innovative approaches for context-sensitive assistance systems are attracting more and more attention in research and development. The aim of the solution approach presented here is to support service technicians on-site in carrying out the necessary work steps by providing context-sensitive assistance. In this way, it is intended that service calls become more efficient and deliver high-quality results. MRO activities are particularly suitable as potential use cases for context-sensitive assistance, as they vary widely. Furthermore, they include tasks that can be easily mapped to tasks in product manufacturing such as set-up and assembly.

Methodology

On the one hand, the increasing interconnectivity of people, objects, processes and services since the introduction of Industry 4.0 represents a major challenge for industry, as the previously rather clearly separated areas of information technology (IT) and operation technology (OT) can no longer be considered separately. On the other hand, the ubiquitous, surrounding networking results in great potential for creating effective and efficient processes in production and maintenance. Enabling technologies and concepts such as the Industrial Internet-of-Things (IIoT), intelligent sensor nodes, edge and cloud computing, smart devices and Digital Twins (DT) have already reached a high level of maturity and, as best practices show, are already in use in industrial production.

Digital twins enable the consequential use, aggregation and target-oriented provision of data for a multitude of applications along the entire value chain. In the field of MRO, the continuous monitoring of the production system's health status as the basis for predictive maintenance as well as intelligent context-sensitive assistance systems for effective and efficient service provision are of particular importance. In the approach presented here, the digital twin describes the virtual representation of a production system including the associated service shares in the sense of an industrial product-service system. This means that information is not only available on the as-designed and as-built status, but also on the as-maintained status. In addition to the current hardware and software configuration, this also includes the individual wear states of the installed replacement parts as well as the entire system history.

Condition monitoring is used to record data on the production system, which can be used to derive the state of wear - and in the best case the expected remaining useful lifetime - of functionally relevant components. In the use case implemented at Fraunhofer IPK, the condition of a ball screw of a feed axis of a machine tool is monitored using vibration data. For this purpose, a MEMS-based 3-axis vibration sensor was mounted on the ball screw nut. Vibration data recorded during a purpose-designed test run is captured by a Raspberry Pi as the edge device, analysed using a classifier based on a machine learning model. The classification result, together with the underlying features, is sent to an IoT platform via the MQTT (Message Queuing Telemetry Transport) network protocol, which is meanwhile widely used in machine-to-machine communication. There, the data is assigned to the corresponding assembly and permanently stored. If the classification result has detected a bad condition of the ball screw, an alarm is generated via a trigger function of the IoT platform. Thus, the preconditions for the initiation of a service call are created and the planning of the call can be carried out in consultation with the system owner.

To enable the service technician to carry out the work steps to be performed efficiently and without errors, they are made available to him in a mobile assistance application. This application then guides the service technician interactively through the process steps on site, whereby the application provides context-sensitive instructions, based on online data of the current situation. The approach chosen at Fraunhofer IPK for this assistance system is based on process models created using either the »Integrated Enterprise Modelling (IEM)« or »Business Process Model and Notation (BPMN)« method. Both methods can be used to model complex workflows and integrate online resources. In this case, the Digital Twin of the system acts as an online resource. In order to create an interactive graphical user interface (GUI) from the process model, a GUI engine was developed that interprets the model and provides the corresponding GUI as a platform-independent HTML page at runtime. Requests are made to the IoT platform resp. the Digital twin via a REST (Representational State Transfer) interface, which is widely used for cloud services, and the next process step is initiated depending on the response. For example, the concept specifies that before starting specific work steps, it must be checked whether it is the correct physical instance. For this purpose, these instances are labelled with a QR code that contains the serial number of the instance.

When performing the work step, the service technician is requested to record this serial number with the camera available in the smart device, e.g. a tablet, and to send it to the digital twin for matching. If the comparison with the information stored there is positive, the next work step is displayed. If the comparison is negative, suggestions are made on how to proceed. The process is similar if different follow-up activities have to be carried out on the basis of a sensor value, e.g. for the assessment of a fill level. Measured values that cannot be requested from the digital twin due to a lack of sensor equipment or IoT connection can be entered manually by the service technician and sent to the digital twin for comparison with a set value. If a component is replaced during a service call, the serial number of the newly mounted component is also scanned and the changed configuration is updated in the digital twin after the upload, whereby the information on the replaced component is retained as history. With this approach, maximum accuracy can be ensured when carrying out the work steps, as potential incorrect entries are reduced to a minimum. In addition, all activities carried out can be documented automatically, considering the protection of personal data, and can also be stored in the Digital Twin.

With the presented approach of a context-sensitive assistance in combination with a Digital Twin, not only service calls can be carried out more efficiently and with higher quality. It also enables the creation of a complete history of the production system, which serves as a machine-readable database for the application of machine learning methods. The modularisation of the process models is currently still a challenge. Reusable sub-models that can be easily transferred to other processes are essential to reduce the complexity of the modelling and thus increase acceptance in industry. Fraunhofer IPK is currently working together with industrial partners to develop a procedure for generating suitable process patterns in order to solve this open problem.

Results

A holistic concept for the realization of context-sensitive assistance based on digital twins and MRO process modelling for mobile technical service was presented. First of all, possible use cases in the context of MRO were shown. Based on this, the fundamental requirements for the necessary system architecture were derived and an approach for a model-based development of context-sensitive assistance was introduced. Furthermore, a concrete implementation was presented by means of an example. The article concluded with a critical discussion of the strengths and weaknesses of the concept.

Towards HVAC system for Industry 4.0: Methodology

Atte Partanen, Jukka Pulkkinen, Genrikh Ekkerman (Häme University of Applied Sciences, Finland)

Problem/Goal

In the past few years, we saw a fast transformation of different smart things to start communicating with each other through the Internet. These smart things called cyber-physical systems (CPS) were made by innovations in ICT (Information and Communication Technologies) and cloud computing. This trend is called the 4th Industrial Revolution, Industry 4.0, which started in Germany. Smart buildings are one domain in this development where the latest technology can be utilized to improve energy efficiency, reduce the CO2 footprint, and increase comfort among the residents.

By most definitions, the semantic roles of different sensory and control systems within a smart building are unambiguously understood by the digital applications and algorithms reading, controlling, and augmenting them. This enables seamless interoperability between different systems.

Building automation system (BAS) holds a role of a system integrator within a building, controlling not only heating, ventilation, and air conditioning (HVAC) aspects of the building, but extending its influence to domestic water, lighting, access control, and beyond. Sensors, actuators, alarms, and other points of interest within a BAS are usually represented as points. Points are often coarsely categorized as digital inputs (DI), digital outputs (DO), analog inputs (AI), and analog outputs (AO) in the system's internal data model. While this encodes some information about the point, most contextual and semantic information (e.g. where the point is located, what it measures or actuates, and to which larger system it belongs) has traditionally been described in the label or name of the point. Different naming conventions with conventions specific to the year of construction, system vendor, and site exist, all requiring implicit domain knowledge[1]. While unified building information modelling and strict procedures can produce newly constructed smart buildings, integrating smart services into the large aging building stock is a bottleneck that affects all positive achievements by Industry 4.0. Our research focuses on evaluating one pathway that aims to solve the issue of moving older buildings with legacy systems towards Industry 4.0 framework.

Methodology

In this study, we evaluate a methodology for the creation of smart buildings according to the Industry 4.0 framework, including data integration between an existing building automation system (BAS) and cloud computing and digital representation of building systems according to Brick Schema [2]. Brick Schema is metadata standard for digital representation for the building covering physical, virtual, and logical points of view and their relationships. The evaluated methodology focuses on modelling the points within a BAS as semantically linked data while taking into account the heterogeneous nature of the naming conventions, presence of human errors, and other irregularities. The BAS connectivity to cloud computing according to Brick Schema creates a platform that enables scalable smart building applications.

The conversion process of BAS point information to Brick Schema ontology started with extracting HVAC point information from the BAS to generate collection entities of system equipment points. These entities were split into groups with different structural parameters. After creating groups, information can be enriched with different rule sets. Rulesets were generated to match different hierarchy models and standards to break up the point information into Brick Schema classes. These rule sets were made to cover each group following Brick Schema ontology by defining collection, equipment, location, measurable, and point. By defining these rules Brick Schema generates relationships between system, equipment, and point. After rule sets were created this information with entity groups are combined and as a result, extracted BAS points have matching Brick Schema ontology model information.

When the conversion process was completed, information was processed to RDF (Resource Description Framework) triples. This RDF then contains BAS point entity information and generated Brick Schema classes. The RDF format can then be used as a query platform to generate APIs to increase possibilities to expand the usage of the BAS system. These APIs can be used in all defined levels of Brick Schema, which includes collection, system, equipment, location, measurable, and point.

Some problems came into account when extracting BAS points. Some of the point information wasn't following the original standard naming format. These points were in most cases empty naming spaces left for the extended equipment. When the structural point naming was changing, this needed to be taken care of in process of handling groping and finding the meaning of each structural form of parsed information. In the conversion process, these points weren't important information to model for Brick Schema by the complexity of changing structures.

Results

The methodology was tested with a case study of the school building in Tampere. Our case study focuses on the heating, ventilation, and air conditions (HVAC) system in pilot building and data integration and its digital representation according to Brick Schema. Our results can be further developed to automate the conversion process in heterogeneous buildings and in this way creates scalability to the Industry 4.0 framework in the area of smart buildings.

In our testing, a school building in the City of Tampere, Finland was used as a pilot platform to process the methodology approach. The pilot had a total of 551 entities of system equipment points. These entities were split into groups with different structural parameters total of 57 groups. These groups then were processed with created rule sets matching the Tampere BAS naming standard.

In conclusion, Brick Schema ontology models were covering Tampere school building points with the focus scope without problems. When rule sets were made match Tampere city BAS naming standard this way the conversion process can be extended to buildings at Tampere city level. This ontology model then enables BAS systems to be integrated with the knowledge that is not included in the point information.

Keywords: HVAC, Smart Buildings, Ontology, Brick Schema

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AI driven analytics service for supporting municipal employees after heavy wind events

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Problem/Goal

Public service faces some major changes and challenges in near future due to demographic changes and upcoming restructuring towards new work forms. Actors in public service need to be prepared for working with fewer and less experienced employees, since many highly experienced employees of high-birthrate years will start drawing pension soon. Additionally, challenges like the climate crisis and upcoming mobility transitions will increase the amount and complexity of tasks public service will be faced with. This will put massive pressure on the public sector to work more efficiently to fulfill all tasks for citizens with constant or even increasing quality. To counteract these effects, municipalities see a need for innovations and adaption of working processes towards more optimized, digitalized, and automated processes. These can be based on data driven services, as data is some sort of experience, all employees can benefit from.

After heavy wind events, municipal utilities or departments must clear cities from windthrow like broken branches, trees, or other items. Often the dimension of necessary work is only visible the day or morning after the heavy wind event. Then, necessary tasks need to be planned and other tasks need to be postponed at short notice. Therefore, it is important to gain knowledge about the risks of upcoming weather situations as early as possible to adapt staff and task planning in advance.

For an efficient scheduling of the clearing work, experience from similar previous situations can help. To improve efficiency and planning quality for all employees, we aim to create a digital service for municipal employees that can predict the risk for windthrow for the upcoming days. It shall display the probability whether the municipal employees need to act within the next days, considering the current weather forecast. Using our service, the task and staff planning can be adapted earlier. The service will be created by analyzing data of previous heavy wind events and their effects using AI and Machine Learning methods.

Existing work on risk prediction services for windthrow and problems after heavy wind events doesn't focus on urban areas and public service, rather than on optimizing maintenance work in industries like railroads or at utility companies.

Methodology

The problem was identified conducting interviews with municipal organizations regarding green care as a major unoptimized focal point. Similar as workers learn to assess weather situations with increasing work experience and estimate the necessary tasks, we try to do this estimation by analyzing historical data using AI and Machine Learning methods. A crucial step for creating a digital service for the municipal employees is gathering data about windthrow. As many departments aren't digitalized enough and do not collect data with the necessary details about work carried out previously, other data must be utilized. Data about emergency calls related to wind can be an indicator for previous points in time, when windthrow happened. However, emergency call data has some drawbacks. The time the call was made does not need to match the time of the incident and emergency calls are often made only if there is personal injury or a potential risk for personal injury. Additionally, in our test scenario emergency calls were archived using the keyword "wind", but the exact incident cannot be identified anymore. Even if emergency call data is not perfectly matching the time points when municipal employees need to get active after heavy wind events, it can be an indicator for when extreme situations occurred previously. For creating this service prototype, we used data about all emergency calls related to the keyword "wind" in a major German city from the years 2010 - 2020.

The risk for windthrow is dependent on the weather situation like wind direction and strength. Therefore, the first step during development was to match emergency calls to publicly available weather data of German Meteorological Service »Deutscher Wetterdienst« (DWD). We used Machine Learning and AI methods to analyse the weather and emergency call data and to detect patterns and extract the characteristics leading to windthrow. Although the presented service is a prediction, we use Machine Learning classification methods to classify weather situations into situations with high risk for emergency calls and windthrow, and in situations with low risk. To build the final service the learned classification model then can be used not only with historical weather data, but with weather predictions to get a risk prediction. This also means that the quality of the risk prediction depends not only on the quality of the classification model, but on the quality of the weather prediction as well.

The used emergency call data contains 1620 emergency calls within the last ten years. Weather data from DWD is collected in one hour time windows. Features for training the Machine Learning model are wind direction and wind strength. The emergency call and weather data get aggregated to 24-hour windows; therefore, the prediction service will also be able to predict the risk for each 24-hour slots. As Machine Learning Model a Random Forest Classifier is utilized. The model is trained on emergency call and weather data from the years 2010-2019 containing 237 days with emergency calls and validated with data from 2020 containing 36 days with emergency calls.

Results

The Random Forest classifier learned characteristics from the historical data to identify days with high or low risk for windthrow. On the validation dataset the model achieves an accuracy of 0.9 which means that 90 percent of all predictions made by the model were correct. As there are approximately 10 times fewer days with emergency calls than days without emergency calls, the metrics recall and precision are better suited to describe a model's performance. Recall and precision evaluate the forecasts on the subset of days with emergency calls and how often the model is correct when predicting a day with an emergency call, respectively. Our model achieves a recall of 0.55, effectively detecting 55 percent of emergency call days, and a precision of 0.5 meaning our models prediction of an emergency call day is correct in 50 percent of all cases. A reference model based on random choices is only able to reach a recall and precision typically between 0 and 0.15 depending on random draws.

This model can now be used to improve current working processes which rely on experiences of employees. In the future we expect a better performance when not solely emergency call data is evaluated but instead the municipalities start collecting data about windthrow and necessary work and supply it to the model. After predicting the risk for windthrow in the whole city, another improvement will be the creation of a classification model for city districts which are most likely affected by windthrow. When knowing not only when windthrow will happen, but also where it is most likely to happen, the necessary tasks can be planned more detailed.

With our service prototype presented here, municipal employees can get an estimation whether they need to clear the city from windthrow within the next days. The service is based on the current weather forecast and presents the probabilities for windthrow in a simple graph. The staff and task planning can be adapted and optimized. The prototype needs to be evaluated in upcoming steps. On the one hand, the quality of the classification model needs to be evaluated to show that a digital service can be created, although the necessary data isn't collected yet, by using other public service data already available. On the other hand, the usage of the service regarding the working processes needs to be evaluated. With the usage of publicly available data, or data which is already available in municipalities, the service is easily applicable.

An empirical study of organizational capabilities for digital servitization and their impact on financial and non-financial firm performance

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Problem/Objective

This study investigates the organizational capabilities required for digital servitization and their impact on firm performance. As many scholars in prior research have drawn on a capability perspective (Gebauer et al., 2017), this research aims to advance the current academic knowledge.

Several authors emphasize the importance of establishing a service-oriented culture, which is associated with managerial commitment to service and corresponding management practices (Kohtamäki et al., 2015; Oliva et al., 2012). On an individual level, service orientation empowers employees to apply service-oriented behavior, characterized by customer-centricity and the ability to adapt to changing circumstances quickly, which fosters customer satisfaction and loyalty (Gebauer et al., 2010). At a company level, service orientation supports intra- and interfirm collaboration and thus organizational learning directed at developing a profound understanding of customer needs, which in turn allows for a higher engagement with customers (Gebauer et al., 2009). Prior research further sheds light on the role of digital technologies as enablers and facilitators of value co-creation in service networks. The capabilities to exploit data collected from the installed base, in combination with the support of corresponding ICT systems, are indispensable not only to ensure efficient operations during the service transition but also for the continuous improvement of existing and the development of new, innovative service offerings (Kowalkowski et al., 2013; Lenka et al., 2017; Ulaga & Reinartz, 2011). The capability to innovate may relate to the particular service offering itself or its development and delivery process. In this context, previous research also highlights the importance of being able to integrate external competencies (Alghisi & Saccani, 2015; Baines & Lightfoot, 2014; Huikkola & Kohtamäki, 2017; Parida et al., 2014). The network of partners and intermediaries must be strategically built up and adequately managed so that all stakeholders involved focus their actions on the best possible fulfillment of customer needs. Regarding the performance impact, several authors capture a non-linear relationship between (digital) servitization and firm performance (e.g., Fang et al, 2008; Visnjic Kastalli & Van Looy, 2013; Kohtamäki et al., 2020); some studies consider organizational capabilities as moderators or mediators (Kohtamäki et al., 2013).

Hence, although there is a broad consensus on the relevance of particular capabilities for mastering the service transition, there remains a lack of conclusive studies on the interplay between organizational capabilities, the extent of digital servitization, and firm performance due to the topic's thematic fragmentation and the scarcity of quantitative analyses that confirm postulated correlations (Kowalkowski et al., 2017; Valtakoski, 2017). Moreover, existing research has widely neglected the multi-faceted conceptualization of servitization, primarily focusing on either financial or non-financial performance (Lexutt, 2020). Thus, the research objectives of this study are to empirically test presumptions about the role of organizational capabilities as enablers of digital servitization and refine existing findings on their performance impact by a consideration of both financial and non-financial firm performance measures.

Methodology

The proposed research model is based on a systematic review of literature on servitization capabilities and the performance impact of digital servitization. It is suggested that organizational capabilities serve as independent variables, as they enable companies to develop and deliver digital services. It is further hypothesized that organizational capabilities exert their effect on firm performance variables through the degree of digital servitization. Hence, the research model considers digital servitization as a mediating variable between organizational capabilities and firm performance. Two separated performance variables, financial and non-financial firm performance, are included. We operationalized the measured constructs through exploratory factor analysis. The research model is tested using a mediation analysis of primary data collected from a survey of 129 European manufacturing companies.

Findings

The exploratory factor analysis yields a solution with ten components. Accordingly, the performance impact of ten sets of organizational capabilities – mediated by the degree of digital servitization – has been tested, resulting in twenty partial results. The findings of the mediation analysis suggest that service orientation, customer involvement capability, and data interpretation capability exert a positive and significant impact on digital servitization, which in turn positively influences financial and non-financial performance. Hence, the effects of these organizational capabilities are fully mediated by the digital servitization degree. Analog results are achieved for organizational adaptability, operational efficiency, employee involvement capability, and service sales capability in the case of financial performance; in the case of non-financial performance, a positive and significant direct and indirect effect is found. Service innovation capability has a direct and indirect positive and significant influence on both financial and non-financial firm performance. Two capabilities, value network capability and service-oriented incentives have no significant positive effects on firm performance. The results confirm the assumptions that it is vitally important for industrial companies which aspire to successfully transform into a service provider should focus on building a cohesive service culture, effectively leveraging existing data, and involving customers in development processes. This is reflected in the overall positive mediation impact by the degree of digital servitization. Capabilities that drive non-financial performance should not be neglected, as they may create a basis for long-term, trust-based collaboration, which could act as a driver of financial performance.

Differentiating from existing studies, this study examines organizational capabilities required for digital servitization on a broad basis. By conducting a quantitative analysis of previously hypothesized relationships between organizational capabilities for digital servitization and firm performance, this study contributes to theory building in servitization research. Moreover, by incorporating two separate outcome variables, the findings provide more detailed insights on which capabilities support financial and/or non-financial firm performance. The proposed research model further allows for gaining information on how each of the organizational capabilities influences the performance variables, directly or indirectly. However, the chosen research model depicts simple mediation; therefore, no conclusions can be drawn about the interdependencies between the individual capabilities. Further limitations arise from the cross-sectional design which neglects the path-dependency of capability development. Moreover, the results are based exclusively on the subjective perception and assessment of managers in manufacturing firms, while other actors within service networks are only indirectly considered.

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Servitization for workplace wellbeing: concept and research agenda

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Introduction

Servitization has become a major management strategy for manufacturing companies to make their business models more resilient (Kowalkowski et al., 2017). Recently, digitalization promotes this shift further under the name of digital servitization (Paschou et al. 2020). Collected data from digital technologies such as Internet of Things (IoT) at customers' workplaces is a strong competence for service providers as well as an essential resource to contribute to the customer.

While researchers and business practitioners of (digital) servitization have a strong interest in operational excellence in manufacturing business, modern companies need to pursue not only the success in their businesses, but also overall satisfaction of stakeholders under Sustainable Development Goals (SDGs). One of the major management issues is wellbeing at work (ILO, 2018). The touchpoints with customer employees through digital technologies may be utilized for promoting their wellbeing. However, the contribution of digital servitization to workplace wellbeing has been rarely discussed in the servitization research.

This study aims at conceptualizing "servitization for workplace wellbeing" as a new research concept in the servitization research. Servitization for workplace wellbeing aims to improve the wellbeing of workers at customers' workplaces with an integrated set of digital products and services. In this study, we introduce our concept positioned in the existing research including servitization, Product-Service Systems (PSS) and other management research on workplace wellbeing. In addition, we suggest a preliminary research agenda on servitization for workplace wellbeing.

Traditional goals of servitization

Vandermerwe and Rada (1988) coined the term 'servitization' of manufacturing, aiming at achieving two goals: promoting environmental sustainability and developing competences with services in manufacturing businesses under the global competition. Although the sustainability through servitization has been a keen topic in relation to circular economy (Paiola et al. 2021), the managerial and research interests on servitization have been mainly placed on operational excellence for both providers and customers. The servitization process mostly aims at providing more integrated solutions to the customer's value chains or ecosystems for establishing long-term relations with customers and providing personalized solutions (Baines and Lightfoot, 2013). Utilization of digital technologies in servitization, known as digital servitization (Paschou et al., 2020) further accelerates this trend in an efficient manner, using collected data from IoT and other digital technologies.

Workplace wellbeing

In the recent research on servitization and PSS, promoting wellbeing of users is becoming an emerging topic (Barquet et al. 2016; Paschou et al., 2020). SDGs as a global agenda for future development promote not only for-profit activities but also prosocial behaivors by manufacturers. Under this trend, we specifically focus on the workplace wellbeing. Improving safety and health of workers and creating meaningful jobs are keen topics for management to attract and maintain excellent workers and to make their businesses more successful. In EU, workplace innovation has been an important agenda to promote workplace wellbeing (Pot et al., 2017). In Japan, the national government raised the national agenda of work style reform since 2016 (Yamamoto, 2017). "Kenko keiei" (corporate management for employees' wellbeing) is another term which emphasizes the management role in promoting the wellbeing of employees (METI, 2020). Especially under the pandemic of COVID-19, workplace wellbeing has been further highlighted and management needs to take a responsible action to this issue.

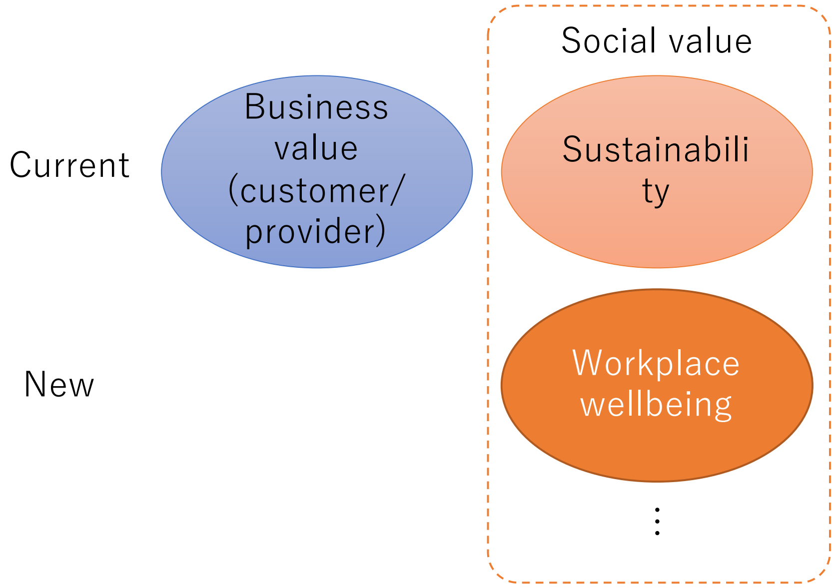
Servitization for workplace wellbeing

Based on the background, we propose a concept, servitization for workplace wellbeing. This concept aims at increasing not only business values for customers, but also wellbeing of their employees. As shown in Figure 1, servitization for workplace wellbeing extends the focus of servitization to broader social values. IoT-based equipped facilities at customer workplaces are key assets for this process. Combining operational data from the equipped facilities and health data from health technologies such as wearable devices, servitized manufacturers could provide new solutions for workplace wellbeing in addition to conventional servitized solutions. The potential solutions include injury/incident prevention, skill training and engagement support in a data-driven approach. We specifically conduct the research in the domain of construction services to implement concrete solutions and assess its impact.

As the preliminary research agenda of servitization for workplace wellbeing, the following research issues are under consideration.

- What kind of servitization process should manufacturers take for successful servitization for workplace wellbeing?
- What are the practical impacts? How can they be assessed?
- How should manufacturers communicate and collaborate with customers? How do they cocreate values?
- What kinds of methods and technologies are available for servitization for workplace wellbeing?
- What are the potential barriers and challenges, including social and ethical issues?

Figure 1. Values created through servitization



Conclusions

This article describes the concept of servitization for workplace wellbeing with its preliminary research agenda. We will further investigate this topic with a concrete case study.

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New work practices in service organizations: ornamental or direction change

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Abstract

New work practices in service organizations are perceived as a key factor to overcome external and internal challenges as well as to maintain a competitive position in the market. As academic literature solely addresses individual or fragmented measures of new work practices, literature lacks a holistic assessment for organizations revising their knowledge and updating their competencies in the field of new work. By applying a qualitative research approach the paper addresses how service organizations can acquire further competencies in the field of new work practices. Respectively, the paper identifies a conceptual framework of five dimensions: recruitment, leadership, organizational, requirements and needs as well as location decision. Therefore, the contribution of the paper is twofold. First, the paper contributes to the understanding of how new work practices are constituted and how they can foster the acquisition of knowledge in this field. Second, it introduces a conceptual framework service organizations can use as an assessment basis to revise and update their understanding of work by implementing the five dimensions.

Key words:

new work practices, service organizations, service research, Gioia methodology

Introduction

The understanding of work is recently changing faster than ever before. Therefore, the acquisition of new knowledge and competencies in how to create work environments has come to the fore of discussion in academic literature (Aroles et al., 2019; cf.Ashford et al., 2007; Singe & Tietel, 2019). Especially, service organizations are facing challenges due to fact that the context of service is affected (Edvardsson et al., 2018) by digitalization or globalization and the urgent need to transform and adopt the way of interaction between customers and service organizations (Askenazy & Caroli, 2010; Lindner et al., 2018; Schermuly, 2021). To overcome these challenges successfully, it is a key point to understand the new working world as well as to adapt respective practices to create an advantage over competitors, and thus, to maintain competitive (Hart, 1995; Teece et al., 1997) in the market in the future. In 1990, Bergmann first shaped the term new work by stating that classic wage labor from a Tayloristic point of view (Bergmann, 1990) will not be able to compete with the transforming work behaviors in the future. In addition, Lindner et al. (2018) and Schermuly (2021) argue that due to increasing digitalization, globalization and a shortage of skilled workers organizations urgently need to revise their current knowledge and update their competences towards the new working world with the help of new work practices. Motives behind adapting new work practices are manifold, enhancement of employees' motivation being the main one (Ollo-Lopez et al., 2010). Due to its transdisciplinary nature and the need for investigations in how new work practices serve organizations further research in the service industry is deemed highly relevant (Aksoy et al., 2019; Gustafsson et al., 2016). Moreover, being the main driver of economic productivity and growth (Anderson et al., 2013; Ostrom et al., 2010; Sheehan, 2006), service organizations represent a crucial industry and receive particular appreciation. In particular, according to Sheehan (2006), service organizations turn out to be the major driver when it comes to job creation within OECD countries. Besides the exponential volume growth in the service market (Anderson et al., 2013; Khanra et al., 2021; Ostrom et al., 2010), it is also observed that service organizations earn higher profit margins compared to organizations from the manufacturing industry (Probst et al., 2016). Yet, the ongoing increase in complexity of problems (Schermuly, 2021) forces service organizations to reevaluate the need of implementing new work practices in order to overcome the above-mentioned challenges and to maintain a competitive position in the market (Aroles et al., 2019; Spreitzer et al., 2017). To date, the majority of academic literature presents a rather disordered picture of many individual or fragmented measures identified as new work practices. In this context, Aroles et al. (2019) discussed new work from a rather theoretical perspective synthesizing new work types in a collaborative economical setting and including the individual or organizational role. Askenazy and Caroli (2010) or Handel and Levine (2004) conducted research on the effect of new work on worker´s health and labor conditions. Moreover, Lindner et al. (2018) casted an eye on the digitalization of work whereas Ollo-Lopez et al. (2010) or Riyanto et al. (2019) specified on employee attitudes, behavior or the importance of work-life-balance. However, to overcome increasing challenges and to maintain competitive in the market, Aroles et al. (2019) suggested that organizations are offered a conceptual framework of new work practices. In relation to this, no such conceptual framework was found so far in literature for service organizations. Despite the rapidly changing and complex context of services (Edvardsson et al., 2018), service organizations have so far missed the opportunity to adapt competences in a conceptual manner when it comes to new work practices. This lack of a framework regarding new work practices (Barley et al., 2017; Leonardi & Bailey, 2008) makes it challenging for service organizations to holistically assess the overall context of new work and to address more than one practice at time. Hence, following Ashford et al. (2007) explorative research is needed in this field, and thus, this paper is guided by the research question of how service organizations can acquire competencies in the field of new work practices to overcome challenges and maintain a competitive position in the market. The purpose of this paper is, therefore, to depict a conceptual framework of new work practices to prepare and strengthen service organizations both for external challenges such as the digitalization and globalization as well as internal tasks such as overcoming a skilled worker shortage, and hence, to maintain a competitive position in the market. The result of this paper is twofold. On the one hand, a conceptual framework based on five dimensions of new work practices for service organizations is developed. On the other hand, this framework aims to serve as an assessment basis for service organizations in order to revise and update current work practices. It, contributes to the scarce, yet growing, literature on new work practices for service organizations.

Theoretical Background

In the last few decades the understanding of work has changed and transformed significantly as the Tayloristic view on wage labour was challenged. Hence, the need to continuously transform organizational business processes and foster the acquisition of knowledge and new competences with respect to new work practices increases.

Service research

In particular, the field of service research offers an interesting foundation as it is not only transdisciplinary in nature (Aksoy et al., 2019; Askenazy & Caroli, 2010; Benoit et al., 2017; Gustafsson et al., 2016) but also organizations operate in various sectors such as the maintenance-, task-, or personal-interactive industries (Mills et al., 1983; Mills & Margulies, 1980), and hence, offer a wide variety of insights. It therefore contributes to knowledge and competence acquisition by promoting the incorporation of disciplines and by focusing on the connection between activities, such as new work practices, and its service on the organizations (Gustafsson et al., 2016). The relevance of service organizations is not only justified by their job creation ability (Sheehan, 2006) but also by their capability of being the main driver of economic productivity and growth (Anderson et al., 2013; Khanra et al., 2021; Ostrom et al., 2010). The majority of interactions within service organizations, especially in the daily work context, is based on human collaborations (Aksoy et al., 2019). The current COVID-19 pandemic has shown that for instance mobile work can initially disarrange the traditionally proven understanding of work (Dubey & Tripathi, 2020). In general, concrete ideas around the implementation of new work practices have recently become more popular as they foster the productivity of organizations (Askenazy & Caroli, 2010) and motivation (Ollo-Lopez et al., 2010) as well as efficiency of employees (Barrett et al., 2015). Therefore, implementing new work practices seems to be capable of creating an advantage for service organizations. Following the logic of Teece et al. (1997, p.516) who define dynamic capabilities as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments", the constitution of a competitive advantage is rather based on the ability of an organization to flexibly revise and update their knowledge and competences. Especially for organizations, concerning new work practices, this is highly crucial to not only obtain one unique resource in this regard but rather act flexible to changing work and market environments (Eloranta & Turunen, 2015; Hobday, 1998). In particular, service organizations can therefore overcome challenges and maintain competitive in the market by implementing new work practices.

New work practices

Rather than offering a holistically and adaptable framework of new work practices, current research offers a diverse amount of either individual or fragmented new work measures that organizations can implement (Aroles et al., 2019; Schøne, 2009). Bergmann (1990) established a realignment of the capitalistic approach towards work by introducing and shaping a first cultural approach connected to new work practices, such as meaningfulness, self-determination and competence development. Nonetheless, these stand-alone measures are rather difficult to adapt by organizations. Furthermore, literature suggests that new work practices are also about moving towards newly defined ways of structural and organizational means, for example communication and an understanding of shared responsibilities, and hence, less hierarchical boarders (Lindbeck & Snower, 2000; Schøne, 2009). This reaches consensus among scholars suggesting more structural and organizational means as reducing hierarchies, enhancing flat organizational structures as well as rising responsibility and increasing job rotation for employees are also seen as new work practices (Ashford et al., 2007; Caroli & van Reenen, 2001; Lindbeck & Snower, 2000; Schøne, 2009). Moreover, new work can also be described as a composition of fragmented measures concerning cultural and organizational means, such as democratization, non-authoritarian style of leadership, cultural change, flat hierarchies, open office, mobile technologies, home office or the degree employees are involved in their work (Handel & Levine, 2004; Schermuly, 2021). While conducting research on the correlation of increased health issues connected to the working environment and conditions, Askenazy and Caroli (2010) defined structural and organizational means such as quality norms, job rotation and flexibility of work schedules as new work practices. Spreitzer et al. (2017, p. 477) identify practices of new work as "three dimensions of flexibility that capture the range of alternative work arrangement: (a) flexibility in the employment relationship, (b) flexibility in the scheduling of work, and (c) flexibility in the location of where work is accomplished." A similar understanding was shared by Hornung et al. (2008), proposing that new work is connected to new work arrangements such as individualizing the conditions of employment. Recently, also the use of information and communication technology (ICTs) was connected to new work practices (Barrett et al., 2015). Besides, academic literature has also examined drivers of new work. In this sense, Ameln and Wimmer (2016) state that digitalization, automatization, demographic change and skilled worker shortage, new job biographies, a change in values as well as complexity and dynamics of markets underline the urgency of organizations dealing with new work practices. Furthermore, in their in-depth literature analysis Aroles et al. (2019) considered four different approaches to understand the new working world. First, the conceptual and methodological considerations outline that transforming and changing work always is a multidimensional phenomenon. Second, organizational as well as non-organizational new work practices (e.g. home or mobile office or the adaption of technological equipment at the workplace) have always been subject to studies allocated to spatial and temporal manifestations within a collaborative economy setting. Third, the individual and organizational level does not only consider working conditions under new work practices but also a shift within the business logic from an organizational point of view. Last, power and control refer to the change coming from new work practices, hence, managers need to adapt their current way of leading or controlling employees due to flexible working modes or enhanced technological settings.

With regard to this paper, new work practices are defined as practices which holistically frame the way work is carried out in service organizations in the future (Aroles et al., 2019). Consensus in literature can be found that new work practices encompass a set of cultural, structural or organizational means, yet, given the complete picture a concise understanding of new work practices has not been developed for the service industry. Therefore, against the backdrop of the complexity and fragmentation of the terminology (Aroles et al., 2019) and the relevance of service organizations the development of a conceptual framework with regards to new work practices and the ability to afterwards update and revise current ways of working can not only foster iterative knowledge and competence building but also can contribute to the current understanding of new work practices from a theoretical and managerial perspective.

Methodology

The purpose of this study is to identify how service organizations can acquire further competencies in the field of new work practices to overcome challenges and maintain a competitive position in the market. Bluhm et al. (2011) point out that qualitative research can be applied in order to particularly understand organizational processes and interpretation of its experiences. In this context a qualitative research approach was chosen in order to develop a conceptual framework for new work practices. The basis for this study is formed by 21 semi-structured expert interviews of 25[5] top and mid-level managers working from different organizations in the service industry. All of these companies are currently involved in re-formulating their organization's strategy towards new work practices. Moreover, all service organizations are located with its headquarters in Germany. In this sense, it is ensured that the conducted information is comparable due to the fact that legal and political parameters are similar. Following the work of Corbin and Strauss (1990) a grounded theory approach is applied, more specifically the Gioia methodology (Gioia et al., 2013). Regarding this methodology a key aspect is to inductively derive concepts in order to build on existing theory or establish new theory (Gioia et al., 2013; Suddaby, 2006). Throughout the process of choosing appropriate interview partners, substantive theory with regards to new work practices such as self-determination or competence development during work (Bergmann, 1990) and the reduction of hierarchies (Caroli & van Reenen, 2001; Lindbeck & Snower, 2000) was considered. Additionally, emergent theory such as cultural changes, new office solutions and non-authoritarian leadership styles (Schermuly, 2021) or flexibility in work modes (Askenazy & Caroli, 2010; Spreitzer et al., 2017) was adapted. Overall, the conducted semi-structured interviews enabled the identification of key new work practices within service organizations and ensured a solid foundation of empirical context.

Data sampling

While sampling the data, in the first step, service organizations were identified through the business networks of the researcher and were included in the population. In the second step, employing personal networks of the researchers and raising respective awareness on social media, e.g. LinkedIn, further top and mid-level managers were directly invited to take part in the study. After conducting the first 15 semi-structured interviews six more service organizations were approached to further validate the initially gathered results.

Data collection

The 21 semi-structured interviews[6] were conducted with 13 top-level and twelve mid-level managers who are actively engaged in the decision-making mechanisms of shaping the future of work strategy within their organization. To involve a practical perspective to implement new work practices mid-level management was interviewed. Furthermore, top-level managers were included to obtain a holistic view of the overall strategic direction of the organization towards new work practices and to understand their organizational meaning (Langley & Abdallah, 2015). In sum, the interviews were conducted in German between March 2021 and May 2021 lasting between 42 minutes and 69 minutes. Following Gioia et al. (2013) a semi-structured interview guideline with open questions led through the interview which was revised and updated regularly throughout the interview process. Interviewees were not guided in a specific direction by the researchers. All 25 interviewees were asked to describe how their organization defines and implements new work practices, to identify the reasons behind the practical involvement new work, to assess the organizational advantages and disadvantages of new work practices, and to explain how the organizational strategy behind new work

[5] In this context, it has to be mentioned that in four out of the 21 service organizations two experts were interviewed.

[6] In this context, it has to be mentioned that two researchers were responsible for the interviews.

practices can potentially evolve further. Finally, recording and transcription of the interviews was performed in order to code the data. Table 1 summarizes the sample and the data set of the underlying paper.

Table 1: Overview of the sample and data set

Sample and data set	
Country	Germany
Industry	21 organizations from the service industry
Total interviews	25 interviews in total
Selection criteria	1) Organization within the German service industry
	2) Re-formulating organization´s strategy towards new work practices
Period of data collection	March - May 2021
Total data set	20 hours 11 minutes 28 seconds
Average interview duration	54 minutes 50 seconds

Data analysis

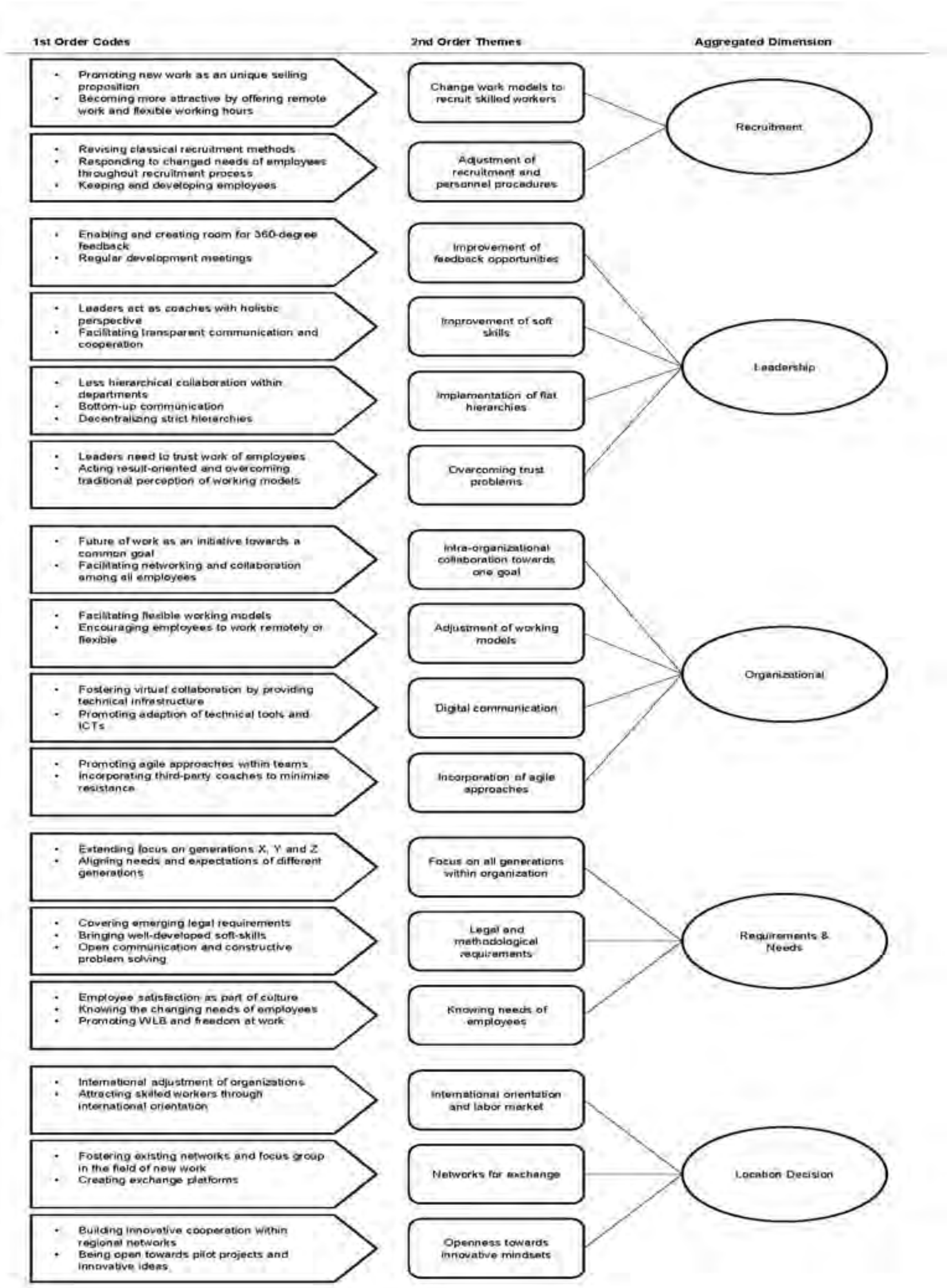
Gathered data were analyzed following the Gioia methodology (Gioia et al., 2013) which was chosen due to its gap-filling capability and ability to derive new theory (Langley & Abdallah, 2015). Three researchers[7] were involved in the coding process, whereas, one researcher was able to, thematically, keep a certain distance and improved the theoretical outcome by analytically reconsidering the data as well as iteratively giving feedback on the coding system (Crosina & Pratt, 2019; Gioia et al., 2013). Due to the iterative process between the three researchers all created concepts, themes and aggregated dimensions were revised critically. According to Crosina and Pratt (2019), Gioia et al. (2013) and Glaser and Strauss (1967), analysis and coding of the data was executed in three steps.

In the first step, transcribed interviews were analyzed using open coding with the help of the qualitative data analysis program MAXQDA. In this sense, first order codes were created more descriptive in nature and adapted closely to the actual quotes. Through the iterations the descriptive first order codes were

[7] In this context, it has to be mentioned that the third researcher kept a certain distance and iteratively gave feedback on the coding system.

systematically organized. In the second step, axial coding was deployed to organize and group first order codes in a more theoretical manner (Gioia et al., 2013). Thus, through the ongoing revision process first order codes were categorized in second order themes. For instance, the second order theme "Incorporation of agile methods" was built by clustering the following first order codes "Promoting agile approaches and methods within teams" and "Incorporating third-party coaches to minimize resistance". In the third step, theoretical coding was applied in the last stage of the analysis. In general, axial codes were revised again in order to find suited forms of aggregated dimensions. Thus, second order themes again served to derive an aggregated form constituting the underlying data structure in this study (Gioia et al., 2013). Therefore, five aggregated dimensions were derived, namely, recruitment, leadership, organizational, requirements and needs as well as location decision. In this regard, Figure 1 presents the data analysis process consisting of first order codes, second order themes and aggregated dimensions.

Figure: 1: Data structure



Results

Building on the notion that an organization can overcome challenges and maintain a competitive position in the market both internal and external capabilities must be identified (Hart, 1995). Hence, the paper reveals a conceptual framework based on five dimensions of new work practices consisting of: (i) recruitment, (ii) leadership, (iii) organizational, (iv) requirements and needs as well as (v) location decision. In the following, the five aggregated dimensions will be presented.

Recruitment Dimension

Observed data identified the recruitment dimension demonstrating the need for organizations to consider practices of new work even before the employment of potential candidates. It further revealed that service organizations should aim for new work practices in order to recruit potential employees and to adjust traditional recruitment measures.

Change work models to recruit skilled workers

As often-stated in the interviews, service organizations need to show an open attitude towards the change of traditional working models. Thus, promoting new work practices as a unique selling proposition to potential candidates will lead to the recruitment of skilled workers. In this context, one expert gave flexible working models as an example and confirmed that *"One thing has changed: We are recently and actively advertising this kind of flexibility within our work models and recruitment processes."* Furthermore, organizations might increase their attractiveness among potential job candidates by offering remote work or flexible working hours from the beginning on. The majority of experts noted that before the involvement with the new world of work it was not possible to fulfill new demands.

Adjustment of recruitment and personnel procedures

To not only attract but also to retain potential candidates, organizations need to regularly update and adjust their recruitment and personnel procedures. To one extent this can be performed through a revision of the classical methods. In this regard, one mid-level manager explained the following: *"Everything starts at the recruiting stage. We will not attract any talents by solely offering them a traditional way of working. We want to shift our focus more on the person itself within our strategic orientation."* Closely connected to this and based on the current expectations is the obligation to quickly respond to the changing needs of employees. This was also verified by one CEO stating that, *"We have to convince and inspire people to work for us. "Is mobile work possible? How is the technical equipment?" After recruiting employees, it is crucial to offer promising opportunities to continuously develop them, and hence, to retain them as they are the organization's capital. Here, we also invest in remote or intercultural leading, in building trust, performance and team cohesion."*

Leadership Dimension

Data analysis showed that the leadership dimension elaborated that managers occupy a decisive and active role in fostering new work practices within an organization. The conducted interviews identified an emphasis on the implementation of flat hierarchies, overcoming trust problems and the improvement of soft skills as well as feedback opportunities when it comes to new work practices.

Improvement of feedback opportunities

As observed in the data, leadership and managers should definitely deal with the improvement of giving and receiving feedback on a mutual basis. Hence, enabling and creating room for feedback opportunities, for example a 360-degree-feedback is crucial in this context. One top-level manager underlined the importance of the regular feedback rounds and specified the following: *"As we also use the scrum method we implemented retrospective feedbacks organization-wide. So, we have project-specific and employee-specific feedback talks,* *employee talks, or probationary period talks. Besides, project managers conduct feedback talks again with their team members, so we got all angles I would say."* Implementing regular feedback cycles also stimulates the introduction of regular development meetings. In this regards, one mid-level manager described that they have already updated the classical performance review and implemented a Personal Development Review which aims to proactively discuss and develop the role of the employees together with them.

Improvement of soft skills

Interviews have showed that while implementing new work practices leaders have to improve their soft skills. Therefore, leaders should act as coaches and obtain a holistic perspective. This is supported by one top-level manager stating that, *"the internal training academy is part of our strategy and composes special soft skill training programs for our managers."* In this regard, another top-level manager revealed that their management has to be in exchange with their employees half the time and further specialize in their subject matter the other half. Moreover, transparent communication and cooperation should be facilitated by leadership in general. This also has been confirmed by one expert as, *„the manager will always put a crucial task on the table of the employee. In order not to let conflicts arise the manager is responsible for enabling and encouraging its employees to communicate and discuss, e.g. the prioritization of tasks, in an open environment."*

Implementation of flat hierarchies

As observed in the interviews one possibility to implement flat hierarchical structures is to promote a certain collaboration within departments guided. Reducing hierarchical structures needs to be planned properly and cannot be executed rapidly. One mid-level manager shared her practical experience with this topic: *"Our divisional thinking should no longer be hierarchy-driven, however, I think we still need some time for that because managers need to adapt their role within the course of this new work topic."* Another possibility is to enhance a bottom-up culture of communication. This way of communication was also observed in some interviews and experts reported that relatively flat hierarchies within their organization fostered employees independently taking up more responsibility and communicated more freely to their managers. A further possibility is decentralization. One CEO illustrated that this aspect is strongly connected to help flatten strict hierarchies and explained that, *"The whole topic of matrix structures will play a greater role for us in the future. Different hierarchy levels will have to cooperate more cross-hierarchically."*

Overcoming trust problems

During the interview an often-mentioned aspect was the lack of trust leaders face within the new work when it comes to new work practices. *"For some leaders the topic around trust is really an issue as they are concerned whether our employees really work at home."* one mid-level manager mentioned. A solution was offered by a top-level manager during the interview: *"I always say that at the end of the day this is not an issue of employees working from home. It's how you measure performance and how you communicate goals to your employees. We need to move towards a culture of trust and measure performance differently."* Closely connected to this is the aspect that leaders have to act more result-oriented rather than controlling the way employees achieve their goals. Therefore, they have to overcome the traditional perception of working models. However, during the interviews it became clear that this aspect will be a longer journey for some organizations. Accordingly, one expert stated that, *"Although we are about to implement new work-related measures we will still have a classic organizational structure with hierarchical levels and will not get away from that at all so quickly in the future."*

Organizational Dimension

As the data showed, the organizational dimension obtains a holistic role as discovered aspects target the whole organization. Hereby, the incorporation of agile methods, digital communication, intra-organizational collaboration towards one goal and the adjustment of working models inspires new work practices.

Intra-organizational collaboration towards one goal

An often-mentioned aspect throughout the interviews is that both top- and mid-level management see new work as an initiative to work as a team towards a common goal. In particular, one expert visualized it holistically: *"We also want to strengthen this cross-divisional approach. We want to avoid that everyone works on his own. We really want to have the common goal in mind and foster more of a process-driven view."* Interviewees find consent in organizations facilitating the networking and collaboration among all employees and departments. In particular, cross-divisional networks should be established to simplify the collaborative work in projects. An interesting aspect was raised by one top-level manager who noted that e.g., *"every meeting should still be held in a hybrid format as I still want to say that I am in a different location but can still take part in the meeting."*

Adjustment of working models

Not only the current COVID-19 pandemic is responsible for the ongoing adjustment of working models but also organizations, management and employees understood that they need to adapt more flexibility to be prepared for the future. *"In the course of adapting new work on an organizational level we gain flexibility. We don't know how working methods will look like in five years but we want to design our working environments in such a way that we all can react flexible to them"* a top-level manager mentioned regarding the commitment organizations have to undergo. In order to establish a solid basis for flexibility it is required to encourage employees to work remotely. Organizations should not solely bow to the pressure of their employees but also promote new working models independently. One expert explained a long-term digital workplace project has been recently completed enabling every single employee to work remotely.

Digital communication

Observed data showed that digital communication and collaboration are only possible if organizations provide the required technical infrastructure available to their employees. Despite the COVID-19 pandemic highlighting the urgency of this matter, experts confirmed that this was also a crucial aspect before as numerous business processes were executed in other domestic or foreign locations. One top-level manager commented that, *"a crucial aspect is to provide your employees with digital equipment. This has to work well and everyone need a laptop and screen. Collaboratively working from home now does not hurt us at all. We somehow didn't have any performance losses at all."* Closely related to this is the promotion of new technical tools and ICTs which enhances the internal capability of communication with different branches and efficiency. This found support by another expert: *"We successfully developed our virtual collaboration by new software tools and ICTs. Especially, the interactions between managers and colleagues and within the operational area got better and more efficient."*

Incorporation of agile approaches

Amid the conducted interviews it became evident that service organizations must actively promote agility within their strategy and amongst their employees. One mid-level manager noted that, *"We recently started to incorporate agile roles such as culture trainers or scouts who act as multipliers moderating workshops or participating in mediations."* Service organizations adapting agile approaches have advantages from a competitive perspective owing to the fact that their clients often work agile. Connected to this, one top-level manager explained: *"Since we are working digitally, also service providers and clients push or pursue an agile work collaboration. We can't let them work in an agile way using sprints and we still do everything according to classic project work. That doesn't work."* Additionally, the incorporation of third-party coaches in order to minimize resistance received increased attention among experts. On the one hand, they are responsible for putting the agile approaches into a framework for the employees and accompanying them during implementation. On the other hand, they can also take a neutral position and mediate in the event of confrontations.

Requirements and Needs Dimension

Observation of the data revealed the requirements and needs dimension, combining central methods with regards to the whole workforce. Therefore, when implementing new work practices promoting employee satisfaction and work-life-balance, a focus on all generations working in an organization as well as methodological requirement come to the fore of discussion.

Focus on all generations within organizations

The need to focus on all generations will be crucial for the future success of organizations. Observed data showed that the focus has to be extended to three generations: X, Y and Z.[8] *"We have thought about this topic from a strategic point of view. We definitely concentrate on the needs of all three generations."* In particular, it turns out that the alignment of their needs is a challenging task as demands and expectations can vary. *"There has been a major change. Generation Y, for example, has in mind to get a reasonable wage or a company car, however, now Generation Z is more interested in holiday days, remote work or the possibility to work from home."* one top-level manager explained.

Legal and methodological requirements

With regard to the implementation of above-mentioned employees' needs and expectations organizations must comply to emerging legal requirements. Some top-level managers pointed out that new work-related topics are not only strategically located in their organization but also in the legal department. One expert described that, "*legal requirements need to be adjusted as some traditional contracts still state a specific number of working hours which now has to be legally changed."* Moreover, organizations value that employees provide well-developed soft skills and characteristics on their own contributing to the implementation of new work practices within the organizations. In this context, as observed in the interviews they especially value when employees provide a degree of self-discipline, flexibility and responsibility. A CEO made this very clear: *"We don't need anyone to just work something off. We are looking for colleagues precisely having skills such as agile working, being courageous, taking risk sometimes, actively addressing critic or being flexible."* Additionally, open communication and constructive problem solving was also an often-observed topic during the interviews.

Knowing needs of employees

Service organizations can only maintain competitive if they know how to adapt labor conditions and working environment in such a way that employees are feeling satisfied. A top-level manager reported that their organizations already started the integration and explained that, *"I believe that employee satisfaction will be given greater consideration and has therefore become the focus of our company strategy and decision-making."* Moreover, knowing employees' changing needs, such as purpose behind their work or benefits, is necessary. Respectively, a top-level manager confirmed that, *"employees now want to know what they are working for, why they are working and what is the purpose behind it."* Another expert commented that *"wages are getting less important nowadays. Our employees are triggered by aspects, such as remote and flexible working models or alternative bonus arrangements, for instance, more holidays."* In addition, service organizations should particularly promote the work-life-balance of their employees and freedom at work. Interviewees reported that more work-life-balance is actively claimed by younger generations. This is also connected to the level of freedom organizations guaranteeing their employees during work, and hence, one top-level manager even argued that, *"one of our pillars for the future of work is to offer our employees a broad degree of freedom in what they do during their daily work."*

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[8] In this context, it has to be mentioned that according to McCrindle and Wolfinger (2009) Generation X was born between 1965 and 1979, Generation Y between 1980 and 1994 and Generation Z was born between 1995 and 2000 respectively.

Location Decision Dimension

The data also confirmed that new work practices as well integrate the location decision of service organizations. Consequently, the establishment of networks for exchange, the international orientation of organizations and labor market aspects as well as the openness towards innovative mindsets are depicted.

International orientation and labor market

The international orientation and the related impact on new labor market possibilities can lead to an advantageous position of service organizations. One CEO recommended that, *"I try to make the company more international right from the start. We have always drafted all internal documents in English, because I can quite easily hire someone, even a remote employee, because all documents are already in English."* Another top-level manager described that the whole company culture is oriented towards the English language. In addition, the international orientation attracts skilled workers from foreign countries, and hence, the skilled worker shortage can partially be compensated.

Networks for exchange

Conducted interviews have shown a lack of networks in the field of new work. This aspect was confirmed by almost all experts stating that they were not aware of external exchange opportunities. The approach towards changing this was presented twofold. On the one hand, existing networks and focus groups need to be fostered among organizations. One expert reported that they were in a regular exchange with their mother organizations. Exactly this network has to be extended and other service organizations could be included. On the other hand, new exchange platforms can be created. Top- and mid-level management expressed their willingness to actively pursue the idea and explained that, *"Until now we are not in an explicit professional exchange about, e.g. how other organizations implement new work practices. But exchange with other organizations would be highly crucial."*

Openness towards innovative mindsets

Integral to the integration of openness towards innovative mindsets within the business strategy of service organization is, on the one hand, the construction of innovative cooperation at work. In this regard, one top-level manager described his experiences: *"I think what really works well and motivates the employees to be more creative are these interdisciplinary teams. We align for instance technology experts with the process experts."* However, on the other hand, the whole staff has to obtain an open mindset towards innovative pilot projects or ideas. Concerning this, organizations need to proactively enable such settings within their business environment. One expert commented on how its organization fosters innovative pilot projects or ideas: *"We also try to implement innovation processes in our strategy. Whenever employees have a cool idea they can describe their ideas and have the opportunity to pitch in front of a committee. If it gets accepted there is budget available."*

Discussion

New work practices are essential in order to prepare and strengthen service organizations for overcoming challenges (Ameln & Wimmer, 2016; Schermuly, 2021; Schøne, 2009; Väth, 2016). Yet, the emergence of a conceptual framework with key practices regarding new work is lagging behind (Barley et al., 2017). Therefore, the proposed conceptual framework will be a key aspect for service organizations to acquire more knowledge and competences in the field of new work practices. The implementation will enable service organizations to enhance their competences, and hence, constitute a dynamic capability (Teece et al., 1997) leading in the end to an competitive advantage (Hart, 1995) in the market.

Theoretical Contributions

The underlying paper reveals a conceptual framework containing five dimensions of new work practices. In the context of service organizations, it helps to understand how new work practices are constituted and how it can foster and support acquiring further competencies in this field. Thus, the theoretical contribution of the paper is twofold.

First, the paper contributes to challenge the literature that considers new work practices as individual or fragmented measures. In this context, scholars suggest that new work practices are defined by single measures such as reduce hierarchies, open offices, flexible working models or digital competences (Handel & Levine, 2004; Lindbeck & Snower, 2000; Oberländer et al., 2020; Schøne, 2009). However, this paper shows that new work practices are constituted by a conceptual framework of five dimensions, namely recruitment, leadership, organizational, requirements and needs as well as location decision. Furthermore, it is argued that single measures identified by current literature need to be placed in a holistic context. Taking this perspective into consideration new work practices must be treated as a conceptual framework rather than identifying the influence of individual or fragmented measures on organizations. Second, the paper contributes to the understanding of acquiring new work practices. The paper challenges the existing understanding of new work practices which are mainly described by cultural, structural or organizational means with individual or fragmented measures. In this regard, the paper extends the current knowledge and offers a conceptual framework of five dimensions of new work practices. The recruitment dimension goes beyond the sole cultural and organizational adaption of new work practices (Handel & Levine, 2004), for instance, through digital forms during the recruitment process (Lochner & Preuß, 2018). It rather describes a multidimensional opportunity to attract potential candidates through new work practices. The leadership dimension was only rudimentary examined by literature stating that only structural means, such as responsibilities need to be shared (Lindbeck & Snower, 2000; Schøne, 2009), or organizational means, such as hierarchies need to be flattened (Ashford et al., 2007; Handel & Levine, 2004), are considered. However, aspects such as overcoming trust problems of new working models or the improvement of soft skills and feedback opportunities turned out to be inevitable. The organizational dimension combines the ideas of cultural, structural and organizational means by having inter alia enhanced digital competences (Oberländer et al., 2020), adapting new ways of communication (Barrett et al., 2015; Lindbeck & Snower, 2000; Schøne, 2009) or creating work-life-balance through flexible working models and new spaces (Schermuly, 2021). Nonetheless, the conceptual framework extends it by also incorporating agile methods and strengthen intra-organizational collaboration in order to work towards a common goal. The requirements and needs dimension includes structural and cultural means (Askenazy & Caroli, 2010) and the idea that new work practices and employee satisfaction and motivation are positively correlated (Ollo-Lopez et al., 2010). Yet, the conceptual framework underlines the importance of knowing, and hence, meeting the needs of the employees as well. Moreover, it also concentrates on methodological requirements and a focus of all the generations within an organization. The location decision dimension has neither been mentioned in current literature nor considered in any measures regarding new work. However, results of this paper have shown that service organizations require a network for exchange, an international orientation when it comes to skilled workers as well as openness towards innovative mindsets at their location.

Managerial implications

This paper has also developed practical implications for organizations. The increasing popularity with regard to new work has led a few organizations to adapt such practices as part of their long-term business strategy. Against this background, the paper reveals how service organizations can use the conceptual framework as an assessment basis in order to revise and update their current understanding of work by implementing the stated five dimensions new work practices. Hence, the practical contributions are twofold.

First, the understanding of top- and mid-level management regarding new work practices, similar to the observed literature (Aroles et al., 2019; Lindbeck & Snower, 2000; Schøne, 2009), is not consistent. Therefore, the conceptual framework does not only serve an extension to current literature but also provides a basis to create a unified understanding among practitioners. On the one hand, service organizations at the beginning of re-examining their new work strategies can take the conceptual framework as a toolbox in order to find out at which dimension and aspects they have to work on. On the other hand, more advanced organizations can use these practices as a basis to revise and update changes they have already made. It is therefore a matter of developing a common ground of knowledge and competences for service organizations. Second, the current COVID-19 pandemic has demonstrated that a drastic change of our working world is not only a theoretical but also a real phenomenon (Dubey & Tripathi, 2020). Yet, a large number of organizations was not willing to make fundamental changes before the COVID-19 pandemic started. Based on this, the conceptual framework supports service organizations to rapidly adapt new work practices and helps them to successfully manage drastic working world changes even in an early stage.

The developed conceptual framework supports service organizations as an assessment basis and to revise and update their new work practices as well as to enhance their knowledge and competences in the field of new work.

Conclusion, Limitations & Further Ideas for Research

In general, the topic around new work implies many promising approaches to both theory and practice. The paper was able to identify five dimensions of new work practices based on existing literature and conducted expert interviews. Initially, rather individual and fragmented measures were observed, however, the results of the data suggested a more holistic point of view proposing a conceptual framework. The conceptual framework, on the one hand, intends to extend literature and to enhance the understanding of new work practices. On the other hand, it contributes to the provision of an assessment basis for organizations to revise their knowledge and to update their competences towards new work practices. Thus, service organizations are guided by the stated five dimensions in a structured way and can check whether they compile with the proposed conceptual framework.

Apart from the theoretical and managerial contributions this study has limitations which should be addressed by future research. First, data collection and analysis were conducted during the COVID-19 pandemic. Hence, evaluation of results might be subject to change if data will be collected and analysed again in a time period where the COVID-19 pandemic is over. In further studies this consideration should be implemented in order to either validate or challenge current results. Second, the paper is primarily based on qualitative expert interviews exploring new work practices. Moreover, the conceptual framework of new work practices was developed out of interviews with solely top- and mid-level management. Therefore, it can be assumed that opinions could have been presented from a rather one-sided or managerial perspective during the interviews. Future research could adapt a different form of approach and apply, for example a quantitative setting from an employee point of view in order to validate and strengthen the identified conceptual framework. Furthermore, further research could investigate within a specific organization using cross-sectional employee opinions or a case study approach. Third, the paper is limited to organizations from the German service industry. Hence, our analysis did not include firms, for instance from the manufacturing or start-up sector. Further research could therefore investigate the validity of the conceptual framework in different industries or even in an international setting. Last, this paper did not assess the outcome after organizations have revised and updated their current work practices and implemented the conceptual framework. Against this background, future studies should incorporate this consideration in order to verify the applicability of the five dimensions and conduct further research on how these dimensions e.g. influence the innovation capability.

Acknowledgments

We would like to thank the interviewees for their valuable time and fruitful insights into the topic of new work practices. We would also like to thank the two anonymous reviewers for their timely response and constructive feedback which enhanced the quality of the paper.

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8
Topic »Geographic, Social and Ethic Aspects of AI«

8.1
List of papers

- **Detecting Social and Ethical Implications of Artificial Intelligence: A Structured Workshop Method from a Social Sciences Perspective**
  Susanne Sczogiel, Ursula Neumann, Stephanie Schmitt-Rüth (Fraunhofer Center for Applied Research SCS of the Fraunhofer IIS)

- **Corporate Digital Responsibility in Construction 4.0 - Ethical Guidelines for Digitization and Artificial Intelligence (AI)**
  Bianca Weber-Lewerenz (Bianca Weber-Lewerenz Engineering, Germany)

- **Smart Salesperson and Smart Service-Owner – New role profiles due to changed competence requirements in the context of digital work**
  Lena Maria Fischer, Marc Schwarzkopf, Synnöve Hochstein, Angelika C. Buillinger (University of Technology Chemnitz, Germany)

Detecting Social and Ethical Implications of Artificial Intelligence: A Structured Workshop Method from a Social Sciences Perspective

Susanne Sczogiel, Ursula Neumann, Stephanie Schmitt-Rüth (Fraunhofer Center for Applied Research SCS of the Fraunhofer IIS)

Problem/Goal

Artificial Intelligence (AI) is affecting all facets of human life: Whether in the medical sector or the entertainment industry, self-learning algorithms and intelligent decision support systems are used to efficiently generate outcomes for a better and more comfortable life. Therefore, the impact of AI applications on humans and society is vast. Machine learning algorithms used, e.g., in support systems that are for example supporting air traffic control or medical diagnosing, are trained on historical data. This data might be biased or otherwise faulty. For example, gender-imbalanced data could be used for training chest x-ray-algorithms, and there are concerns about using decision support in diagnosing skin cancer because the algorithms are primarily trained on fair-skinned populations (Kaushal et al., 2020). This might potentially lead to sex or race discrimination in receiving quality medical care, which is objectively unethical. Social constructs of everyday life are also affected: Biased AI decisions about subjective measures such as beauty have a spillover effect to what individuals perceive as beautiful (Rhue, 2019), therefore perpetuating the biases the algorithms learned from the beginning. Thus, it is very important to anticipate social and ethical consequences of potentially biased AI for humans and society as early as the selection of training and testing datasets in the development process.

Governments, NGOs and major tech companies are continuously working on guidelines for ethical and socially acceptable AI; e. g., the EU Commission established a high-level expert group on artificial intelligence (AI HLEG) that published both the "Ethics Guidelines for Trustworthy AI" as well as policy recommendations and an assessment list for trustworthy AI (European Commission, 2021). Their human-centric approach highlights safety, privacy, and transparency concerns, as well as fairness, diversity and non-discrimination, and the benefit of AI to society and the environment. However, most common ethics guidelines, such as the EU one, share one problem: There is no concrete guidance for AI developers and users on how to implement these abstract guidelines.

There is evidence that even simple interventions such as reminding AI developers of possible biases in data can already reduce error rates (Cowgill et al., 2020). Raising awareness in developers and stimulating ideas for their respective AI application they are working on seems a viable option for reducing biased errors. For a structured scientific analysis of potentially harmful outcomes, we therefore propose a special methodological approach that sensitizes developers for possible biases in their data and potential outcomes of ethically and socially dubious decisions based on their algorithms. In carrying out this intervention, we want to help the developers to find ways to take action against those potentially socially and ethically unwanted outcomes. To address these demands, we developed a structured workshop method for AI developers called »AI-DISTIL (DetectIng Social and eThical ImpLications)«.

Methodology

Based on an approach typically used in social sciences as psychology or sociology, AI developers participate in a structured workshop in the early stages of their project's development process. The workshop uses a prospective approach towards potential biased outcomes and provides tools to analyze potential causes. The workshop method is composed of three main parts:

Presentation and discussion of information on ethics guidelines and common biases

During the first part, developers get to know common ethics guidelines by governments, NGOs and big tech companies to better understand the underlying concepts of trustworthy and ethical AI. Then, common data biases such as historical bias, representation bias or funding bias (Mehrabi et al., 2021) are presented and further explained with relevant examples. Afterwards, relevant biases are discussed in relation to the developers' current projects.

»The Darkest Timeline«: Using the Critical Incident Technique to build a scenario of undesirable social and ethical outcomes

AI developers work on a "Darkest Timeline" scenario using a method based on the Critical Incident Method (Flanagan, 1954). In relation to their current AI project, the posed questions help them to describe a scenario in which their project generates ethically and socially critical outcomes. They identify the outcomes in detail, such as: Why is the scenario problematic? Who is going to be affected? How can one realize that this scenario has come to pass? What are consequences for users/the target group/society? The developers then evaluate the scenario in relation to the ethics guidelines they learned about prior.

How Did We Get Here?: Using a fault tree approach to examine what can lead to the undesirable scenario and how to deal with it

AI developers examine the potential causes of the »Darkest Timeline« scenario using a fault tree analysis. They are provided with tools and guiding questions in order to identify all events and their causes in the data that would lead to the Darkest Timeline scenario. Developers work on this task until they find the "root causes" for each event that leads up to the worst scenario. The causes in the data are then discussed in the context of the data biases the developers learned about prior. Ideas on how to avoid these causes and biases are discussed and outlined.

Researchers and practitioners using AI-DISTIL must learn about the developers' current AI projects first before conducting the workshop. Basic knowledge about AI applications and machine learning is required in order to carry out the workshop. The method focusses on the specifics of the use case as well as the training and test datasets behind the algorithm in order to prevent potentially negative social and ethical implications of the later product.

Results

The methodological approach »AI-DISTIL« has been tested with developers of two high-risk AI applications from the ADA Lovelace Center for Analytics, Data and Applications: A system helping to diagnose colon cancer cells (head of development) and a system supporting autonomous driving (head of development and team).

For example, the result of the workshop with the developer of the colon cancer diagnosis tool was the detection of many potential sources of data bias and possible errors in the data selection. Based on the scenario »The application fails to compute the tumor surface correctly«, the causes for this potential outcome included, but were not limited to, traced potential measurement biases in the data (differences in scanners, differences in colouring the samples), representation biases (variation of preparation of samples, no knowledge of individual patient characteristics) or evaluation biases (inter-observer-variability). The possible causes of these biases were detected and in-depth discussions of the results provided the developer the information needed to conceptualize countermeasures.

In the evaluation, participants noted that in spite of trying to consider ethics in their developmental progress beforehand, they were unaware of many of the potential data biases presented in the first part of the workshop and how they occur. The participants found both the scenario technique as well as the fault tree analysis helpful for the further development of their projects; it was especially impactful to identify the critical variables in their own datasets because of the direct implications and outcomes they could test afterwards. The workshop helped the participants to better understand the possible outcomes of their projects. They provided feedback that they felt better prepared and sensitized to take countermeasures regarding possibly biased datasets, such as better data selection and more specific test processes for their algorithms.

Corporate Digital Responsibility in Construction 4.0 - Ethical Guidelines for Digitization and Artificial Intelligence (AI)

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Acknowledgement

I would like to thank all interviewed experts and mentors for their valuable support of this research. The numerous supports by multiple expertises led to the foundation of the *Excellence Initiative for sustainable, human-led AI in Construction* as part of a larger global network. For the great cooperation throughout scientific research studies I thank *Fraunhofer Institute IAO*, the *European Association for REsearch on SERvices (RESER)* and *buildingSMART Initiative* joining forces to embedding the ethics debate as the driver of success in construction for digital innovation and digital economy.

Article Highlights

- Identify CDR and its ethical principles as the key driver for success, resources-cost-time efficiency and sustainability using digital technologies and AI in construction engineering.
- Formulate recommendations for action for decision-makers from business and politics to move digital innovations in diverse and inclusive environments forward.
- Define Construction branch`s role model function in value-based human-tech interaction for a worldwide "AI – Made in Germany" seal of quality.
- Create awareness of potentials and offer constructive approaches and orientation to shape new technologies like Digitization and AI for the common good.
- Pioneer with this new field of research and embed the construction industry in the ongoing interdisciplinary, international "Ethics in AI" debate.

Abstract

Digitization is developing fast and has become a powerful tool for digital planning, construction and operations. Its transformation bears high potentials for companies, is critical for success and thus, requires responsible handling. This study provides an assessment of calls made in the Sustainable Development Goals by the United Nations (SDGs), White Papers on AI by international institutions, EU-Commission and German Government requesting for the consideration and protection of values and fundamental rights, the careful demarcation between machine (artificial) and human intelligence and the careful use of such technologies. The study discusses digitization and impacts of Artificial Intelligence (AI) in construction engineering from an ethical perspective by generating data via conducting Case studies and interviewing experts as part of the qualitative method. This research evaluates critically opportunities and risks revolving around Corporate Digital Responsibility (CDR) in construction industry. To the author`s knowledge, no study has set out to investigate how CDR in construction could be conceptualized, especially in relation to digitization and AI, to mitigate digital transformation both in large, medium-sized and small companies. No study addressed the key research question: Where can CDR be allocated, how shall its adequate ethical framework be designed to support digital innovations in order to make full use of the potentials of digitization and AI? Now is the right timing for constructive approaches and apply ethics-by-design in order to develop and implement a safe and efficient AI. This represents the first study in construction engineering applying holistic, interdisciplinary, inclusive approach to provide guidelines for orientation, examine benefits of AI and define ethical principles as the key driver for success, resources-cost-time efficiency and sustainability using digital technologies and AI in construction engineering to enhance digital transformation. Innovative corporate organizations starting new business models are more likely to succeed than those dominated by conservative, traditional attitude.

Keywords

Construction, Digitization, AI, Ethics, CDR, Digital Responsibility, Digital Transformation

Introduction

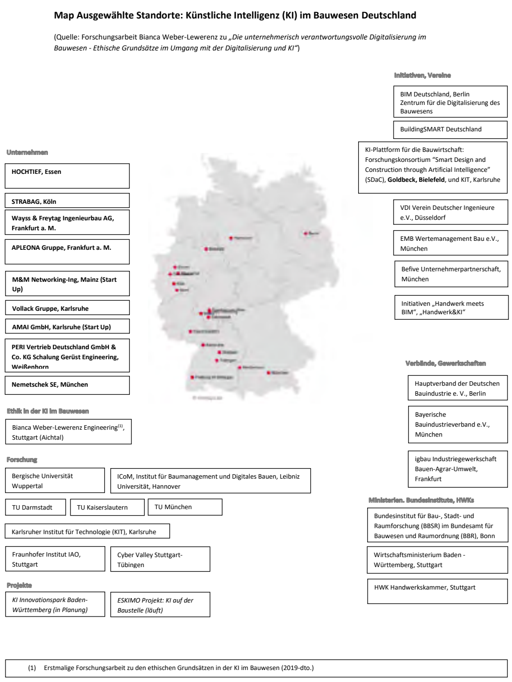
When science and technology, such as AI, meet human application, ethical moral issues raise. The debate is not new. Experts in Medicine, Biomedicine, Healthcare, Automotive, Ethics, Theology and Philosophy have long been critically evaluating the ethical aspects of technology`s impact on human being and society. Including multidisciplinary aspects and revealing key factors for success in business testify that such an approach in construction both accelerates the development of a trustworthy AI and uses the potentials of AI in a sensible and safe manner. These results are beneficial for the introduction of ethical AI debates in construction. Technical ethics, used as basis for ethical reflections in technical sciences, is part of ethics and, as a science, belongs to philosophy. It has a high practical application value because technical decision-making processes are about evaluating and weighing up advantages, disadvantages, opportunities and harm, and influences on the common good. In order to get closer to the design of possibilities of a successful, sustainable digital transformation in the construction industry – which means taking concrete steps towards a more efficient, economic project life cycle with safe use of innovative digital technologies, the study critically illuminates and points out both how AI may support sustainable activities and how risks lead to the need for responsible digital innovation guided by ethical principles. Transformation and digitization are based on AI. AI makes software intelligent and is based on data - the more, the better. Algorithms evaluate this data and recognize patterns and features. AI is the so-called umbrella term for applications in which machines provide human-like intelligence such as learning, judging and problem-solving. Developing, applying and maintaining such data driven technologies require orientation for being able to answer related digital responsibilities.

The core of this study lies in specifying the framework of CDR, defining various responsibilities that corporate units need to take to carefully develop, apply and adjust technologies in the field of AI and recognize its related impact factors. These factors are analysed from different angles via expert interviews from various disciplines and areas of responsibility. Only by carefully selecting the underlying data collection and methodology key elements could be identified. This rapidly evolving topic cannot develop its full informative value without such extensive qualitative research, set of surveys and insights into the issues of ethical AI in the German construction industry. Against its traditional, conservative attitude, the construction branch in particular is encouraged to increase the willingness to innovate nothing is shaped more than the individual manufacturing process of each individual building by human hands, in the close exchange of construction project actors. The construction industry clearly stands out from other industries due to its individual, unique and highly demanding manufacturing process, but also based on its small-scale, fragmented industry. Therefore, new opportunities to apply AI do exist. Civil engineers have a particularly high level of responsibility in the design of living and working spaces, cities and infrastructure, in making full use of supportive technologies for the efficient, sustainable work and ethical decision-making processes. The human shall develop and design AI, adapt it to new developments, control it, define fields of application and use it sensibly. The human shall use the potential, break new ground that the technologies offer - geared towards the common good.

The study follows an "*embedded ethics approach*" in the development of AI. The study succeeds in clarifying the relationship between technic and philosophy and in using ethical reflection in technical decision-making to empower a safe and successful human-machine interaction. The "*Ethics by design*" includes ethical aspects from the very beginning: moral questions, aspects of value. Ethics is an integral part of AI development, since AI is developed, designed and used by humans. AI technologies shall assist and ease human work. In Germany, this form of ethics in engineering is referred to as so-called Technical Ethics following the scientific theory of technology assessment. Like Socrates and the philosophy dealing with the main question on how a person should live in order to lead a good life. The central research question is: *Where can Corporate Digital Responsibility (CDR) be assigned and how must an adequate ethical framework be designed to support digital innovations in order to fully exploit the potential of digitization and AI?* Such holistic research goes beyond dominant financial focus, aims to create societal and economic benefits at its core and may encourage other branches to recognize the benefits of ethical principles of digital transformation for a strong corporate culture. The study comes to the conclusion that the human must be put in the center of all technological developments, but must also be familiar with the possibilities of technology. An ethical framework provides basis for CDR to cope with the challenges of AI. This research fills in a new scientific niche with almost no treatment in the scholarly literature. The study uses the extensive set of surveys and expert interviews. The results of the evaluation of survey data enhance a deeper knowledge about ethical implications in AI, specifically in the German construction industry. Diverse aspects of human-machine interactions add value to applied sciences and just emerging scholarship in this area. There are several various ways of operationalizing responsible, morally reasonable handling of emerging technologies in corporate environments. The results and discussion section identifies the benefits of AI and answers requests made by high level social and economic and political institutions for trustful, transparent AI. It clarifies, that CDR goes far beyond corporate responsibilities and reaches out the societal, economic and environmental ones, empowering human-friendly digital innovation.

The evolution of Technical Ethics provides the understanding for the herein applied method, significance of selected Case studies for this study, the most recent State of the art and the need of ethical frameworks for AI in construction. This new field of research extends over ethical, social, and economic impacts of digitization and AI on human, societal and technological development. The theories of Assessment of consequences of technologies and the critical theory of reflection in applied Technical Ethics support this design of research. Ethical impacts of emerging technologies are critically evaluated, leading to new framework of technical development and application. Thus, such practice-oriented solution, deriving from this theoretical background of research, sets foundation for corporate learning culture - in the sense of the common good and to achieve and maintain sustainable development goals [1] [2]. The term ´AI´ was coined by John McCarthy, in 1955. In 1975, the Asilomar Conference set a milestone by scientists and engineers` announcement of their obligation to assume responsibility. The philosophical discourse on moral and ethical questions of technology had its breakthrough with Hans Jonas' Principle Responsibility in 1979. In the 1990s, technology was considered value-neutral. Moral and ethical problems in development, design and handling of technology were reflected by Grunwald in 2013. Since the 1980s, the literature on technical ethics has increased in two areas: engineering ethics related to professional ethics and ethical questions about the newly developed technologies. With increasing technological progress and complex human decision-making processes technology ethics emerged by offering orientation to normative fears. Scientific research on human-friendly AI for the common good took off, especially in philosophy, theology, law, social and economic sciences, leading to the term 'Ethics in technology'. Grunwald [3] is leading in this field of research. As a result of exploring trustworthy AI, corporate Codes of Ethics have been developed, not least to counter the legal pressure due to allegations of discrimination. With increasing digital and AI technologies, research in these fields was followed by human-operated technology and the evaluation of ethical use of technology to meet sustainability goals. The finding that trust and understanding of its function can only be created through education, awareness-raising and transparency, led to "Explainable AI". IEEE developed the first ethical standard for technology development. The increasing research in Germany in construction on digitization, AI and ethical aspects is a milestone (**Fig. 1**).

Fig. 1: Map Selected locations: AI in Construction Engineering in Germany ***Source: Bianca Weber-Lewerenz***



While the study of ethics has a history dating back to Aristotle in the 4th century BC [4], with philosophical research by Immanuel Kant [5], it remains a salient area of study, and its presences in the area of AI is illustrated by publications from the Roman Catholic Church [6], the UN [7], EU Commission [8] and Data Ethics Commission of the German Federal Government [9] among others. When dealing with digitization and AI the General European Data Protection Regulation 2016 prioritized the protection of personality, data and privacy. On the international level, the White House Office of Science and Technology Policy responded with a report on how to deal with AI technologies responsibly within the rapid global digital transformation [10]. Scientific literature reflects the broad discourse on human-centered AI design and CDR with titles such as “Possibility of the good - Ethics in the 21st century” [11], “Digital ethics - A value system for the 21st century” [12], “Digital humanism - An ethics for the age of the artificial Intelligence” [13], “AI - What it can do and what awaits us” [14], “An algorithm has no tact. Where artificial intelligence is wrong, why it affects us and what we can do about it." [15]. Construction literature is missing and the argument to fill in the niche with this study.

Methodology

The research gap was addressed through Case studies from business practice as part of the qualitative, structured research methodology. Experiences and observations on multiple real-life applications, as part of empirical social research for systematic data generation, provided adequate resources. The reason for choosing such method is that the field of research is a marginal area; the topic represents a new scientific field. Intensive expert interviews conducted by the author as part of this study`s qualitative method design offer best way for gaining knowledge and deep insights on the status and use of technologies, ethical attitudes, opinions, motivations to act, needs, tendencies, critical reflections, social problems, recommendations for constructive solutions [16]. The Case studies are extremely illuminating in that most of the shared experiences and background knowledge explain the complexity of impacts and influencing factors. These are mutually dependent. CDR was found as to best allocate constructive approaches with an ethical framework to strengthen digital innovations in the construction industry. The development of interview guidelines on the research-relevant criteria, subject areas, indicators, with open and closed questions served as an instrument for data collection. This helps to map the complex practice from everyday values and empirical values: the identification of additional influencing factors, gaining systematic knowledge of entrepreneurial thinking, handling and proceeding, recording, processing and documentation of data, deriving strategies, localizing responsibilities. The surveys are conducted on a yearly basis - the first was performed between November 2019 and December 2020 - applying partially standardized scientific questionnaires and field notes on ongoing interactions in various types. Most essential for data collection for this interdisciplinary, holistic approach were the personal and written interviews by personal or telephone meetings, observations (in person in the research field or by video), written documents (media reports and files), Email communication and round-table discussions with respondents. German and international construction engineering associations, Chambers of construction trade associations, Departments for digital transformation in German Ministries, Research Centers, educational and academic institutions and Ethics and AI Institutes participated in that survey. Such frequently conducted surveys allow regular monitoring of a more accurately generated set of data, along the relatively new development and applications of these technologies. The present study is based on the first round of interviews and the author selected 50 leading experts from research, transfer institutions and associations with focus on the research area. AI in large companies and medium-sized companies is still in its early implementation phase, the understanding and awareness increases. In an early market phase, scientists are usually more familiar with the opportunities and challenges of the new applications than representatives from practice - due to a lack of pool of users. The interviewed experts mainly come from the transfer area at the interface between science and implementation in practice, so they are familiar with the challenges of the digital era. As AI and digitization are in its early stage, the interviewees, adopting these methods and tools, belong to a younger generation - 30 to 45 years old - and are academically trained in new innovative fields of engineering and IT. Around 20 AI and ethics experts are representatives from Fraunhofer and Max Planck Institutes, AI and Ethics Research Associations in Baden-Württemberg such as the Cyber Valley in Tubingen - Stuttgart, AI Research Centers at universities, country-specific BIM clusters and institutes for business ethics and academic representatives of Civil Engineering. Table 1 visualizes the extract of the survey`s questions. Around 30 representatives from politics and economics took participated, including steering groups for sustainability and digitization, global corporations. Selected companies are pioneers and best practices implementing digital technologies. Selected aspects of the results of the survey were then subjected to an in-depth analysis with the help of expert interviews (Table 2). Additionally, the study made full use of collecting data by national and international research literature, books and journals, exchanges between experts shared by international virtual panel discussions and forums, cyber forums, AI and Ethics roadshows, virtual summits, presentations, interviews and speaker series, group discussions and observations on media reports. Each interview conversation was planned and systematically analysed afterwards. Typing and interpretation were used for the evaluation process. In the qualitative content analysis, the interviews were interpreted and evaluated according to a rule based on a question [17]. On this basis, a summary content analysis can be carried out. Here the examined material is reduced to a manageable short text. Only the essential content is retained. In this way, a manageable body of all the material can be created. The summary content analysis is particularly useful in this research, as one is interested in the content level of the material. With the help of case and group comparisons, similarities and differences between individual respondents could be worked out, as well as final generalizations could be derived [18]. The study`s highlight is the study on "AI in Construction Industry" [19] in cooperation with Fraunhofer IAO Institute Stuttgart. The research results are also made available to an association that certifies and audits ethics management in construction companies, including potential corporate adjustments that this study recommends for the meaningful use and safe handling of digitization and AI. It should be emphasized that this is an expert survey. Therefore there is no claim to representativeness. Furthermore this study is about an in-depth assessment by technical experts.

Table1. Extract of the survey questions, *Source: Bianca Weber-Lewerenz*

1.	What is your opinion on the status quo of digitization and artificial intelligence (AI) in the construction industry?
2.	Why does only a minority of construction companies use digital method such as BIM?
3.	Do you use? If yes, what are your experiences? If no, what are the problems and limitations?
4.	Where do you see the potential of ethical framework and standards for the use of digital technologies and AI in construction?
5.	Compared to other branches, construction industry plays a special role in modem digitalization methods. What is it about?
6.	Where do you identify and allocate the use of digitization and artificial intelligence (AI) in the construction industry?
7.	Your company increasingly uses digital methods and AI. Which ethical standards and framework are necessary for the responsible handling in construction companies, especially with data, from your point of view?
8.	Why do you think ethics should be part of academic engineering training?
9.	What`s your estimate of the need for digitization and AI in construction? And what are the most important skills of engineers - professional and personal – to successfully face the challenges of digital transformation?
10.	What`s your estimate of the willingness of construction companies to integrate digitization?
11.	What limits and risks does a company experience when implementing digitization and what opportunities arise? (e.g. in the field of technology, people and specialists, company structure, ethics, mission statement, law, politics, etc.)

Results and discussion

Results

The construction industry is challenged by both Corporate Social Responsibility (CSR) and CDR in an

Era in which AI is expanding. Thus, technologies require corporate responsible handling by reflecting its own social responsibilities towards humans and society.

Table 2. Selected expert representatives interviewed by the study`s survey , *Source: Bianca Weber-Lewerenz*

Interview Survey with Expert Representatives / Function	Institution/Quantity of members	Company	Research/Academic
President	**FIEC (Association of European Construction Industry)** 32 Member Associations in 28 european countries. As the european head of associations of the construction industry it represents the interests of the european construction industry in front of european institutions (Commission, Council and Parliament).Additionally, the FIEC represents the employer`s interests within the european sectoral social dialogue for the construction branch. In 2019, the construction industry's building volume of the 28 Members of the european union consisted in 1,4 Billion Euro. In Europe there were approx. 3,3 Mio. of construction companies with almost 15 Mio. employees.		
Head of Business Area Technic, Sustainability and Digitization	**HDB (Main Association of German Construction Industry)** represents all german big and medium sized german industrial construction companies Members of all german states, Employers' Association of Industrial Construction Companies in the Federal Republic of Germany. It also sees itself as a trade association and trade association for construction technology.		
Executive Director	**Bayerische Bauindustrieverband e.V. (Bavarian Association of Construction Industry)** more than 200 corporate members incl. Global players and small and medium sized companies		
Deputy CEO, Executive Director	**EMB Wertemanagement Bau e.V. (German Association for Certifying Ethic Management of Construction Companies)** 210 corporate members incl. Subsidiaries		
Board members, Head of digital transformation, Head of diitization and AI	**various german companies** **Construction and Mechanical Engineering**		
Academics in leading positions (Areas: Construction, Engineering, Automotive, Ethics&Sciences, Science, Philosophy, Theology) Civil Engineering - here: Digital Methods + BIM, Informatics, Science Informatic, Wirtschaftsinformatik)			Universities, Technical Universities, Universities of Applied Sciences (Germany, Switzerland, Austria, France, USA, China)
Members of Boards, Institutes for Ethics in AI			Research
Head of Faculty 'AI in Construction', Fraunhofer Institute IAO Stuttgart			Research
Researcher, Max Planck Institute, Experts from CyberValley, in BadenWürttemberg			Research

CDR was found a key factor for enabling successful digital transformation in companies and to fulfil its responsibilities. As a result of the high demand for both technological development and value-based decision making, CDR has come into focus within the construction industry as a feasible holistic approach to enable the implementation of human-led digitization and AI in construction. Making full use of Case studies, the study reviews status quo, new technologies, interdisciplinary interfaces, current research, design of practical implementation and the ethical and legal framework. One of the evaluation results of the interview surveys is the strong need of guidelines, standards and binding rules, also in legislation. Further, the educational landscape must be adjusted such that the next generation of engineers not only have expanded skills in digitization and AI, but also possess the necessary ethical and multidisciplinary competencies. Therefore, the construction industry has proven to be best example for demonstrating existing gatekeepers, barriers, partial prejudices, negative attitudes and a lack of both digital and AI education and encouragement of constructive approaches to overcoming and strengthening a sustainable digital age. Strengthening of inclusion and diversity not only follows ethical responsibility, but also the principle of the common good [20] and the value chain's expansion as to mobilise resources to achieve 'ecosystem of excellence' [21].

Despite strong order books, construction and engineering companies face sustained cost pressures and lack of skilled workforce. New digital technologies and AI help to realize new operational efficiencies, new business models, increase education for newly required qualifications and offer new workplace solutions and job opportunities. New digital technologies include digital twin, 7D simulation, 3D modelling by building interior scan and exterior drone scan, Visualization and building accessibility. Methods of AI base on Machine Learning, Deep Learning, Predictive Analysis and Technologies as to enable applications such as AI-based data and project management, AI-based process performance, AI-based technical building automation and automation of engineering tasks, Parametric Design, Generative Design by programmed algorithms, visual image recognition, semi-automatic component recognition.

The construction industry plays vital national economic role. E. g. it added more than $900 billion to the US economy in the first quarter of 2020 - the highest levels since the 2008 recession [22]. Thus, this branch could benefit significantly by implementing the strategic decision-making processes, planning and operational phases more efficiently by both standardizing digital technologies, methods of AI and - with a powerful effect for diversity - increasing corporate women leadership. However, diversity is essential to the cutting-edge portfolio in construction to shape digital transformation holistically, successfully and sustainably. Construction is considered a major driver of the German economy and also the sector with the highest CO^2 emissions, specifically in cement production. As a result, the construction industry and its associated companies bear significant responsibilities for environment and climate. The challenges can be met by data-driven technologies that decrease the use of ressources, ease efficient project-life-cycle, ease human work and make it safer, and support all sustainable activities involved such as long term corporate digital business models and the education of qualified personnel. The current performance of construction projects lacks to keep within budget, time and high quality, but especially lacks efficiency in all involved processes. Digital technologies and AI could enhance significantly the efficiency at all levels, but therefore needed corporate responsibilities have to be mastered. The increase of complexity of processes and the occurring risks of digital transformation on both human, technologies and human-machine interaction itself lead to a need for responsible innovation, orientation, sensible and safe development and an overall CDR culture in the construction industry. The study identified the design of CDR for digital transformation process as key option. Although CDR can help enlarge value chains, save long-term costs, and achieve sustainable development goals, it is not yet broadly used and thus its full potential has yet to be reached. Stakeholder concerns, missing transparency, environmental restrictions are among the obstacles that hinder widespread adoption of CDR [23]. In fact, to achieve sustainable innovation, including use of digital methods and AI, it has been suggested that ethical decision processes should be institutionalized in corporate culture on a global basis [24]. Instead of examining the question "Is the new airport in Berlin a curse or a blessing?" the study is devoted to "CDR in the construction industry and ethical principles" in order to urgently raise awareness of methods and potential fields of applications of digitization and AI. The study identified moral and ethical principles as key for orientation in both researching and applying these technologies, and as essential factors for successful sustainable digital transformation in complex decision-making environments.

The study delivers first approaches to develop, control and apply technology and science in an ethically and morally justifiable manner. The evaluation of respondent`s results show that AI has potentials in many fields such as ease human work, data accessibility, increase project time and cost planning efficiency, quality, safety and risk management, protect natural resources and climate, enable new competitive, innovative business models. However, the study`s approaches by the construction engineering discipline answer international, national and UN white papers´ requests for responsible, safe and sustainable human-technic interaction in the frame of this vibrant and quickly growing AI technologies. Thus, it should be understood as an asset, especially on an economic, social and ecological level. Germany has an important role model function for other countries to lead into the new century of technology.

The collaboration with Fraunhofer Institute IAO for including this study`s ethical aspects in the study on AI in construction, commissioned by Cyber Valley in 2020, highlights the pioneering role and urgent action in embedding ethical principles into the earliest phase of technological development and its fields of applications. This close cooperation between strong partners coming from research and applied science sends strong signal, especially to corporates, both to intensifying awareness on ethical fundamentals in digital transformation discussions and setting focus on the significant potential of AI technologies and methods in construction industry as well as providing adequate corporate digital infrastructure. The study`s results not only mean an added value to scientific, multidisciplinary discussion on 'Ethics in AI' and complement current research debate on the potentials in construction, but enhances the project life cycle`s efficiency and sustainable digital transformation led by ethical principles and a human-led AI. The study led to elevate the construction industry into the most recent research study called AI ULTRA, promoted by German Federal Ministry of Labour and Social Affairs, aiming for guidelines for action and an evaluation toolkit. Organizations can fully exploit the potential of AI technologies, face this complex human and technical transformation process and use AI-based technologies sensibly and safely. Since this is a whole new scientific field of research and the topic hasn`t been examined before, this study could not include a section that highlights a comparative analysis with previous studies.

Discussion

One of the core tasks in the digital era for decision-makers in social, political, educational and corporate environments is to identify the benefits of AI and how to operationalize it in a responsible, morally reasonable way [25][26]. There is a consensus between all interviewed experts: it is key to strengthen entrepreneurship ecosystems by diverse approaches. The study shares the essence in the following and adds interpretations deriving. Emerging technologies play a fundamental and catalytic role in digital transformation. The pandemic crisis has highlighted the need, value and appreciation for empathic and humble leadership styles. The Critical Path consists also in strengthening inclusion and diversity that does not only follow ethical responsibility, but the principle of the common good and the aim to expand the value chain. The construction industry, experiencing a continuous decrease of skilled workmanship, could benefit in various ways from an inclusive debate using women`s potential to empower digital innovation and digital economy as the facts speak for themselves: a not negligible part of financially successful companies are led by women. AI subsumizes numerous applications that have one common characteristic: taking over cognitive tasks that previously only could be done by humans. This is why human and machine increasingly move closer together. Thus, in this context diversity represents the key to avoid gender bias in developing data driven tech.

Furthermore, despite strong order books, construction and engineering companies face sustained cost pressures and the lack of a revised and adjusted educational landscape to produce skilled workforce. New digital technologies and AI help to realize new operational efficiencies, new business models, increase education for newly required qualifications and offer new workplace solutions and job opportunities. The construction industry plays a vital national economic role; e.g. it added more than $900 billion to the US economy in the first quarter of 2020 - the highest levels since the 2008 recession. Thus, this branch could benefit significantly by implementing the strategic decision-making processes, planning and operational phases more efficiently by both standardizing digital technologies, methods of AI and increasing corporate women leadership. In short, diversity is essential to the cutting-edge portfolio in construction to shape digital transformation holistically, successfully and sustainably. Proof of hard facts such as the increase of economic efficiency (ROI) and overall excellence in corporate digital culture -evidenced in yearly corporate reports - rationalize gender discussions. It is time to fundamentally rethink technological progress enabling new business models in construction and keep up with digitization in a sustainable manner, by empowering digital innovation, digital economy, inclusiveness, gender parity, safe and transparent human-machine interaction. To achieve such goal, societal and ethical issues need to be identified and dealt with as rapid technical developments such as AI require control and orientation on what is harm or added value for human. Technical business transformation includes digital transformation by synchronizing and harmonizing with a profound human transformation. This transformation will cause technological, social and cultural disruption that will redesign the way we live and work. To shape this transition successfully, Ethics itself is perceived as an empowering way to recognizing values of a society in corporate culture and decision-making processes, empowering human growth, technological development, trust, responsibility, and consciousness. Intensified by digital change, inclusion, diversity, corporate governance, integrity, gender gaps, mandates and boards for financial and societal benefits increasingly come into focus [27]. Ethical and moral aspects are the top priority when it comes to ensuring corporate governance, required by legislators and stock exchange regulators as a result of corruption scandals, racism, and manipulation of technology in various industries. Over the past years, stakeholders increasingly requested transparency in the yearly corporate reports. Another option considered as a corporate responsible response seemed to be to hire a Chief Ethics Officer. Often such a department covers corporate diversity, inclusion, the promotion of women in management and leadership positions. More and more companies realize the significant role of HR, digital ethics, and corporate digital responsibility to shape a successful digital transformation. Thus, digital change speeds up the process of these previously separately working units to increasingly grow together. Diversity and digital transformation are closely linked. It is seen, that the widespread implementation is essential to exploit important potential for both the entrepreneurial and the common good. On the one hand to conserve resources, the climate and the environment, to think through the construction cycle from the project idea to dismantling and recycling, on the other hand to create attractive structures that are optimally embedded in the landscape and efficiently operated and usable for generations, supported by constantly evolving technologies, used sensibly. The scientific debates in the areas of quantum computing, blockchain and digital currency, which are developing just as rapidly as AI, have recognized that ethical issues must also be incorporated.

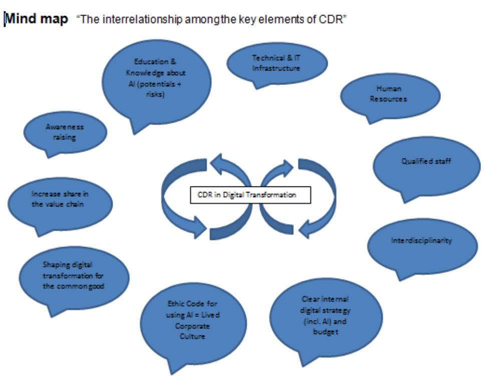
It is a goal, to achieve a relation of morality and technology and human-tech interaction, that are healthy for human, taking responsibility as corporate for digital environments, the fields of using AI, evaluating its chances and its risks, and to get engaged developers' and users' ethical responsibilities. To allocate and examine opportunities and risks of human-led technologies undergoing digital transformation is seen as key responsibility in order to deal with them in a targeted manner. One of the major outcomes of this scientific study in construction, in addition to studies in other sciences on AI in general, is the finding that standards and binding rules of the ethical framework for using AI must be set on the political level and by law. The background is as follows: pure personal responsibility is no longer enough, because many companies ignore it. Furthermore, AI is manipulated and developed and used in a discriminatory manner. Another finding is that the educational and academic landscape must be adjusted such that the next generation of engineers not only has expanded skills in digitization and AI, but also possesses the necessary ethical and multidisciplinary competencies. In fact, to enlarge value chains, save long-term costs, and achieve sustainable development goals (SDGs) it has been suggested that ethical decision processes should be institutionalized in corporate cultures around the globe. This study is part of a larger research project of the author, goes beyond dominant financial focus and aims to create societal and economic benefits for the construction industry at its core. The construction branch is envisioned as to encourage other branches to recognize and fully use the potential of the ethical implementation of digital transformation within a strong corporate culture. This research is met with the utmost approval to widen the awareness, education and application, so that in 2020 the author founded the "Excellence Initiative for sustainable human-led AI in Construction". It strengthens the dynamics of such process in order to make this industry a pioneer. To a larger extend, the initiative symbolizes a milestone on the way bridging the gap between technology and philosophy by an interdisciplinary bridge. Here, the construction industry is not yet visible. Digital transformation and AI are changing this. Language transfer, transparency and education are essential for gaining trust in new technologies, participating and shaping the digital transformation process, moving forward and fully using all potentials. Construction has just started applying first digital methods, and the first AI tools can simplify, augment and amplify human efforts. The understanding and knowledge of such technologies is still limited to a minority of people in research and development, leading to the conclusion that its opportunities, the technologies' risks and weak points need stronger education, communication and transparency. These new technologies offer new fields of qualifications and competencies. These new technologies create more economical and efficient handling of projects, transferring routine processes to machines, increasing protection of climate and of human and material resources and fulfilling sustainability goals. First experiences in practical application show how these new technologies relieve and support people, ease and make communication more efficient and work processes even more secure.

Ethical responsibility in AI has been emphasized since their application is soaring without much consideration of both positive and negative impacts on the construction industry. The importance of Ethics in AI and the lack of consideration of the construction industry`s CDR could not be more emphasized than by the lack of research prior to this study. The high level of practical relevance strengthens the construction sector. The study appeals to large, medium and small companies as the interviewed experts share their experiences with such corporate backgrounds. The construction industry has a special position: nothing is more shaped than the individual manufacturing process of each individual building by human hands, in the close and reliable cooperation of a comprehensive network of construction project actors. Construction - a specialist discipline characterized by craftsmanship - clearly stands out from other industries due to its individual, unique and highly demanding manufacturing process.

All interviewees resume, that, to plan, execute and operate projects more efficiently - especially on a more sustainable economic, social and ecological level - digitization and AI are indispensable to support human work, performance and processes. In terms of the precautionary principle, technology is not just a question of ability. In spite of all human freedom, the understanding of progress should lead to the design of technology that is healthier, more humane and more social for us humans. Civil engineers have a particularly high responsibility: to create working and living space of the highest quality for people and to work in a way that conserves resources. On the one hand, protecting climate and environment through the construction life cycle from the project idea to dismantling and recycling, on the other hand, to complete building projects even faster, cheaper and at high quality, provide optimized infrastructure, create attractive buildings and cities that are optimally embedded in the landscapes, efficiently operated and usable for generations. In doing so, the processes are supported by constantly evolving technologies. Construction industry is associated with multiple high risks in cost and budget, time planning and quality. These can be minimized with the help of digitization and AI. The civil engineer creates places to live, to work, places to meet, but also faces increasing complex data environments. The responsibility to use these technologies sensibly in the design, implementation and use of buildings, must be met morally and ethically - consciously and well beyond the technical standards and regulations. Because only by bringing together the core competencies (civil engineering, interdisciplinary technology, technical ethics, digital ethics, philosophy, information technology and software) the topic of digitization and AI in construction can be comprehensively dealt with and firmly anchored in research and teaching.

One of the results after evaluating this study`s interviews is the omnipresent interaction of key elements of CDR elaborated together with experts in the construction branch. These elements are mutually dependant - visualized at a glance using a "mind map" (Fig. 2): building up knowledge and competencies, designing all basic technical requirements, interdisciplinary cooperation are important building blocks for helping to shape the digital transformation responsibly and with long-term effects. Leading such intense debate on human tech interaction, responsibilities involved and framing ethical standards requires a clear distinction between human and artificial intelligence in order to define risks, overall potential, and areas of application.

Fig. 2: Mind Map "The interrelationship among key elements of CDR", ***Source: Bianca Weber-Lewerenz***



Because following the interviewed IT developers statements, it remains human key responsibility and belongs to human intelligence that programs, guides, controls, corrects, manages and maintains AI: digital transformation has the great potential to aid both the economical and efficient building project life cycle, but technologies involve and require responsible handling, deployment, management and monitoring. This overall research project discusses social, educational, economic and political impacts of AI from an ethical perspective. In order to fundamentally rethink technological progress in construction and keep up with digitization in a sustainable manner, everyone involved is challenged to lead this process to success and shape this process proactively with qualified human resources, an open discourse on new technical possibilities and the allocation of potential fields of application. Coping with this challenge is a top priority in construction. Nevertheless, there is a lack of recognizing fields of application and a lack of diversity. Knowledge about digital technologies and methods must first be acquired comprehensively to be able to assume digital responsibility for something that many do not yet know or cannot assess. It is a prerequisite for the greatest possible social benefit, economic prosperity and protection of our natural resources. It is time to set new sails to navigate digital times in a powerful, enriching, sustainable way. Best Practices are evidence that disruptive changes to existing corporate digital culture are a driver of more efficient corporate and project processes, and thus, for the increase of human and financial profits. The incentive to disrupt older processes will often spring forth new systems and methods that have the potential to be leaner, more efficient, less prone to error, and more cost effective across the enterprise.

Unfortunately, algorithms all too often have a "gender bias", a gender-related distortion effect, for example male thought patterns in the selection of job applicants. Thus, it is even more important to perform targeted training of machines, algorithms, and learning systems by multi-diverse teams. Understanding such interactions and dependencies among each other, AI is seen as an answer on sustainability and a fair gender future;

it is the approach for operationalizing the White Paper on AI of the European Commission. There are four main pillars of disruptive and transformative change our society needs to undergo due to the technological advances: educational, professional, cultural and governance.

Some of the latest emerging technologies (such as Blockchain, Artificial Intelligence, Next Generation Computing, 5G and 6G, 3D, IoT, AR, VR and XR etc.) can serve as catalysts or gateways to enhance inclusion and diversity when deployed mindfully. However they can also easily become the conduit for severe unintended consequences that worsen the gender gap. Developing state of the art proactive digital ethics programs that facilitate and accelerate the attainment of the United Nations Development Goals would be optimal for long term success.

Four basic ethical principles of AI have been laid down by the EU Commission in its ethics paper - promoted by the Enquête Commission of the German Bundestag "Artificial Intelligence - Social Responsibility and Economic, Social and Ecological Potential" [28]. These are more relevant for the construction field than ever: AI should preserve human autonomy, avoid social damage, act fairly and remain explicable. This study derives the ethical framework by bridging the gap between these principles and virtues, ethics, digitization and AI in construction. German companies consider corporate culture, ethics, appreciation, and wellbeing of people as decisive strategic importance for corporate success. But how do we want to design this technology? What are our expectations? How should it support us? Can values be guidelines for this technology design? How do we best familiarize ourselves? Which fields of work do we not transfer to machine? Which problems do we see, where do we allocate and how do we solve them? Algorithms are part of everyday life for computer scientists. Thus, a negligible proportion of society is familiar with AI and speaks such expert language. Trust in this new technology can only be established and built up by having access. Therefore, AI needs to be explainable, awareness must be created, and people must be sensitized. The respondents clearly distinguish between human and artificial intelligence: it is human intelligence that programs, guides, controls, corrects, manages and maintains AI. Digitization and AI are ethical challenges, human values and morals remain the most important tool kit to integrate. They help answering questions as to whether and how these technologies and methods can be reconciled with our moral ideas, what kind of concerns are perceived, which opportunities and advantages of technology should be used from an ethical point of view in the sense of the common good.

The ethical component of AI provides orientation for action. A vivid corporate culture practiced by corporate management is beneficial both to stand out from the competitive market and rapid global change and to strengthen human values in increasing complex working environments. Algorithms make assumptions containing evaluations, but humans provide data and personal assessment. Construction has just started to examine first digital methods, applying BIM and use first tools from AI, considered to be a new work-life that makes human work on construction easier. The understanding and knowledge of such technologies is still among a minority of people who develop or start using them. The study came to the conclusion that its opportunities, the technologies' risks and weak points need stronger communication and transparency. Ethical principles for human-led AI in construction have not yet been recognized although there is a strong need to develop and enhance a value-based AI consistently. One of the study's intentions was to engage the construction engineering discipline for multidisciplinary dialogue on 'Ethics in AI' and to define its own ethical framework for the benefit of its own branch. The impacts of AI on society are reason to perform this study now. To the author`s knowledge, this field of research is new and material that can be referred to only exists in other sciences.

Opportunities and high potential of digitalization in construction offer approaches to adopt new methods from AI, build on existing digital data structures, e.g. BIM, and make them more efficient. One of the study`s findings is, that success and sustainability can only be achieved by recognizing opportunities, actively shaping digital change, interdisciplinary critical analysis, changing perspectives and complementing one another. One model-based working method that takes advantage of the innovations of the digital age is BIM. This method enables up to 7D - modelling of buildings, building equipment of all integrated specialist disciplines, and construction process planning. Data can be linked over the entire lifespan of the building, be added and exchanged continuously by all parties involved - including building owner, planner, architect, engineer, technical building automation (Technical Building Equipment and Automatization: electrics, plumbing, ventilation, heating, light). This digital method can be assigned to tools of AI, in short: AI may enlarge existing digital structures of BIM and a more efficient functioning, simulation modelling. Facilitating forecasting and corporate strategy based on simulation models, it provides decision-making sources for the planning and construction process. By integrating all digital devices, data can be secured and interfaces can be merged within multidisciplinary environments.

The question is why do only 5% of German construction companies use BIM [29] even though BIM is required by law since 2020 for the tendering and execution of public works contracts [30]? Representatives of the German construction industry share and help identifying some of the reasons and possible solutions in expert interviews. All project participants´ responsibilities, in each individual project phase of the construction project life cycle, lay the foundations for the corporate digital infrastructure and its application: from the company management, executors to the building users and operators. By this study`s evaluation, the problem sources for the low number of users of BIM and their hesitations could be localized in unresolved questions of contract law (ownership of the building model data etc.), missing definitions of interfaces, ignorance of the benefits and advantages, as well as uncertainty in the application, open liability and copyright issues. Further key reasons are unanswered questions about the coordination management of BIM, cost aspects of new BIM software, training, and IT infrastructure, questions about the compatibility of BIM (technology, software, data security, data protection), non-existent legal regulations since BIM application of public and private clients and contractors has not yet been legally required. BIM may serve as technical requirement for new digital technologies such as AI. To comply responsibly with both shaping the design of the digital transformation process and sustainable, resource and climate-friendly construction, active participation is required at all levels. The study builds on these initial findings in order to draw new conclusions as to how a successful digital transformation can be enhanced by ethical guidelines. To cope with these two significant requirements, in addition to CSR, considerable amount of responsibility is allocated with corporate management: utilizing digitization, acquiring comprehensive knowledge of fields of application, benefits, forecasting options and risk areas, enabling access to digital technologies, offering training, participating in the technical progress, recognizing human values, taking measures to protect them, protecting data - including company data, personal data, and protection against data misuse, using AI for routine processes that lighten the workload and designing efficient work processes such as Lean Construction [31]

The responsibility of the project participants among others - as the study examined - is to carry out regular Lessons Learned to supply data, to avoid data loss, and to share knowledge, use historical and new project data for comparative analysis (fast data access also means using economical, time and personnel savings potential, and take measures to protect against data misuse. This use allocates the responsibility of owners and operators of buildings in conserving resources and ensuring the economically, environmentally and climate-friendly use, management and maintenance of a building (Technical and Building Facility Management).

However, little has been done to move forward and increase understanding of the ethical principles in corporate construction engineering environments to face the challenges of digitization and AI sustainably. This overall research project examines such relationship, which has so far not been discussed nor in corporate sustainability literature nor in the Ethics in AI research discourse.

The more experts could be interviewed, the more sensitive analysis of the influencing factors could be analysed and experiences from practise in-depth could be discerned, the more accurate responsible handling of digitization and AI could be described. Each company bears responsibility for educating knowledge, designing structure and providing creating the requirements for participating in the digital transformation process. This form of corporate responsibility is referred to as CDR.

Bauer demonstrates the building-specific contextual relationships between science and practice [32]: "*Due to the competition focussing on the price, the building industry is forced to maintain a high level of innovation through many special proposals. Digitization plays a significant role. …. The many interfaces with other parties involved in construction make the construction process particularly time-consuming because of the many coordination requirements for digitization. ….*"There are security problems with the fact that the data containing specific know-how of the data producer must be freely exchanged and used between those involved in the construction. …. contracting parties must clearly regulate that the data always belongs to the person who creates it and is only used by others for a specific construction project allowed to. Planning services and, thus, BIM models are subject to copyright; the General Data Protection Regulation (GDPR) also protects personal data.

Data always allow conclusions to be drawn about the people involved, such as the equipment driver and the work group. Bauer therefore suggests the precise definition of "*which data are used for quality assurance and which are only used to put people under control.*" Experience in construction practice, so the common tenor of the interview partners demonstrate, that the greatest difficulty lays in complying with data regulations. That is why there is a need for specifically developed and specific regulations. The handling of digital methods in construction, in particular the ethical principles, must be examined further. The author`s survey of representatives of the Bavarian Construction Industry Association reveal that legal requirements by the state are absolutely necessary for safe and secure handling of data. The handling and protection of data in the age of digitization must be legally regulated [33].

A fundamental part of the study`s CDR concept consists in creating awareness, in educating people about what digitization and AI can do, in analysing where chances and potential and also the risks lie, and how to deal with digitization and AI responsibly [34]. This is the only way to succeed in "taking people with you", making AI explainable and building trust. The centre of the ethical orientation of corporate action originates from three questions about first, the "highest good", second the correct action in certain situations and third the freedom of will. Confidence in technology is achieved only through the ethical consideration of the use of a technical method, understanding of the functions, understanding the structure, transparency, but also communicating dangers and risks with regulated control mechanisms and reliable design. As soon as people understand, that they have control over digital application, their awareness of their self-responsibility in setting the digital course increases. Such corporate culture is a fertile breeding ground for value-oriented, trustful more efficient processes. To do justices to their significant influence, construction companies have a moral responsibility of self-commitment, supporting the individual processes in favour of common good purposes [35]. CDR increases innovation and growth in companies and strengthens the shared added value both for companies and society [36].The study identified key elements for responsible digital transformation: clearly defining requirements (data, processes, qualification), quality features and interfaces, ensuring the consistent digitization of all planning and execution-relevant information data, and providing the consistent data platform that is used in all process phases by all participants. CDR goes far beyond compliance with legal norms [37].When dealing with data or using AI systems, a company bears foresighted social responsibility. Corporate responsibility implies creating one of the most important basic requirements: the partnership-based cooperation of all those involved in the construction project [38].Most research institutes for ethics in AI perform interdisciplinary investigations by forming a working group with multidisciplinary representatives. Specialist knowledge enables holistic analysis and evaluation, e.g. in automotive industry, medicine, biomedicine, law, care sector.

The trend of 21st century of growth with disproportionately high demand for new digital technologies and methods of AI not only signalizes the ethical impact of AI on society as a whole, but its call for a rapid shift from experimental to applied technology, adaption to new organizational capabilities and establish of internal governance emerging as key area. The increasing need to deal with AI shifts the competitive landscape and searches for improved, new methods for preserving the societal and human good [39]. This study complements previous work but adapts to technologies that are new and have severe impacts on people, society and diverse environments in the immediate future. The study identified Best Practice companies as Case studies, concluding that a culture of knowledge as the key resource to get engaged in the digital transformation.

The previous understanding required the specialist with special knowledge. Research findings show that today's experts in their field must have interdisciplinary knowledge ensuring holistic research. The study defines the engineering part as the integral part of professional and holistic examination. Interviewees highlight, that ethical reflection in AI needs to be integral part of academic education. Thus, engineers in their daily work are able to weigh values and interests and run an assessment of potential consequences. The engineer of tomorrow must have interdisciplinary knowledge and technical, social and personal skills to meet the challenges of his new fields of application, which make digitization and AI necessary. The discussion about human-led technologies include the engineer of tomorrow`s preparation to cope with value-based decision making processes and possess adequate skills. This field requires further in-depth research and long-term academic adjustments. The Institute of Ethics and AI at Oxford University in England is one best practice teaching "Ethics in AI for engineers" with the aim of teaching ethics as part of the engineering profile ("teach ethics as a skill"). Engineers are given the tools for ethically responsible use of AI in training via developing ethical awareness and the willingness to make ethical considerations part of daily decision-making processes.

During interviews and discussions in construction, ignorance, rejection, reservations about scientific interface work, a lack of foresight - often in management positions - were reflected. Part of the result of the study is that these imbalances have to be mentioned by name, because they not only hinder the exchange between specialist disciplines and the search for holistic solutions in the design of the digital transformation process, but particularly the innovative progress in Germany. "In the technical sciences it is still a long way off, that values and principles are used and that ethics training has to be anchored in training." [40]. The study observes critically that progress and reform depend on dialogue and a new quality of discussion. The study contributes to shape value-based, sustainable digitization and AI and raises awareness of the responsible role the construction industry. Ethical values and Codes of conduct must be further developed to strengthen trust in and promote new technologies, to use them sensibly and to provide orientation [41] [42].

After two years of work, the German Bundestag's study commission provided recommendations for action for human-centered AI. In Baden-Württemberg "Cyber Valley Stuttgart-Tubingen" and "AI Innovation Park Baden-Württemberg" aim mapping globally competitive research and high-tech locations - similar to Silicon Valley. The study notes that there are initiatives approaching "ethics in AI" on the German level (including DEK), the European and the international level (including SDGs, Roman Catholic Church). They inspire considerations in the construction industry. Successful companies that anchor an ethical strategy and a vivid corporate culture and mentality - this is proven by the expert interviews - possess an awareness of the added value potential resulting of applying digitization and AI methods and its employees` identification across the company.

For the majority of companies, there is still a high need for getting digitization and AI explained and trained in to be able to allocate where the use of AI makes sense and to allocate its benefits. Experts share their Case studies and experiences applying AI and, thus, contribute to an eye-opening effect showing trust and transparency among users. Digital change requires trust, competence and value-based corporate culture according to what is presumed as "Trusted Human-Centered Engineering"[43]. More than ever, technology is the key to a new era of European culture of innovation. Corporate activity, social and ethical responsibility and environmentally conscious technological innovations merge into one another. The sustainable, value-based design of the living and urban worlds of tomorrow, sustainable urban infrastructures is only made possible by ethical principles in dealing with digital technologies and AI.

The construction industry holds significant potential to create value in the digital transformation process. Merging new AI methods with existing digital models may lead to new working environments with eye catching concepts of AI (**Table 3)**:

Table 3. Key elements of AI in construction in its early phase of research and first implemented technologies,. *Source: Bianca Weber-Lewerenz*

- Digitization tools beyond BIM e.g. helmets with Webcams, digital markers, digital online site visits with Virtual Reality Glasses, Simulation of Renovation concepts + Construction during use of building, Simulation Acoustics and Fire protection concept, AI Sensors to detect defects and damages, Sensors of material failures, changes of temperatures, humidity, AI Monitoring + Controlling according to construction progress)
- Mixed Reality (MR)-Glasses, Hololens Glasses, Augmented Reality (AR) (Measurements of building elements sections by creating digital twins)
- Networking of all digital devices for complex data collection from all technical trades
- AI-based accurate mapping of consumption and billing, AI-based Remote monitoring functions
- Forecast and strategy data systems as an entrepreneurial basis for decision-making (predictive technologies)
- 3D - 7D twin systems used for simulation, reality and forecasting models
- Robots for automatic 3D-scans onsite
- Self conducting construction machines, autonomous and semi-autonomous bulldozers
- AI data evaluation / derivation of recommendations / data use for training machine learning
- The use of machine learning, deep learning, and social computing
- Automatic analysis of building sections
- Show the failure risks of construction machinery in real time using machine learning
- Systems for structuring data complexity
- AI based identification of similarities to existing construction project data and use for new construction project data for highest efficiency in resources, climate-friendly, cost and time
- Smart Technology and Smart Buildings, and
- Self-learning construction sites.

Ideally, digital transformation assists architects, planners and operational part of construction, makes the interaction between workers and machines more efficient, performs partially-automated processes and uses existing data to provide new experiences, its values and the basis for strategic decisions (= Self-learning construction site).

Experts conclude that machine learning has an estimated potential of value creation of $ 5.8 trillion. This means that Artificial Intelligence has greater potential than the steam engine [44]. As one key outcome, the study identified precise indicators being advantageous by integrating AI and its use in the construction industry (**Table 4**). Simultaneously, companies learn "undesirable side effects" initiated by digitization and how corporate responsibility has to change accordingly, thus, a process of continuity. A key question becomes how successful companies are able to develop their own individual strategy of digital responsibility and how they use management tools to implement in dynamic markets and social environment.

Table 4. Indicators to the benefit of integrating AI in the construction industry, *Source: Bianca Weber-Lewerenz*

- minimizing errors where people fail,
- structured data complexity,
- routine and standardized processes carried out by the machine,
- more efficient time management: giving people more time for the processes that no machine is able to perform (those that require creativity, human morality e.g.),
- knowledge networking across all digital borders,
- cost-efficient, sustainable and responsible resource-saving construction,
- increasing stability through "lean" building processes (Gehbauer 2006),
- a tool for monitoring and fulfilling climate goals,
- a tool for implementing the Sustainable Development Goals given by the UN (SDGs),
- high social contribution to the change towards a climate-friendly society, and
- increasing the share in the value chain.

Some of the best practice companies share their experiences: "*Such dynamics goes hand in hand with corporate responsibility and embedding ethical value management in a society that is increasingly fundamentally changing from digitization and artificial intelligence technologies*," said Schäfer [45]. "*We are in the middle of a renaissance of value orientation*", emphasizes Wieland; *"moral values need to be implemented and routinized"* [46]. A long-term Head of Civil Engineering faculty sees the education of values and ethics as an integral part of the engineer`s academic training, because the course for the success of construction projects is already set there - by well-trained engineers who are prepared for digital transformation.

As such, companies increasingly search for ways to include ethical moral aspects into technical development and application from the very beginning and following their corporate responsibility based on the precautionary principle. Some discover ethical frameworks as enabler of new ways of thinking and acting: efficient orientation and support for managers and specialists in becoming more agile, acting more collaboratively, and focusing on new goals and business models. Peter Mendler knows *how to create trust, openness and fairness, because ethically justifiable products are more competitive. They are usually better received by the customer. Success and acceptance can only be achieved in projects such as the construction of the AI innovation park if, in particular, the ethical aspects are of essential importance. Dimensions are taken into account and integrate* [47].

Thomas Gebhardt's core task is the transfer between teaching, research and application [48]. *For him, the entrepreneurial responsibility in the digital transformation consists particularly in re-thinking process and communication improvements in order to remain competitive …raising awareness, education and knowledge transfer require appropriate language. … In order to efficiently train algorithms, you need significant amounts of data. Cooperation is required, no isolated solutions, more networking. Ethics and framework conditions for digitization in construction are still a long way off. Thus, this pioneering study deserves full nationwide support and sends a very positive signal to the construction industry.* [49]

Case study I: PERI Digital Transformation & Corporate Development [50]

PERI is working on various potential fields of application of AI (object identification and automation of engineering tasks) based on a wide variety of methodological and technological approaches. Successful digital transformation at PERI means 'taking people with you', getting excited about AI, with methods that solve a problem. The most suitable AI solution must support people by raising awareness, education and transparency. People are human capital; you don't want to keep people occupied if the same task could be solved *faster and more efficiently by a machine. The integration of value chains - across companies - is the critical path to the success of digitization in the construction industry. What is important is a sensible use of AI, geared towards the common good. We have anchored a large part of the "ethical" aspects in our management principles, significantly shaping our corporate culture.*

What risks and problems do you see in the use of digitization and AI? *In order to develop meaningful AI techniques, the problem and the field of application must be defined first. The main question is: at what point does it make sense to address a problem? The network is missing to connect this question among the actors; this is a big weak point. There is a high need for education of AI due to the lack of knowledge about the possible uses of digital technologies and AI, which makes balanced, well-thought-out decision-making paths ethically highly questionable… Ethics and misuse are closely related, it is part of the corporate commitment to deal with and to look for value-based solutions. The aim remains problem solving for the benefit of the community! (especially in the case of resource bottlenecks, at high costs).*

Case study II: Wayss & Freytag Digital Construction (Royal BAM Group, NL) [51]

"Digital Construction", business unit of Wayss & Freytag founded in 2016, copes with the challenge, that digital transformation and entrepreneurial culture form a cross-cutting issue. The associated change management is embedded in the daily work, and contributes to the acceptance and enthusiasm of everyone working in the company.

The construction industry has traditionally been conservative. Structural problems exist with contracts, fragmented value chains, there is no networking and the influence of certain actors is missing. However, in order to develop useful AI techniques, the main question is: at what point does it make sense to address a problem? I also see risks and problems in the need for development of a) consistency of the digital process, b) data management on the construction site: previously administrative too much time, c) data security, data protection: close company-internal exchange with appropriate experts (legal components are covered by our legal department in the company), d) biggest hurdles for AI: data sources, data availability, big data far away, further use and use of the data, localization open.

Overall, I rate the existing lack of knowledge about the possible applications and the need for education about digitization and AI as very high. AI is supposed to help solve people's problems. Ethics means a guideline; for us, this is the focus for ensuring efficiency, best quality and safety.

How important is ethics in the age of digitization? *It is very high and one of the Wayss & Freytag's guiding principles is the company's Code of Ethics and Code of Conduct. We do not have an additional code of ethics or ethics guidelines specially tailored to digitization and AI. It is part of the corporate commitment to deal with value-based solutions. A problem solution for the benefit of the community! Common good makes the guideline! Value chains have to be integrated more and more.*

Is it important to regulate the ethical framework by law? *Legal rules are important as a supporting function. The most important thing remains the appeal to corporate responsibility and a trustful cooperation between all those involved in construction. No additional legal regulations are required; these are more of a hindrance to innovation. We see this in Germany, as part of the BAM Group, compared to UK and the NL.*

Case study III: APLEONA [52]

In practice, there are barriers to adapting digital / AI solutions. The reason for this is, among other things, the specification-based contract models between FM companies and their customers, which are still common in Germany. The need for clarification at this point is high.

For Apleona, digital transformation means a win-win-win partnership between our customers, us and our subcontractors. In addition, we see the opportunity through digital solutions to expand our service portfolio (always primarily based on the business case: solving a customer problem, economically efficient (fast amortization phase, high energy savings).

Where do ethics play a role? *It's always about problem solving. The starting point for every consideration of a digital solution: focus on people, design thinking for the "use case": and here the "user" is the key factor.*

What are the difficulties in FM when dealing with data? *Dealing with the customer's data is a challenge. …The principle is that the data generated by the customer also belongs to the customer. The AI methods that we are partially using are self-learning technologies in energy and CO^2 optimization. We are aiming for a "fully automated building technology control" (Predictive Control, already implemented). … in some cases building owners do not want to give building control out of their hands; in addition, successful implementation requires an initial effort, an investment that must be borne by one of the stakeholders. Ideally, that should also be the one who benefits from the savings.*

These Case studies highlight the urgency of taking corporate responsible measures, and defining approaches and ethical principles to make full use of the potentials of digitization and AI. Companies consider themselves as actors, seize opportunities, weigh up risks and deal with them safely, reflect on values, design ethical standards and framework conditions [53], and make their contribution in the value chain. The practical guide CDR [54] on corporate responsibility and sustainability management in the digital age pays particular attention to Ethics.

In order to design state-of-the-art city systems, efficient city logistics, mobility and innovation systems fulfilling SDGs, the question arises in some interviews: who are the actors, the masterminds and designers, who are the executors? Local climate adaptation strategies, digital strategies, the living and urban worlds of tomorrow, sustainable urban infrastructures, sustainable design of space and society can only be achieved with the help of experts and know-how.

This study comes to the conclusion that standards that both promote the efficiency of human work and comply with SDGs should be established. Not only developers of AI but users and political and societal decision-makers among the interviewees support standards by law. AI structures and evaluates data complexity and prepares it for human use in a clear manner that affects all industries, enabling minimization or prevention of human errors, continuous access and maximum transparency. Ethically moral decision-making processes can be supported by AI and thus help people during the process. Protection of natural resources can be ensured by using AI-supported calculation, analyses and forecasts (e.g. material savings, logistics efficiency). Climate protection can be strengthened through forecasts and recommendations for action developed by AI. AI data evaluations facilitate corporate strategy development. AI increases human work efficiency: if routine and standardized processes are carried out by AI, humans can spend more time concentrating on creative work processes which cannot be transferred to machine or artificial intelligence. Since AI is trained and managed by humans with the aim of providing the most human-friendly and economically efficient support, humans determine the areas in which AI should be applied. People control AI, not vice versa. Such knowledge builds trust, relieves fears, and clarification. AI builds up and maintains security and safety where human failure and error may occur. The ethical strategy in AI in construction could be designed as follows - split into goals and standards:

Goals:

- to meet the sustainability goals,
- to make Germany and Europe the leading location for the development and application of value-based AI technologies with targeted promotion of a culture of awareness and alignment of AI with ethical values, supported by the associated legal regulations.

Standards:

- to ensure the common good-oriented development and use of AI,
- to secure the competitiveness of the construction industry in Germany,
- to embed AI ethically, legally, culturally and institutionally in society as part of a broad social dialogue and active political shaping,
- to support education and awareness-raising for the potentials, opportunities and risks of AI,
- to set up a concept relating to the ethical standards in AI (Common European Path) that applies to all European member states.

It applies to all Case studies and there is a consensus: responsible innovation and ethics remain as challenging as before and undoubtedly even more difficult in increasing complex environments and new, rapidly developing data-driven technologies such as AI to shape their outcomes [55]. Human-machine-interaction represents a partnership that distinguishes between human and artificial intelligence. It is a commitment for a balanced technology. Some corporate and stakeholder interests may not be in line with legal standards. The interviewees agree in opinion, that function of AI shall be transparent, its application safe, support human workman sensefully, enlarge human and economic efficiency, maintain safety and security of data and make an overall added value to the common good - far beyond financial interests only. But there is no consensus on whether the self-commitment is sufficient on the longer run or standards by law need to be binding for each firm and institution. There is a huge gap on how to mitigate such risk of greenwashing and how binding standards shall look like. The status quo consists in recommendations and general principles that shall guide more or less, but have no binding act.

It makes a big difference whether a company cultivates and upholds a culture of values, compares its technological progress with safe, meaningful and responsible human-machine interaction, or relies on PR campaigns that encourage particularly ethical, fair action by the entire company or strategies put in a "green" light (greenwashing). On the other hand, legal requirements can force a company into senseless documentation efforts, make processes inefficient, and delay technical developments and progress. When examining who can best fill out the supervisory authority for compliance with ethical standards, the majority of those questioned in this study appealed to self-responsibility or called for an independent supervisory authority. For reasons of data protection in particular, the surveyed experts demand uniform regulations from the legislature.

Grunwald *advises to debate the economic efficiency hand in hand with ethical issues* [56]. *Society sets the values, people shape society. Businesses can be forced to fulfil ethical responsibilities by their customers, the users. That means corporate standards need to be enforced - it's a kind of awareness and informative level, a very proactive way. Ethics should accompany the process of AI development and decision-making from the beginning.* Kiefer, Consultant for international occupational policy and technical education at the Association for German Engineers VDI [57] *starts with the integration of ethics in engineering training and teaching. The sensible use of new technologies …. requires ethical principles right from the very start. The engineer is required a holistic, moral, value-based, interdisciplinary approach. Digital transformation changes the engineer`s profile, qualifications and competencies. Responsibility and ethical behaviour require adjustments in the academic education and teaching. In times of digitization and AI, ethics and interdisciplinary cooperation are mutually dependent as education and awareness-raising are the linchpin for explainability, transparency and trust in the new technologies. …Compared to Germany e.g. the separate consideration of "technology ethics" and "engineering ethics" does not exist in all countries.*

Survey results evaluated in this study revealed that in their role model function - particularly in politics, academic teaching, research and science, but also the professional chambers and professional associations – institutions and companies are multipliers for the ethical discussion about digitization technologies in construction and regulate compliance with ethical principles in a binding manner. The specification of the European regulatory framework for AI should be part of binding European legislation. Not least to make the European data strategy the most secure in the world. It is the corporate self-responsibility to responsibly train knowledge, provide the infrastructure, fulfilling requirements for shaping digital transformation and anchor values in the corporate culture as to bridge the gap between Ethics and practice for trustworthy AI technologies. Some of the large companies engage Ethics Boards. The presence of a CDO (Chief Digital Officer) or CIO (Chief Information Officer) is often an indicator of the structural change as part of corporate digital transformation. Such personnel infrastructure modifications and tailored departments are only affordable due to the financial background of large companies, required to demonstrate ethically correct behaviour to investors and stakeholders. Another reason is the in-house R&D carried out by large companies in order to successfully master existing and future challenges - up to and including the technological role model for competitors.

SMEs often do not have such strong financial backgrounds; they face market competition, and can only survive by offering low-cost services. Confronted with economic bottlenecks, the majority is busy with surviving day-to-day business. Most of SMEs are not involved in research collaborations, nor do they develop technologies themselves. The study examined a high level of dissatisfaction with the digitization in-house.

Companies experience increasing complexity and quantity of data. Independent of their size they must adopt uniform data platforms, accessible to all parties involved, to have data available at all times, in the updated version and in its entirety, without any loss of data. Construction companies do not want to miss being part of digital transformation, perform efficient business, reduce costs, remain and increase competitiveness, increase customers` confidence and generate new orders. One of the key factors, the study identified, is stability and sustainability by setting up safe digital to handle corporate data securely and protect against misuse.

Perhaps the communication language required for digital transfer is also different, because not everyone is an AI expert or has access to this specialist knowledge.

Interviewees underline that large companies and SMEs have in common, that they possess the potential to build up knowledge and skills, to contribute to reducing CO^2, to do their work in a more resource- and time-efficient manner, also for the benefit of society. Because services that are based on comprehensible ethical standards tend to be more successful in the market, 49 percent of companies consider their services most competitively when in compliance with ethical standards [58]. This means that ethical standards are rated more important than functionality. The pressure from consumers' expectations for compliance with ethical standards is increasing.

Large and SMEs want to achieve success and add value, but the majority neither knows or searches for ways or their own digitization strategy to achieve this goal, nor recognizes or searches for their own advantages and potential fields of application.

Pushing digital innovation forward by government funding, many interviewed political decision-makers state that many companies still benefit from the success of past years, and plan “on sight”. They feel no need for switching to digitization, start innovative paths or change business models. To them, AI is considered far away. Interviewees from large corporate entities, representing best practices and adapting to innovative strategies and new technologies, confirm this existing attitude of such companies and estimate their competitiveness very low and survivance of business very critically. However, it is precisely these companies that exclude themselves from digital project contracts because they are not compatible with customer`s digital project infrastructures. A new company cell phone and construction plans or time schedules on paper do not go together. Being unable to answer tenders digitally is a rejection criterion, as it demonstrates a company`s inefficient project process, without digital networking. Having to search for information in the office first and not offering a uniform data platform to employees is no longer up to date. Regardless of the size of the company, clients trust in and award companies for new projects that are up-to-date and deal with the invested budget responsibly, transparently and with high-quality performance. The same applies to selection criterion for graduates and highly qualified workers for choosing a company and applying for jobs.

There is a gap between desire and reality: many construction companies and suppliers are just spectators, not co-designers. Scepticism can only be resolved through knowledge. The cooperation between industry and SMEs with technology start-ups and the formation of regional networks and clusters is seen as the most important solution, because it has developed positively in recent years. Start-ups are particularly suitable for SMEs that localize the options for using AI and introduce and train the appropriate technological solution for the company. The German Federal Association for AI (German KI Bundesverband e.V.) is committed to ensuring to use this technology in best sense of European and democratic values and to achieve European digital sovereignty.

For all companies, key to success is building up knowledge about digitization and AI and using it responsibly. Times of crisis prove once again that the digitally well-positioned companies are flexible to act and enable to continue their work. The National Institute of Standards and Technology, the Defence Innovation Board and the National Security Commission on Artificial Intelligence joined the public discourse and released their own recommendations for ethical AI use. Such acting and setting guidelines on a highly official level sends strong signal and underlines the study`s importance. This study invites leaders and users of digitization and AI to take responsibility to shape the ethical framework for AI and step in international debates, e.g. EU-uniform concept for ethically justifiable AI, European Ethic Guidelines for trustworthy AI, European Data Strategy, Digital Europe and Digital Technologies Initiatives, European Green Deal, SDGs by the United Nations, Rome Call for Ethics and the Center for development and progress of AI, funded by German Ministry of Economic Affairs.

Limitations

CDR is limited. What use is openness and basic technical equipment if knowledge and specialist knowledge are missing? Here, the focus is on the educational landscape, which must enable targeted training in specialist knowledge in AI. Respondents´ shared experiences show that companies urgently need qualified staff in order to introduce new digital technologies into the company and determine its ethical framework.

But the process of understanding, knowing its advantages, potentials, chances and risks and to whom to address questions lack adequate language transfer between science and construction industry. One of the key factors of building trust and knowing the sense of using these new technologies lays in its explainability towards companies and potential users. Another key factor is that the construction branch benefits from past years` orders. It is a critical path, that Construction industry still follows traditional ways as long as there is no pressure for change or raised by regulations by law. The Construction industry consists mostly of SMEs, but large companies represent the minority taking a model role in starting researching and applying AI. The use of AI and getting familiar with applications is still limited to large companies. The ethical understanding as part of their CDR urges them to share their findings and knowledge and communicate with SMEs. In Germany, however, some parts of construction industry lack awareness of adopting new perspectives and consider approaches made in other disciplines. They lack recognizing the advantage in taking up social, explicit ethical approaches in the field of engineering and building technology and at the same time, this attitude prevents economic growth, data safety and gains from active prosperous participation in the digital transformation process. This is even more critical since every company is required to deal with increasing contemporary technical challenges combined with new digital technologies in changing global markets. In order to accelerate technical digital progress, a radical rethinking - far from deep routed ways of thinking - and further research is required. Funds that have not been used up to now reflect the un-used potential. Overcoming such limitations, Germany can set a milestone for its national location of research and education and increase significantly its share in the value chain. In principal, the interviewees agree, that AI should be used where it makes sense, supports people, ensures safety of human work, and increases the efficiency of work processes. The ethical framework helps to overcome the existing limitations mentioned by this study, gives sense to human being and human action and thus, represents the key to highest human performance.

An additional limitation is represented by academic teaching that has not yet adjusted both academic teaching staff`s skills and competencies to train and prepare students for ethics and digital transformation processes and its requirements. Companies are not able to fill positions with qualified engineers and experts having completed their academic education as they are not prepared for daily ethically balanced decision-makings and applying digital technologies and AI methods.

The study`s research moves the Body of Knowledge forward by providing constructive solutions, framework and inclusive approach to fill these gaps and to shape digital transformation with focus on the specific needs of supporting the construction industry at all levels.

Conclusions

The study found that the CDR concept in the construction industry, incorporating ethical principles, provides the critical foundation for the use of innovative digital and AI technologies. Developing adequate skills based on adjusted curricula helps companies to master a successful human, technical transformation. Still, there is a lack of recognizing fields of application and potential. Knowledge of digital technologies and methods must first be acquired comprehensively in order to be able to assume digital responsibility for something that many do not yet know or cannot assess [59]. It should be of such a design, that companies can guarantee secure data management, as well as access and use of new technologies by everyone. Fortunately, there is growing awareness by leading AI researchers and developers that human-centered designs are needed [60]. The study comes to the conclusion that a sustainable digital transformation can only succeed if human are placed in the center of technological developments. Ethical guidelines are seen as orientation. However, they offer orientation for balanced decisions with increasing complexity of data and decision-making options.

The study`s findings, Case studies with shared experiences with applied AI and new aspects support RESER`s excellent interdisciplinary linkages.

The results and limitations presented in the study show that successful companies have recognized the advantages of ethical principles and have embraced them in order to use new innovative technologies for themselves with a firm will. What is lacking are the required technical and personal qualifications of tomorrow's engineers, an adapted academic teaching, the interdisciplinary dialogue, courage and the will to innovate, though these factors represent the key competencies for a competitive construction industry.

This study can be used for the validation of follow-up studies in order to check developments in the human-technology relationship and to introduce recommendations for any necessary corrections into the scientific discourse. This supports the further development of technology ethics with advancing technology and increasing challenges for people.

A field of tension in the educational landscape is seen in the balancing act between engineering qualification and new job profiles requiring new technical skills. On the other hand, universities use their strategies of excellence to differentiate themselves from the competition with targeted clusters of research, innovation and interfaces.

Same perceptions can be made in large companies, active around the globe, redesigning their attractiveness as employers, but also want to meet their social responsibility. So far unused funds that are available for AI research and application show that too few are still grappling with it. It is time for a radical rethink, especially in large companies and SMEs: breaking boundaries and set the sails. Engineers, architects, designers and craftsmen are not only designers of living environments, but shape technical, social and human change in Construction Industry 4.0. The research provides constructive approaches not only fulfilling technical regulations but setting a milestone using AI sensibly, reliably and responsibly. A transparent and ethical AI, made in Germany not only follows a national strategy, but rather a European one in the role of a prosperous, strong global partner. However, further research is needed. To understand what AI, its function, its chances and risks are about, how certain methods may enable improved or new business models, what measures and which responsibilities must be taken responsibly, the communication language between research - education - practice need adjustments.

The study sends strong signal on how important it is that construction industry strengthens its own competitive role to not lose track in digital transformation. It is the historic chance to make full use of the disruptive role of the emerging technologies and lay path for the next generation in a diverse and inclusive environment. Best practices increase attention for integrating considerations of ethics and values into development of digital technologies and AI [61] [62]. There is a strong need for responsible innovation by inclusion for currently emerging data-driven technologies to rethink how these shall be conceptualized, introduced, and implemented [63]. This concept and framework of CDR offers not immediate beneficiaries but long-term benefits and orientation for human, society and tech with strong sustainability over the next decades. This lays foundation for AI and digital technologies helping humanity prosper. This study is especially valuable in understanding the critical path and key processes of the digital transformation in the construction industry. The findings define CDR´s opportunities and risks to deliver significant improvements on corporate business models using AI safely and for the benefit of both corporates and the common good. The study identified CDR with ethical principles as the key driver for success, resources-cost-time efficiency and sustainability using digital technologies and AI in construction engineering.

The study suggests the intrinsic value of a successful innovation culture that can be allocated and shown in annual group reports ("Combined financial and sustainability report") transparently as an independent item, as well as the human factor contributing to reducing costs. This could increase the trust of stakeholders, entrepreneurial identification and attractiveness in terms of external impact.

Compliance with Ethical Standards

The author has no relevant financial or non-financial interests to disclose. Publication permission was given by all respondents. Some public statements from internet, literature and archive research underline the quality and statistical values of the expertise obtained, as well as limitations and urgently necessary measures. The author conducts external, fully independent research and is not financially supported by third-party funds, companies or any institution. She is free in her research and shares her findings at the interface of "Application Practice - Applied Technical Research - Economic and Social Transfer". The author researches critically and inclusive - and promotes the ethical debate about the AI technologies in Construction.

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Smart Salesperson and Smart Service-Owner – New role profiles due to changed competence requirements in the context of digital work

Lena Maria Fischer, Marc Schwarzkopf, Synnöve Hochstein, Angelika C. Buillinger (University of Technology Chemnitz, Germany)

Introduction

In industry, data-based value creation is being provided as digital services in addition to traditional production. These digital services, also called smart services, are based on data generated by machines and offer end customers additional value (Reinhold et al., 2021). In this context, the boundaries between traditional production and data-based value creation are fluid, and the term hybrid value creation is established (Breit et al., 2017). In particular, the establishment of digital business models and processes has a deep impact on value creation as well as on production and work processes (Koldewey et al., 2019; Plass, 2020). In this context, especially small and medium-sized enterprises (SMEs) from the manufacturing industries of mechanical and plant engineering see themselves insufficiently prepared for the changing areas of human-machine interaction (technology) and organization (Dumitrescu et al., 2020; Abel & Wagner, 2017). In this situation, companies face fundamental challenges, profound organizational changes, and new work requirements. New task and cooperation situations arise for the employees in the company, which set the need for changed and new competence requirements (Heim et al., 2017; Dumitrescu et al., 2020; Mlekus, et al., 2020).

Therefore, it is necessary to adapt and (re)design work processes and structures, especially role profiles, in order to qualify employees in SMEs in dealing with new technologies (acatech, 2016; Bullinger et al., 2017; Diewald et al., 2020). In this changing environment, role profiles enable the definition of dynamic, changing tasks of employees in self-organization or teams. In this context, the development of role profiles in companies is declared to be a challenge, as it is accompanied by cultural and process-related changes as well as changing competence requirements (Ulmer, 2019). Furthermore, the distribution of roles between smart service providers and customers is being eminently changed by the increasing possibilities of information procurement (Haab et al., 2019). In addition, employees in particular need a targeted idea of the roles and task areas assigned to them in order to be able to proactively manage the disruptive changes emerging from smart services (Nettelstroth & Schilling, 2020). In addition, the question arises which role profiles (competence and qualification profiles) employees should have with regard to the implementation of smart services in SMEs.

State of the Art

The introduction of hybrid business models transforms the value chain of companies as well as the potentials of the sales areas (Reinhold et al., 2021; Everhartz et al., 2016). The use of smart services results in transformed and new supply of information for employees in sales and for customers. On the one hand, this leads to a realignment of competencies, tasks, and roles within the company, and on the other hand, to changes in the behaviour of customers (Gorich, 2019; Wolf & Heidlmayer, 2019). Digitalization enables customers to obtain extensive information about products, which transforms the process of buying behavior (Biesel & Hame, 2018). As a result, the classic salesperson will evolve into a consultant with decision-making authority, who in particular will have entrepreneurial thinking as a primary competence and act accordingly (Gorich, 2019).

In summary, roles and the associated competencies are significantly affected by the transformations resulting from the introduction of hybrid business models in the company. Gorich (2019) postulates that, in particular, traditional sales is subject to far-reaching changes, and companies are inadequately prepared for this or face far-reaching challenges in successfully implementing digitalization strategies (Gorich, 2019). Based on this finding, the following research question arises, which will be answered in this paper: *What are the transformed competence requirements for the role of the classic salesperson?*

Changes in role profiles in the transformation process to a smart service provider

The transformation from classic to Smart Salesperson

The role of the traditional business-to-business (B2B) salesperson is basically to manage and design sales processes and structures (Binckebanck et al., 2020). Furthermore, in classic sales, the detached sale of non-data-based products takes place. Furthermore, the salesperson acts as a problem solver and first point of contact for customers and prospects. As a result, the salesperson must analyse the customer's individual situation, identify problems and communicate possible solutions internally and externally, and perform advisory activities in this regard. Furthermore, the salesperson acts as a coordinator and information provider between the company and the needs of the customer, e.g., by communicating the customer's needs to the R & D department within the company (Ackerschott, 2002).

The implementation of hybrid business models is transforming the requirements for the competencies of sales staff. In the sale of smart services, products are much more individualized and adapted to customer requirements, which necessitates a more protracted consultation and decision-making process in which sales staff support customers in developing their product (Niehaus & Emrich, 2020; Everhartz et al., 2016). In this process, they often face several contacts from different areas of the customer company, who together make a purchasing decision (Everhartz et al., 2016).

The sales process as such remains in its fundamentals: initiation, conception, handling, and aftercare of a customer also form the essential process steps here. Furthermore, from a sales perspective, a smart service not only includes the sale, but rather the joint, customer-specific development, implementation, and its continuous support throughout the entire life cycle (Everhartz et al., 2016). In this context, the sales department acts as an interface between the supplier and the customer, in the context of which the coordination and control of the sales process is of greater importance than in traditional sales. In this context, the salesperson mediates between meeting the customer's needs and observing the needs of the provider of hybrid services (Everhartz et al., 2016).

In order to better illustrate the changes in the changing role profiles in companies, the term "role" will be discussed in more detail at this point. A role is understood here as the description of various tasks and responsibilities that are to be implemented in the company. The focus is not on the hierarchical position of the corresponding employee who performs this role, but on the competencies. The role, however, can be executed by more than one employee and is not, in contrast to the "job", person-bound (Schiller & Meiren, 2020). In particular, the execution of the role in the organization is about satisfactorily meeting expectations regarding task performance. In this context, the role relationships between the members in the company are focused on, with the competencies that the executing employees possess being particularly crucial for task performance. Moreover, it becomes clear that the role is influenced by various internal and external factors and by various expectations, such as technological and organizational changes, interpersonal relationships (Wolf & Heidlmayer, 2019).

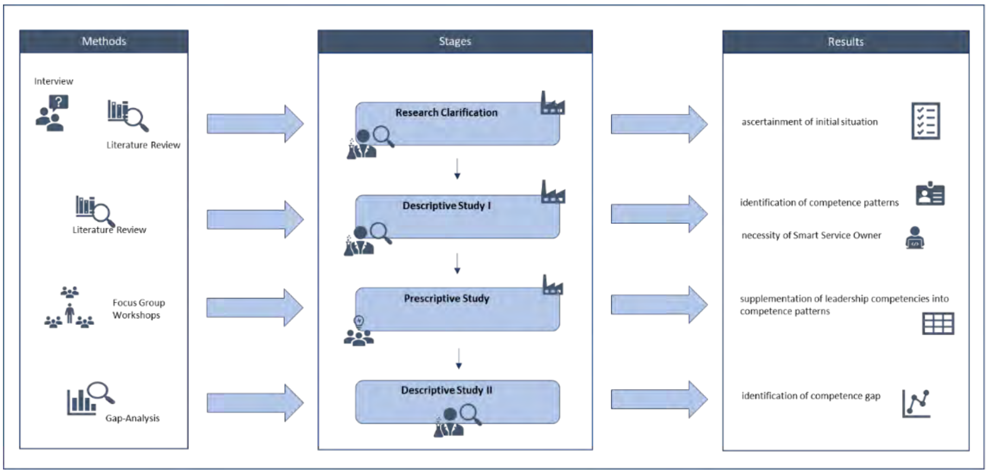
The Smart Service-Owner as a new role profile

As shown at the beginning, individualization, in the sense of adapting the smart service to the specific needs of the customer, plays a major role in the sale of hybrid services. To this end, the support of the entire process in the sales company in particular is eminent. This task is assigned to the newly developed role of the Smart Service-Owner (SmS Owner), who, similar to the Scrum Master in agile software development (Köster, 2020), is not part of the development process itself, but moderates it. The SmS-Owner is therefore responsible for the entire product lifecycle within the smart service provider. In addition, he coordinates the continuous improvement of the Smart Service and acts in an advisory capacity within his own company. Furthermore, he is endowed with extensive powers, which is intended to promote the development and implementation of the smart service (Köster, 2020).

Methodology

The methodology for identify the competency requirements for the role of the Smart Salesperson and the yet fictitious role of the SmS-Owner were completed using the Design Research Methodology (DRM) approach according to Blessing & Chakrabarti (2009). The model is divided into a total of four phases. In the first phase, the research objective that is based on the literature review is stated (1). Furthermore, the initial situation and target situation are considered (Research Clarification (RC)). In the second phase, a Descriptive Study I (DS-I) is conducted, which focuses on the individual requirements of the companies. In the context of Smart Services, this consists of identifying key competencies (2). The Prescriptive Study (PS) follows in the third phase. Furthermore, the requirements and findings from the DS-I are located here, on which the PS procedure is based. In addition, the target profiles of Smart Employees are created (3). In the last phase, the second Descriptive Study II (DS-II), in the form of a comparison of the created target and actual role profiles, is conducted, with the result allowing the derivation of initial recommendations for action. (4). Figure 1 illustrates the model for the methodology.

Figure 1 DRM Framework



The four phases of the DRM are presented below, which were conducted together with two SMEs and one corporation to identify the role requirements for the Smart Salesperson and the SmS-Owner. A total of ten (two to four executives per company) participated, from engineering, sales and management.

Research Clarification: Analysis of the initial situation

In Phase I, based on a literature analysis on requirements and challenges in the transformation process to a smart service provider, interviews were conducted to identify the initial situation with regard to the changing work tasks and organizational structure. The insights gained were the starting point for the further survey of the individual initial situation in the company, related to competence management and learning. For this purpose, a literature-based phase model for the process of competence management was applied based on Sanders et al. (2019). This model is divided into seven phases. The literature-based phase model included questions on internal company process structures for requirement profiles, initial target and actual competence requirements in the context of smart services, and questions on qualification in the company. For this purpose, a digital workshop was conducted with the three companies. The workshops were held with each company individually.

The results from the first phase create the basis for understanding the individual initial situation in the company in the context of smart services, which constitutes the basis for the further procedure.

Descriptive Study I: Elicitation of literature-based competency requirements

Based on the findings from Phase I, a structured literature review (following Wächter, 2018) was conducted for the elicitation of competency requirements for smart services, analyzing 72 sources. The extracted competencies were assigned to the four competency categories (basic competencies) according to Erpenbeck (2012). The basic competencies here include technical-methodical competence, social-communicative competence, personal competence, and activity and action competence. The more frequently the competencies were mentioned in the literature, the more they were weighted for the smart service area (see Appendix 1). Competencies that were mentioned at least five times were defined as relevant competency requirements. The limit of at least five mentions was derived from the mean value determined across all identified competencies (M = 5.34).

Parallel to the literature analysis of the competency requirements, further literature analyses were carried out with regard to the need for an additional role, which included the key words service owner, smart service owner and smart services. As a result of these literature reviews, the so-called SmS-Owner emerged as a roughly sketched role.

Together with companies involved in the study, the competence requirements were mirrored in a further step to the size, customer structure and industry of their companies. As a result, the competencies extracted from the literature have already been adapted.

Furthermore, based on the current state of science, relevant competence requirements for the changing roles of the classic salesperson to the Smart Salesperson and the SmS-Owner were identified and extracted from theory and mirrored to the needs of the project partners from business.

The competence requirements extracted from the literature were checked for duplications in a focus group consisting of three experts from the fields of organizational development and business administration and merged using qualitative content analysis (Mayring & Fenzl, 2019).

The results were then presented to the companies again and discussed in a digital workshop. The workshops were conducted with each company individually.

Prescriptive Study: Identification of competence requirements

In a moderated workshop, which contained three parts, the requirements for the two role profiles of the Smart Salesperson and SmS-Owner as well as the identification of needs and requirements of the three companies were collected. After each part, the findings were summarized by the moderating person and discussed with the participants to ensure that the content was correctly understood by all participants.

In the first part of the workshop, the educational profile, as well as relevant and optional qualification requirements were collected. In the second part, core tasks, potential secondary tasks and team or department affiliation were surveyed. In the third part, the competencies extracted from the literature in Phase II were weighted according to their competency requirements on a four-level scale for the competency areas "activity and action competency", "technical and methodological competency", "personal competency", " social-communicative competency" and “miscellaneous knowledge” (e.g. computer skills, driver's license, etc.) (1=no competency, 4=very high level of competency, tasks can be mastered confidently and independently). In addition, the participants were given the opportunity to add and weight further competencies in the respective categories. After the workshops, the weighting and the additional content added by the participants were evaluated by a focus group consisting of three experts from the fields of organizational development and business administration. The additional points mentioned were compared and, if necessary, reformulated so that they could be applied across all industrial sectors. Role characteristics that received a weighting of two or less on average were excluded from the further consideration process. In the course of the survey, it became apparent that the four basic competencies according to Erpenbeck (2012) are not sufficient to describe the role of the Smart Salesperson in the opinion of the companies surveyed. Reflecting the needs of the project partners, leadership competence was added as a fifth category. In addition to weighting individual competencies by the number of times they were mentioned, the survey also determined the required level of each competency.

Descriptive Study II: Evaluation GAP analysis

The fourth phase consists of comparing the target and current profiles of the smart employees. In the literature, it was not possible to identify sufficient competence profiles for the traditional sales person that were also suitable for the companies surveyed in terms of size, customer structure and industry. Nevertheless, an initial profile of a classic sales person was necessary for further investigation with regard to the changes in role and competence requirements. This was created on the basis of job descriptions and requirement profiles of the sales employees of two of the three companies surveyed. Based on the requirement profiles and job descriptions, the competencies necessary to fulfill them were derived. The competency atlas according to Erpenbeck (2012) served as the theoretical frame of reference here, with the competencies being assigned to the four basic competencies according to Erpenbeck (2012). Subsequently, the competencies mentioned were listed and clustered according to the frequency with which they were mentioned. The actual profile created in this way served as the starting point for the gap analysis. Here, the competence requirement profile (target profile) of the Smart Salesperson was compared with the competence profile (current profile) of the classic salesperson and examined for distinctions between the individual competences. Since the number of mentions of the individual competencies based on the job descriptions examined differed significantly from the number of mentions by the workshop participants, the weighted average was calculated for each of the competency clusters.

Results

As a result of the first phase, it became clear that the companies surveyed see a high need for change in classic sales. Furthermore, the companies stated that there is a need for an additional role in the company that has knowledge of the entire product life cycle of the smart service: the Smart Service-Owner (SmS-Owner).

As a result of the Descriptive Study I (Phase II, a total of 24 competence patterns were derived, which serve as requirements for the Prescriptive Study (Phase III).

The results of the literature analysis (Phase III) regarding the competences of classical sales showed that social-communicative competences, such as communication skills (N=20), were mentioned most frequently, the fewest mentions concerned personal competences, such as personal responsibility (N=4) or learning ability (N=1). Leadership skills were not mentioned (Table 1).

The results of the Prescriptive Study workshop (Phase III) show that a high level of personal and leadership competence is required for smart sales. Social-communicative competences as well as activity and action competences are of secondary relevance to fulfil the role of the Smart Salesperson. New competences were identified during the workshop (Table 1). These were mentioned for the role of the Smart Salesperson, but they could not be identified in the creation of the competence profile for the classic salesperson. The newly identified competences were mainly in the area of personal competency as well as technical and methodological competency and leadership competence. With regard to social-communicative competency, comparatively few new competences were mentioned. There were no new findings of activity and action competences.

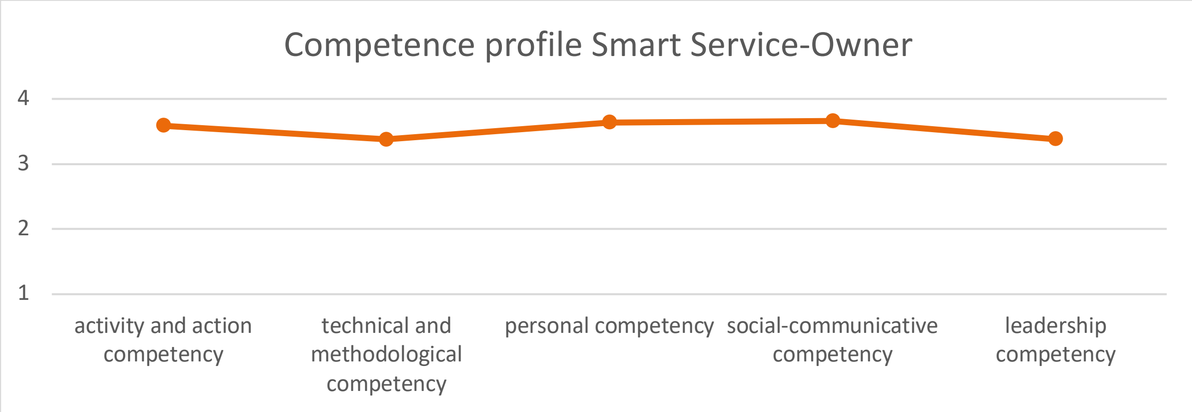
Table 1 Identified new competences for the Smart Salesperson

Competence area	Competence	Characteristics (weighted average)
Technical and methodological competency	Data security	3,50
	Process understanding	3,33
	Affinity for data	3,00
	Enthusiasm	4,00
	Resilience	4,00
	Technical understanding	2,00
	Perception	2,00
Personal competency	Sense of responsibility	4,00
	Critical ability	3,50
	Presentation skills	4,00
	Negotiating skills	4,00
	Judgement	3,00
	Networking	4,00
	Saleability	4,00
	Load-bearing capacity	3,00
Social-communicative competency	Intercultural competence	3,57
	Understanding the requirements	3,00
Leadership competence	Entrepreneurial thinking and action	3,43
	Role model	3,25
	Assertiveness	3,67
	Motivational skills	3,50
	Networking	3,00
	Evaluation ability	2,00
	Empowerment	3,00

Another result of the Prescriptive Study (Phase III) is the target competence profile of the Smart Service-Owner. Parallel to the survey of the competence requirements for the Smart Salesperson, the competence requirements for the SmS-Owner were also surveyed during the same procedure. Due to the fact that the SmS-Owner will act in an advisory and coordinating capacity and will have the authority to issue directives, the four basic competences according to Erpenbeck (2012) as well as the leadership competences were also considered here.

Table 1 shows the survey results of the participants of the Phase III workshop with regard to the expression of the five competence areas for the role of the SmS-Owner.

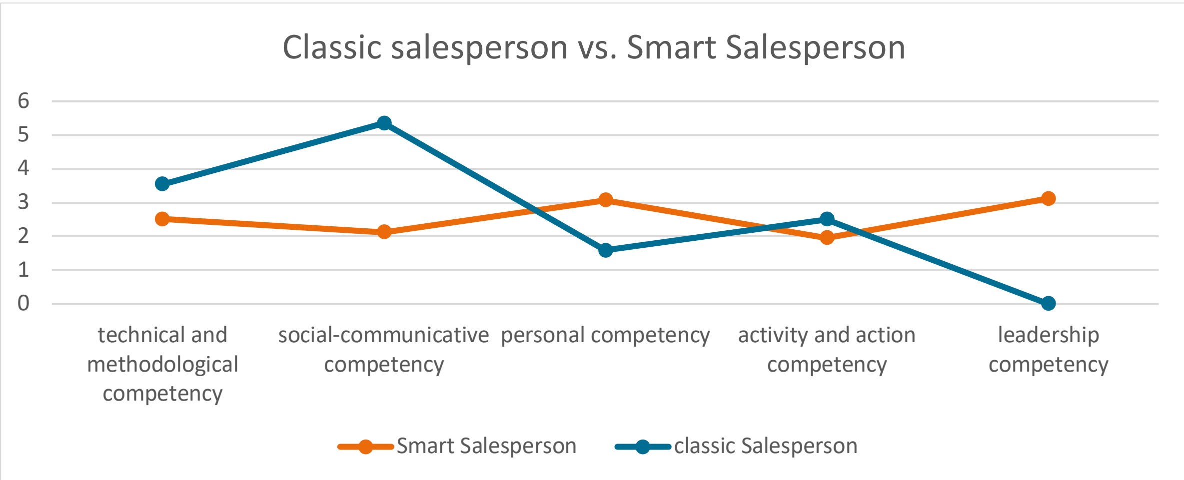
Figure 2: Role profile –Competencies of the Smart Service-Owner



All areas of competence show a high level of proficiency. Compared to the other competences, technical and methodological competence as well as leadership competence are .3 weaker in average (M = 3.4) compared to the other competencies (M = 3.7).

The gap analysis (Phase IV) shows a clear difference in the competence profiles of classic sales and smart sales.

Figure 3: Comparison between competence profiles of classic & Smart Salesperson



Thus, the competence profile of Smart Salesperson focuses on personal competence and leadership competence. The competence requirements of classic sales, on the contrary, do not include leadership competence, and personal competence is the area that receives the least attention. The focus of classic sales also concentrates on social-communicative competence.

Discussion

When considering the results, it should be noted that the competences of the classic salesperson were obtained in a different process than those of the Smart Salesperson and the SmS-Owner, which does not allow a direct comparison of the classic salesperson with the other roles mentioned. Nevertheless, a trend can be derived from the results.

The research results show that in the role of the classic salesperson, the focus is mainly on social-communicative competences, such as communication skills, assessment skills and customer orientation dialogue skills. Personal competences, such as learning ability or creative ability, only assume a subordinate role. Leadership competence could not be identified within the study as a component of the role of the classic salesperson.

On a contrasting basis the role of the Smart Salesperson focuses on personal competence and leadership competence. Social-communicative competence is less focused on. The technical and methodological competence has the lowest level in the competence requirement profile of the Smart Salesperson. This suggests that the smart salesperson is not adept at technical details, but must understand and be able to model the processes on both the customer and company side and offer the appropriate product.

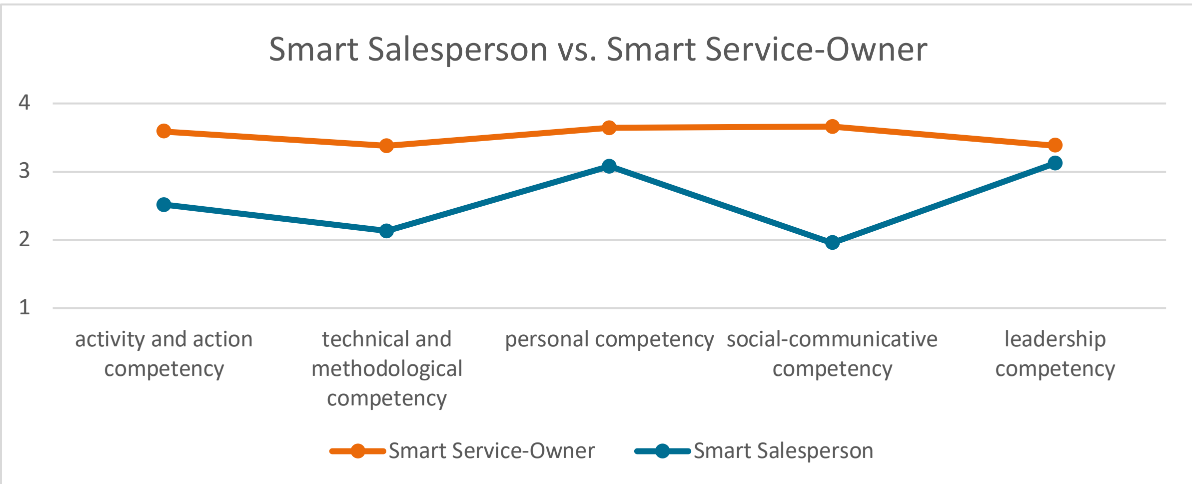
Within the framework of the study, a variety of additional competences were identified that the role of the Smart Salesperson should additionally encompass.

Thus, in the area of technical and methodological competence, the confident handling of data, but also enthusiasm, resilience and process understanding will become more important in sales in the future than they have been in the past. In the area of personal competence, networking, sense of responsibility and negotiating skills are gaining in importance for the Smart Salesperson.

This is also in line with the new requirements mentioned at the beginning that will be placed on salespeople in the future in the environment of hybrid value creation. The competence requirements of the Smart Salesperson will increasingly come into focus with regard to the handling of data and digitalisation as well as process design.

The research results from the Descriptive Study I also showed the necessity of establishing the role of the SmS-Owner based on the changing demands regarding the Smart Salesperson. Their competences show a high to very high level for all competence areas. This clearly shows the generalist orientation of this role. It is striking with regard to the results of the survey that although the social-communicative competence is very high, it contains comparatively few competences. In the survey, only 6 of 16 possible competences of the competence atlas were mentioned.

Figure 4: Comparison between competence profiles of Smart Salesperson & Smart Service-Owner



A comparison with the competence profile of the Smart Salesperson shows a clear distinction in the area of social-communicative competence as well as in the area of technical and methodological competence. The reason for this can be found in the comparable orientation of both roles in terms of content. However, the role of the Smart Salesperson is more focused on the initiation, the sale and its follow-up, whereas the SmS-Owner is responsible for the process coordination within the company and the user-centred product development of the hybrid service across all stakeholders. In terms of personal competence and leadership competence, both roles have a similarly high level. This also corresponds to the content of the roles, as both move in the same, constantly changing and highly complex subject area, in which competences such as openness to change or self-management can make a decisive contribution to successful hybrid business models.

However, the ecological validity of the results is limited, as the validation of the competence requirements was only carried out with three companies in a theoretical framework and holds no validity for all sectors of the economy. Furthermore, the roles presented are theoretical constructs that have not yet been evaluated in practical business situations. Furthermore, the roles presented are strongly dependent on the technical development and the organisation within the companies, which is why the competence requirements of the roles are linked to future developments.

For the competence profiles of the Smart Salesperson and the SmS-Owner, no actual profile could be recorded at the time of this publication in order to identify possible competence gaps and to verify the recorded profile. At that time, the companies surveyed were at a point in the transformation process to become providers of hybrid services, where the role of the Smart Salesperson, just like that of the SmS-Owner, had not yet been established in the company structures.

Conclusion

The procedure described in this paper and the following explanations on the development of job profiles are to be understood as practical guidelines, especially for SMEs. The results presented in this paper show numerous competences that will become relevant for the future role of the Smart Salesperson, but are not yet relevant in the role of the classic salesperson. These should be given special attention within the framework of competence development and be specifically placed in the development focus. The same applies to the recruiting strategy. The acquisition of future sales staff should be based on the role profile of the Smart Salesperson and special attention should be paid to complementing the classic competences already existing in the sales team. In addition to development and external re-procurement, the competence gap can also be closed by recombining skills from employee. In this way, an interdisciplinary staffing of the sales team would be possible, in which employees from other specialist areas could supplement the missing competences. In contrast to competence development and recruiting, which are long-term and medium-term strategies, this would be a short-term approach to closing the competence gap. Companies that create value through hybrid services should focus on continuous competence development, as the technical and organisational requirements within which they operate are constantly changing. With regard to the roles of the Smart Salesperson and the SmS-Owner, this means that their competence requirements should be subject to continuous review.

Furthermore, when designing the organisational structure, it is advisable to assign the role of the SmS-Owner close to the sales department or to establish a separate staff position for SMEs. Although the distribution of smart services does not fall within the scope of the SmS-Owner's tasks, he or she bears the process responsibility for the joint development of the smart service with the customer. In addition, the SmS-Owner is responsible for the internal process control and should have short ways to the sales department for an optimal communication flow.

Hybrid business models and value chains require agile corporate structures, which are achieved by employees acting on changing environmental requirements (Wolf & Heidlmayer, 2019). Based on the competence development process, it emerged that the role and thus also the requirements and concrete fields of action of the classic salesperson change fundamentally in the context of the introduction of smart services. The analysis of the workshop results showed that there is a need for the classic salesperson to develop into a "Smart Salesperson". Thus, the above-mentioned research question could be answered in all three companies, in the SMEs as well as in the group, by showing that changed competence requirements arise for the role of the classic salesperson. The further development from the classic to the Smart Salesperson shows that changed competence requirements can be found in particular in the area of personal and leadership competences. In the future, the Smart Salesperson will sell hybrid services in the B2B area to customers. Accordingly, skills and competences such as data analysis, data security (affinity for data), interdisciplinary understanding and openness to change play an increasingly important role. Furthermore, the Smart Salesperson will increasingly use changed or new communication channels to inform customers and get in touch with them. The supply of information will become an essential factor, both internally and externally, which needs to be structured and more strongly networked with the customers. The Smart Salesperson represents the interface between B2B-customers and acts as the first contact person for the implementation of the smart service at the customer. This requires the sensitisation of sales staff to customer-specific situations and problems.

Furthermore, it has been shown that a new role, that of the SmS-Owner, is required for the performance of coordination tasks in the customer-centric development of smart services, which has emerged as a fictitious role through the transformation process to a smart service provider in the companies. The SmS-Owner represents the internal and interdisciplinary interface in the company and accompanies the entire life cycle process of the smart product. It should be noted here that the relevance of this role is particularly prevalent in SMEs due to the structures. In the study, however, the group only showed an optional need, which was justified with the complex traditional structure. In summary, it can be said that the contextual factors (degree of transformation in relation to hybrid value creation, company size, financial and human resources) of the companies influence the design of the roles.

However, further evaluation is needed on the extent to which larger companies offering smart services need the role of SmS-Owner, as well as validation of the results in SMEs to ensure a high level of ecological validity.

Acknowledgements

This contribution is based on the BMBF-funded joint project "IMPRESS - Instruments for pattern-based planning of hybrid value creation and work for the provision of smart services", (FKZ 02L17B077).

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Appendix

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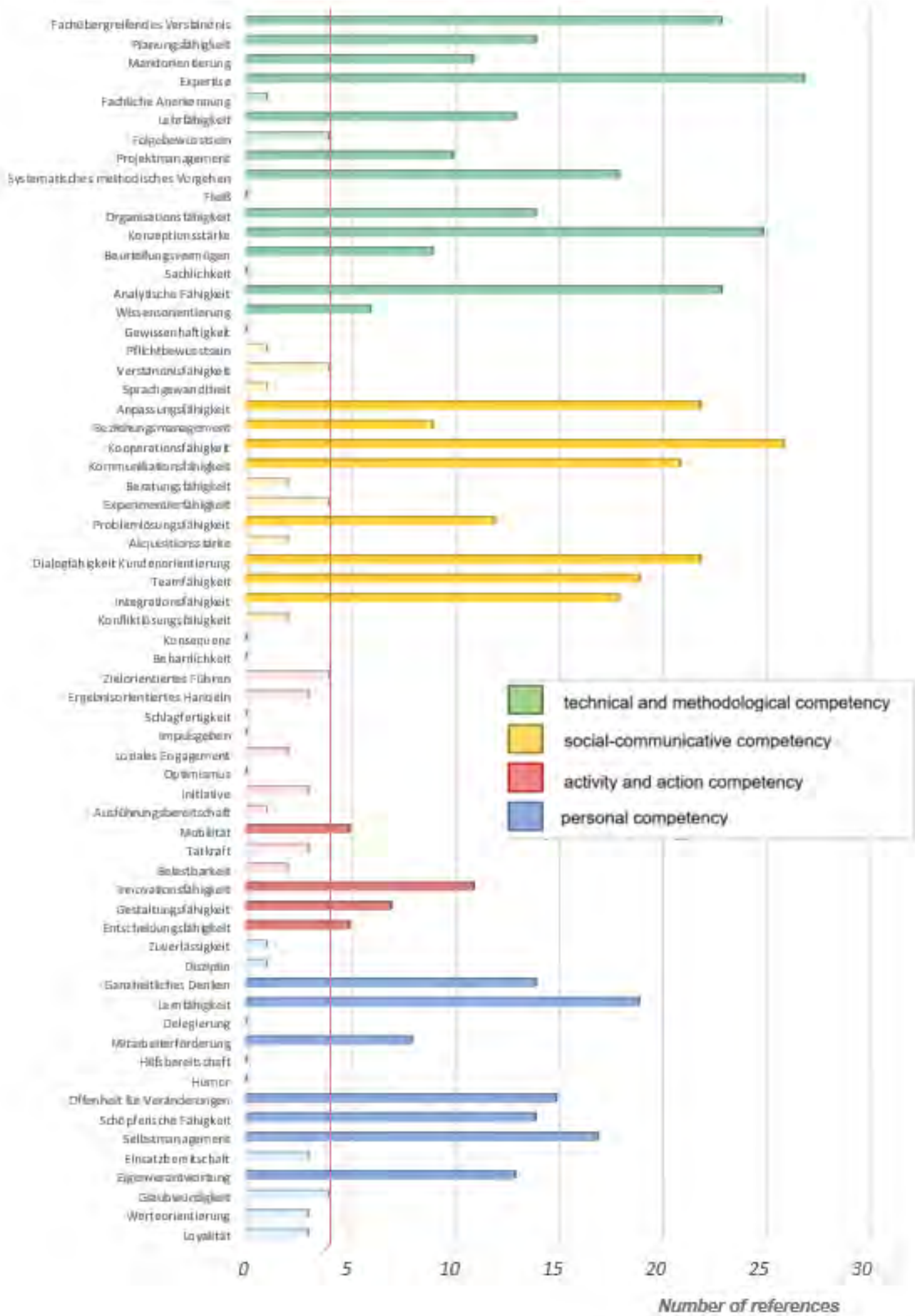
- Appendix 2: References

Appendix 1 Identified competence requirements in the literature (incl. frequencies of mention). Only competence requirements with at least five mentions (red line) were considered relevant (the colours correspond to the competence categories (see legend)).



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9
Topic »AI driven Service Ecosystems and Value Chains«

9.1
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  Reutlingen University, Germany)

HVAC control scenario to demonstrate district heat energy consumption potential

Iivo Metsä-Eerola, Jukka Pulkkinen, Genrikh Ekkerman (1. Häme University of Applied Science, Finland)

Background

The current status in energy systems is that Heating, Ventilation, and Air Conditioning (HVAC) accounts for as much as 40% of energy consumption of a building [1] and a district heating plays an important role in the strategy of European Union for reaching energy efficiency targets [2]. Our research aims to reduce district heat consumption of public buildings in HVAC systems. We focus on one pilot school building to find an easily scalable solution which is readily applicable to a wide range of buildings.

HVAC systems in public buildings are large and complex. Also, one typical feature is that the usage of these buildings is scheduled which is not the case in residential buildings. This means that indoor air quality (IAQ) parameters like a temperature and CO2 concentration need to be inside the required tolerances only when the building is occupied. The relaxation of IAQ requirements during off-hours introduces an opportunity to save energy by lowering HVAC heating network control setpoints. In this study, we focus on providing building owners accurate estimates of energy consumption for alternative HVAC control schedules. These estimates are obtained using Machine Learning (ML) forecast models for district heating energy consumption. This study is a two-week case study of an alternative off-hour control schedule in a school building.

Methodology

ML approaches are used to create models that can learn from large amounts of available structured or semi-structured data. These models can then be used for complex problems without extensive contextual knowledge requirements of the underlying system [2]. The ML model applied to this context is a Recurrent Neural Network (RNN) with GRU activation functions first proposed by Cho et al. [3]. This model is a sequential model designed to capture long-term dependencies in the underlying system which is useful for HVAC system with innately slow response time. By capturing the longer-term dynamic behavior of the HVAC system, the ML model can forecast district heating energy consumption quite accurately while preserving the scalability not offered by more physics-based models.

Hourly input data was fed to the model in four-hour sequences which contained eight Building Automation System (BAS) parameters, five temporal parameters, average CO2 concentration of the building, and two weather variables: total of 16 input parameters. After training the model in a way which maximizes the generalization capability, i.e. the ability to forecast accurately from unseen data, scenario testing was conducted. This was performed by tinkering with water temperature setpoints in radiator and ventilation networks at one of two networks functioning at the pilot site, which are controllable and main sources of energy consumption in large-scale HVAC systems. Limiting the adjustments to only one of the respective networks was a cautionary measure, as the school was in use normally on days while the testing was conducted during the night.

On the first week of testing, the setpoints of radiator network water temperature were artificially lowered during off-hours from 21:00 to 06:00. For the second week, the same adjustments were executed on the ventilation network. The manual disturbances to setpoints grew in magnitude gradually during the week while the IAQ of the system was monitored daily; at the start of the week the decreases were 2°C while during the weekend the adjustments were 6 or 7°C, depending on the week.

After obtaining the data from site through cloud platforms, the scenario testing data was split to two separate datasets: one for each scenario i.e., testing schedule. After that an additional version of the data set for each scenario was formulated by removing the scenario controls from the data set. As a result, two parallel sets of data were obtained: one for what happened during the scenario testing and the other for what would have happened if no scenario testing was conducted.

To quantify the impact an alternative control schedule had on district heating energy consumption, the parallel sets of data were input to the ML model to simulate energy consumption in the case that no disturbances were made to the conventional control schedule. In addition, to achieve as realistic comparison as possible, the original data sets were also used to predict energy consumption. This way, the energy consumption resulting from two different control schedules can be sensibly compared.

Results

When model predictions were run with alternative schedules, the modeling showed 2-5 percentage savings in district heating energy consumption obtained while testing the radiator network. When comparable adjustments were conducted on the ventilation network, the savings were estimated to range from 2 to 6 percent. Moreover, the measured air temperature at site did not seem to dramatically react to these adjustments. Despite similar testing schedules, these savings are not strictly comparable since the background circumstances between the weeks are not similar.

In conclusion, according to this specific case study there are achievable energy savings with simple off-hours adjustment to heating networks control schedule. When combined with the fact that IAQ of the building did not deteriorate during or after the testing, these adjustments seem attractive – even easy savings. Besides, only one of two parallel heating networks functioning at the site was adjusted during scenario testing. This careful approach to testing suggests that full potential for energy savings was not properly quantified in this case study.

Scheduled adjustment of radiator network temperature is not widely used in practice due to the unknown impact to the energy consumption and to the indoor air temperature. In addition, the impact of scheduled adjustments varies between different buildings and HVAC systems. The results of this study encourage us to continue our research further regarding the energy consumption savings and focusing on the ML modelling to learn the detailed dynamic behavior of each building to be used in the fine-tuning of the scheduled heating network setpoint temperature. Furthermore, research has shown additional uses for energy consumption models [4]. These opportunities create basis of value creation to building owners by scaling the cloud-based solution to cover large amount of the buildings.

Keywords: Smart Buildings, Machine learning, Recurrent Neural Networks, energy optimization, HVAC

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An architecture to forecast a dynamic price for supporting load management and optimizing the utilization of charging stations

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Introduction

Electric vehicles are becoming more and more prevalent in modern mobility and with their equally increasing charging needs come challenges on how to manage the load on the electrical grid, especially during peak load times. To a lesser extend the electrical grid is also facing changes in load management outside of peak load times, due to the continued expansion of renewable energy sources such as solar and wind power, as well as the changing landscape of the European energy market. To face said challenges, solutions are required which provide load management that is tenable for both the charge point operators as well as the customers. The charge point operators are interested in avoiding fees due to increased peak loads of their realty. The customers are interested in reliable low-cost charging possibilities. One such solution that aims at keeping both sides content is to manage charging loads via dynamic pricing, resulting in a win-win situation.

Dynamic pricing as a mechanism to control charging load is based on many aspects from different fields. Borenstein et al. (2002) describe the theory, practical implications, customer response and a vision for dynamic pricing and show that "even customers whose demand peaks coincide with the systems' could benefit, because the incentives for conservation at peak times would reduce prices at those times".

The process of dynamic pricing is described by Meng et al. (2013) based on categorized appliances (non-shiftable, shiftable and curtailable) and an input of the customer regarding a scheduling interval. The psychologic effect of dynamic pricing is described by Spann and Skiera (2020). However, these approaches aim at maximizing the profit. Fewer peaks in the load are only a side effect, in contrast to the idea of this paper where that's the main goal.

Flath et al. (2012) address the prediction of charging loads by clustering load profiles in different groups. As a result, there are scenarios, e.g., for winter and summer as well as for weekdays and weekends. The actual data mining is based on CRISP-DM, which is used in this paper as well.

The prediction of the price can be seen as an optimization problem where existing algorithms have low efficiency (Zhang et al., 2019). This paper therefore advocates using machine learning to find the optimal pricing for charging electric vehicles. In contrast to the related work, the focus of this paper is to describe the architecture of the software to be built.

A software architecture to realize dynamic pricing

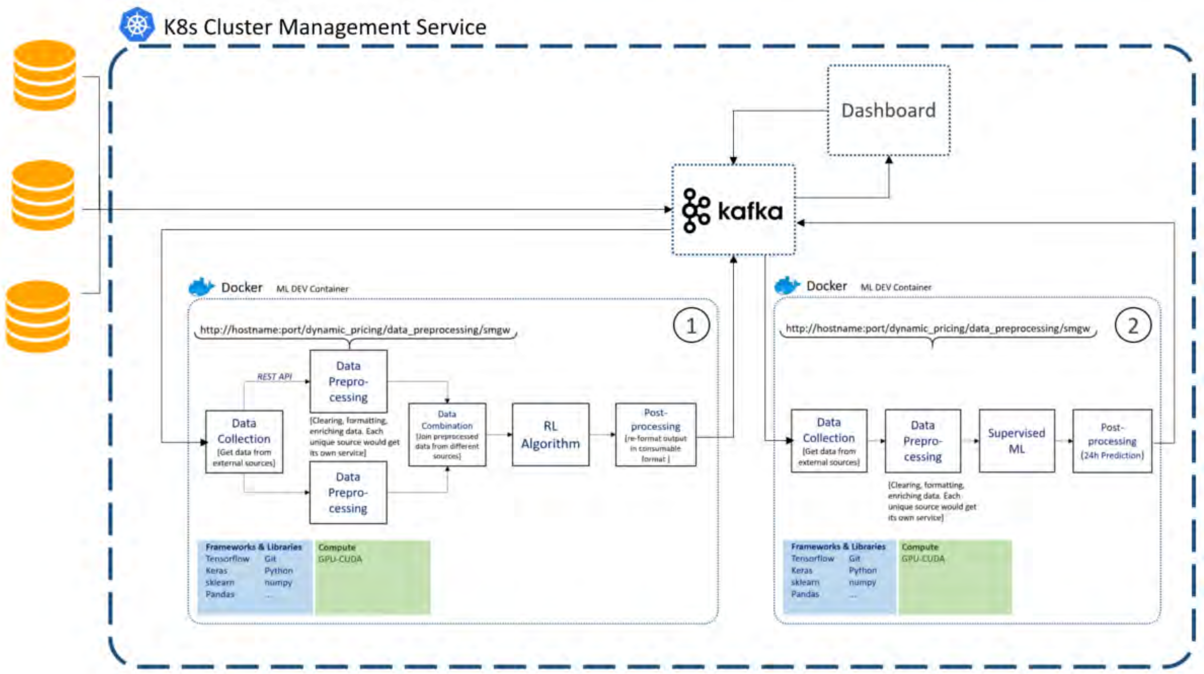
We created a concept and a software architecture based on machine learning to forecast the price for charging electric vehicles at public charging stations. Using dynamic pricing can add value to the classical load management: high prices will be useful to delay charging processes while low prices will make immediate charging attractive. The goal of this approach is to reduce the electric power demand in peak times and to increase the power demand in low points, in other words, to reduce peak and valley values in the power consumption curve or even to synchronize power demand and offer - one of the main problems when scaling electric mobility.

The software architecture's core is to collect data from multiple sources, e.g., data from the electric grid via smart meter gateways, weather data or information about single charging points, and to prepare the data for the machine learning algorithm. The orange databases in figure 1 represent the different sources for the algorithm. Apache Kafka is used as event streaming platform to guarantee real time processing and decoupling of data streams from the subsequent data processing. This way the architecture supports a software that is horizontally scalable, fault-tolerant and that has a low latency – important non-functional requirements when millions of data items need to be processed in the future. Another benefit is the event-driven architecture of Kafka: when all needed data arrives, the forecasting of the dynamic price can be initiated.

For the whole process of forecasting the dynamic price we used CRISP-DM, a structured machine learning approach. Figure 1 shows a schematic representation of the single steps of data processing. The first step is the data collection - getting all resources from the Kafka cluster. The second step consists of cleaning the data and pre-processing, e.g., replacing missing data. The third step, data combination, is for joining data from the different sources. The next step is the algorithm for forecasting the dynamic price. Finally, the result is post-processed to improve the result furthermore, e.g., by formatting.

Based on the data the algorithm makes a short (1 hour) and a long (24 hours) forecast of the pricing. The whole software architecture is structured in a way that the application can be connected to any platform via a REST interface.

Figure 1: Architecture for a scalable dynamic pricing application



Conclusions

The results of this research will be on the one hand a different mechanism compared to the classical load management. The dynamic pricing approach discussed in this paper builds on the load behavior of the people, not on technical aspects like reduction of the charging rate. It does not replace the classical load management but complements it. On the other hand, dynamic pricing increases the chance to guarantee the charging time of electric vehicles and optimizes the overall capacity of charging stations. In contrast to the classical load management, it is useful for both sides: the operators of charging stations do not suffer from blocked charging spots as a result of charging rate throttling, and the car driver benefits by a more accurate charging time prediction. In this paper we have shown an architecture of the software system that will implement the dynamic pricing approach.

The first results of the dynamic pricing algorithm fed by simulation data has shown that this approach can have a significant impact on reducing peak loads. Another scientific finding is that the price is highly correlated with the capacity of the charging points.

In the future we will connect our algorithm to real data sources and implement the architecture presented in this paper.

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- Figure 1: Architecture for a scalable dynamic pricing application

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Aligning Ecosystems with Shared Logic

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Problem/Goal

In the management context, ecosystems bring together different members who rely on complex interdependencies to pursue a joint goal. More precisely, ecosystems have been described as "a set of actors with varying degrees of multi-lateral, non-generic complementarities that are not fully hierarchically controlled" (Jacobides et al., 2018, p. 2264). Ecosystems are heavily shaped by the focal offering that defines the joint goal for all the members (Adner, 2017; Kapoor, 2018; Shipilov & Gawer, 2020) but also by the non-redeployability of members efforts and investments made to attain the joint goal (Jacobides et al., 2018). Simultaneously, the lack of full hierarchical control or formal contractual agreements differentiates the ecosystems from many other organizational forms, such as networks, alliances, or supply chains.

However, the lack of formal agreements poses new challenges to the management of joint activities, especially regarding when sharing the jointly created value. Since each ecosystem member will have their own goals, incentives, and justifications for partaking, an ecosystem becomes a composition consisting of many business models both at the firm and ecosystem level (Adner & Kapoor, 2010; Kapoor & Lee, 2013). The ecosystem value creation, value alignment, and value sharing have been often approached from the perspective of individual actors and their business models (Jacobides, Knudsen, & Augier, 2006). Diverse control methods, such as technological interfaces and centralized governance models have been implemented to combine different business models and to solve the ecosystem value sharing and capturing challenges (Jacobides et al., 2018). Such centralized governance structures might not be perceived as true ecosystems, as they are defined in the literature. Therefore, the challenge remains in transforming the individual actions of the ecosystem participants into an ecosystem-level business.

In this paper, we further develop the concept of a Shared Logic (Thomas & Autio, 2014), which provides an artifact to align value creation and sharing activities between the ecosystem members. We argue that understanding the interconnections between actors is essential for ecosystem-level business. The Shared Logic can be used to aid the understanding, helping actors to perceive their dependence on ecosystem value creation, as the entire ecosystem value creation can be perceived broader than from an individual firm's perspective.

Methods

A literature review was conducted, aiming to integrate fragmented knowledge into a substantive theory of ecosystem alignment while focusing on organizational field debate. Our theoretical argumentation is supported by illustrative case evidence from the healthcare sector, drawn from a case study that takes place in the Finnish chronic care context. Chronic care consists of a multi-provider environment where specific services complement each other's actions. However, the service system consists of diverse service providers, specialized professions, and hospital districts, resulting in sub-optimization within one service provider and fragmented service environment. The system is lacking a shared mission. To summarize, our case study provided valuable insight to support our theoretical argumentation from our literature review.

Results

Our work combines the theories of business model activity models and ecosystems, applying them to an illustrative case study. We thus create an understanding of the interconnections between ecosystem actors and their dynamics in value creation and sharing.

Our study demonstrates that the definitions of ecosystems are still largely subjective, allowing for alternative or overlapping interpretations of members of a particular ecosystem. Therefore, we argue that a Shared Logic is needed to identify actors that are pursuing the same goal and committing to a shared mission. Shared Logic refers to the interdependence links between ecosystem actors and it is essential in understanding the dynamics between the actors. In the ecosystem, direct and indirect interconnections between the actors remain blurred and the overall picture of the ecosystem value flows is limited, leaving an incomplete understanding of the ecosystem-level business. In ecosystems, it is challenging for actors to understand the value of the ecosystem more broadly than their own business. To abstain from nested hierarchies, there must be a mutual understanding of the connections between actors among the ecosystem participants.

As illustrated by our case evidence, Shared Logic aligns the ecosystem's focal offering and firm-centric solutions in service delivery. Through the visualization of interconnections between the ecosystem actors, the value creation of an entire ecosystem becomes clear. Shared Logic enables a modular and configurable form of organization that provides the structure for deliberate ecosystem alignment and governance.

In our argumentation, the activity system perspective on business models (Zott & Amit, 2010) is raised to the ecosystem level using the Shared Logic concept. Shared Logic increases understanding of the underlying ecosystems participants, the different views, and institutions they represent, and the strategies which might be shared among the members. Shared Logic then enables an explicit recognition of the structure of interdependence and interlinked actions in the ecosystem and connects the ecosystem activities to a joint mission.

Ecosystems are based on dynamic interlinkages and activities, which may take various forms depending on the context. While value creation and sharing may be best understood as an activity system aiming for materializing a focal offering (Adner, 2017; Kapoor, 2018), it is vital to remember that ecosystems are in constant flux. Furthermore, the lack of hierarchical governance (Jacobides et al., 2018; Shipilov & Gawer, 2020) implies that there will not be formal contracts or bodies of authority determining what changes to the system of activities or their interlinkages can (or cannot) be made. As they are defined by the focal offering, ecosystems might define or state the desired result but will remain indifferent about the different activities or members needed to get there. Shared Logic frames the ecosystem alignment issue into an organizational design challenge where the interlinked actions are aligned towards a common goal or an ecosystem's focal offering.

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IP-traceability: Discussing suitable technologies for tracing data from creativity processes in interorganizational R&D projects

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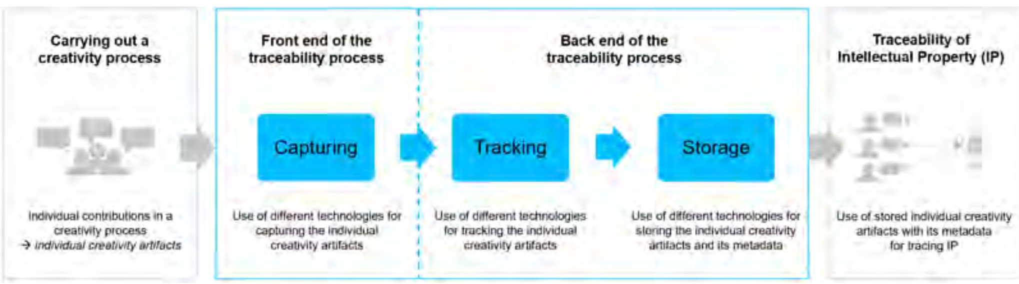
Introduction

Due to a high product and technology complexity, companies involve external partners in their research and development (R&D) processes (Bullinger and Warschat 2007; Fraunhofer-Verbund Innovationsforschung 2018). Particularly for solving complex problems, firms engage in coupled open Innovation activities and form partnerships with complementary, external organizations (Bagherzadeh et al. 2019; Gassmann and Enkel 2004). On project-level, interorganizational R&D projects result which are temporary organizations (Sydow and Braun 2018). When collaborating in R&D and conducting for example creativity processes, a major problem comes from the protection of intellectual property (IP) (e.g., Barnes et al. 2000). This can lead to conflicts in a project or even to project cancellation. Tracing the ideas of each team member in creativity processes which can become IP enables an identification on who was involved in the invention and thus has a proportional exploitation claim (see Schönhals et al. 2018). Hence, interorganizational project members know that their achievements are recognized and rewarded which can enhance their motivation. Moreover, conflicts with regard to IP can be minimized (see Schönhals et al. 2018).

A traceability process mainly includes the three phases capturing, tracking and storage (see Schönhals et al. 2018; Zerkte 2018). When carrying out a creativity process, each team member has individual contributions through which individual creativity artifacts result. These artifacts need to be captured in a first step of the traceability process. Hence, capturing represents the front end where data are collected (see Fig. 1). Depending on how a creativity process is conducted and which data are generated, different capturing technologies can be used. By contrast, the phases tracking and storage represent the back end of the traceability process (see Fig.1). The scientific discussion on traceability in the context of IP mainly focuses on the back end of traceability processes, especially on the usage of blockchain technology (e.g., Lin et al. 2019; de la Rosa et al. 2016; Schönhals et al. 2018; de la Rosa et al. 2017). However, as in the front end, also in the back end of the traceability process different technologies can be used both in the tracking phase for tracking the individual creativity artifacts and in the storage phase for storing these artifacts and its metadata. The stored individual creativity artifacts with its metadata are then used for tracing IP (see Fig. 1).

Figure 1: IP-traceability process in interorganizational R&D projects



Thus, focusing on the different technologies which can be used in the single phases becomes essential, especially for interorganizational R&D projects. Because a traceable documentation is beneficial for a trusting collaboration in these projects due to the interconnection of the three collaboration levels “organization”, “relation” and “content” on an operational level (see Dieterich et al. 2021). Hence, this paper raises the following research question: *Which technologies are suitable for tracing data from creativity processes in interorganizational R&D projects?*

The aim of this paper is to show different technologies which can be used in the front and back end of a traceability process and discuss these technologies in terms of their suitability for data from creativity processes in interorganizational R&D projects. The structure of the paper is as follows. Section 2 gives an overview on interorganizational creativity processes in R&D and a definition of intellectual property. Then, in section 3, blockchain technology is briefly explained and its use in open innovation contexts, especially in IP-traceability, is shown. Section 4 describes the method on how the research was conducted. Then, in section 5 the resulting technologies from the literature review are shown. In section 6, these technologies are discussed and recommendations regarding suitable technologies for tracing individual creativity artifacts in interorganizational R&D projects are given.

Interorganizational creativity processes in R&D

Coupled open innovation processes combine the integration of external knowledge and competencies with the externalization of own knowledge and competencies by forming alliance with complementary partners (Gassmann and Enkel 2004). For solving complex problems where the respective organizations know which knowledge from which organization is needed, they form nonequity partnerships. This kind of partnership usually requires highly complicated contracts and still has high opportunism risks (Bagherzadeh et al. 2019). Furthermore, the organizations differ, for example, in size, industry or organizational culture. This has an influence on the collaboration of the **interorganizational project** (vom Brocke and Lippe 2015). So is the collaboration in these projects characterized by a lack of trust, since building trust with previously unfamiliar partners is a difficulty (Thoma 2018; Dieterich et al. 2021). However, for achieving project scope, interorganizational project members need to work on an operational level closely together, for example in creativity processes (Dieterich et al. 2021).

Creativity processes can be conducted online, offline or hybrid. Especially because of the current COVID-19 pandemic, creativity processes are mostly conducted online with collaboration tools. When conducting a creativity process, many creativity methods, such as Brainstorming or 635 method, focus on a free flow of ideas among the participants (Lindemann 2009). However, ideas are intangible and communicated ideas can quickly evaporate. Therefore, a trust base among the participants is important to promote a free flow of ideas (Brattström et al. 2012). In the further course of the interorganizational R&D project, resulting data from creativity processes, such as ideas, models or construction sketches can be processed to intellectual property (IP). This is the joint intellectual property, the so-called *foreground IP*, which is generated during the collaboration in the interorganizational R&D project (see Bader 2006). Baldwin and Henkel 2011 define **intellectual property** as "knowledge that is exclusively controlled by a particular firm and thus can serve as a source of economic rent. Such property includes the classic legal forms of IP –patents, copyrights, and trade secrets– but also includes confidential information known to the firm's employees and suppliers" (Baldwin and Henkel 2011, p.4).

With the characteristics of interorganizational R&D projects and of creativity processes, interorganizational creativity processes in R&D face the challenge that a trust base is required among participants where there is none. With tracing data from creativity processes, the individual inputs to an IP can be measured (Schönhals et al. 2018). Thus, it can be identified who has a proportional exploitation claim regarding the foreground IP. This can increase the motivation of the interorganizational project members to express ideas freely.

Open Innovation and blockchain technology

Previous studies in the field of Open Innovation have mainly focused on blockchain technology since a blockchain is always then beneficial, when there is no confidence among partners (de la Rosa et al. 2016; Schönhals et al. 2018; de la Rosa et al. 2017). A blockchain is a contiguous sequence of blocks, updated over time, that stores committed transactions (Zheng et al. 2018; acatech 2018). The blocks are backward linked, what means that each block in the chain points to the immediately previous one (Zheng et al. 2018; Antonopoulos 2018). To validate whether transactions are authentic, blockchains use digital signature with a private/public key pair as asymmetric cryptography mechanism (Zheng et al. 2018; Rehmani 2021).

In an Open Innovation context blockchain is especially because of its features highly interesting. Because a blockchain is decentral, persistent, anonymous, auditable and has a consensus mechanism, based on which the validators, who are called "miners" in the bitcoin use case, agree on which blocks are appended to the blockchain (see for more information Zheng et al. 2018; Sharma et al. 2020; acatech 2018). Moreover, there are mainly three types of blockchains: Public blockchains, private blockchains and consortium blockchains, whose differences are shown in table 1.

Table 1: Comparison of public, consortium and private blockchain, following Zheng et al. 2018

Property	Public blockchain	Consortium blockchain	Private blockchain
Consensus determination	All miners	Selected set of nodes	One organization
Read permission	Public	Could be public or restricted	Could be public or restricted
Immutability	Nearly impossible to tamper	Could be tampered	Could be tampered
Efficiency	Low	High	High
Centralized	No	Partial	Yes
Consensus process	Permissionless	Permissioned	Permissioned

Due to the characteristics of a blockchain, there are more and more discussions about using this technology for protecting intellectual property in open innovation contexts (e.g., de la Rosa et al. 2016; Schönhals et al. 2018; de la Rosa et al. 2017). Blockchain contributes to IP related functionalities, such as timestamping, proof of existence or notarization, IP registry services, record keeping, licensing, NDA management, access control, industrial property rights (trade secrets, patent, trademarks), traceability, citations tracking and reward mechanisms (de la Rosa et al. 2017). It ensures trust and integrity in a relationship between strangers since cheating becomes difficult (de la Rosa et al. 2016). Thus, in an open innovation context, it enables authors a "tamper-proof evidence of ownership" (de la Rosa et al. 2017, p.12). This is important, since individuals can show who contributed to an invention and thus has a proportional exploitation claim.

Schönhals et al. 2018 show how Design Thinking can be conducted in Open Innovation by using blockchain technology. They show four phases for tracing IP which are dockable to the individual steps of the Design thinking process. This so-called "dockable tracking cycle" comprises the four phases capturing, tracking, storage and suggestion (Schönhals et al. 2018). **In the first phase capturing**, the utterance and behavior of the individual persons are digitally recorded. For digital recording, Schönhals et al. 2018 identified the five outcome channels verbal, non-verbal, written or sketched, modeled or constructed and performed. For each outcome channel different technologies can be used, such as RGB cameras, ultrasonic sensors, (3D)-scanning or optical character recognition (OCR). Afterwards, **in the tracking phase**, meta information are supplemented to the recorded artifacts (Schönhals et al. 2018). The resulting bundled data package is the so-called "digital innovation object" (DIO). Then, **in the storage phase**, the digital innovation objects are stored and protected by creating a unique hash of the DIO. On the blockchain the fingerprint of the DIO is embedded by using OriginStamp service. The storage of the DIO is centrally in the database where all participants have access to (Schönhals et al. 2018). With embedding the fingerprint on the blockchain, the DIO can be verified. **In the suggestion phase**, the gathered data are used as a basis for the generation of helpful hints or recommendations which are passed to the participants of the Design thinking process (Schönhals et al. 2018).

To conclude, tracing individual creativity artifacts which can become IP is beneficial to address the special features of interorganizational R&D projects. Because with a traceable documentation a trusting collaboration in these projects can result. Furthermore, there is already a small selection on technologies which can be used in the front end of a traceability process for capturing individual creativity artifacts. In the back end, due to the characteristics of a blockchain, this technology seems to be suitable in an Open Innovation context for tracing IP. However, to the best of our knowledge previous studies do not discuss whether the use of blockchain technology is the best solution in the back end of a traceability process in the context of Open Innovation. Moreover, these studies do not focus on a particular Open Innovation mode. Hence, this paper expands the small selection on technologies in the front end and discusses the resulting capturing technologies in terms of their suitability for use in interorganizational R&D projects. Furthermore, this paper contrasts blockchain technology with other tracking and storage technologies and discusses them in terms of their suitability for use in interorganizational R&D projects. At the end, recommendations for both front and back end regarding suitable technologies for tracing individual creativity artifacts in interorganizational R&D projects are given.

Method

To take a closer look on which technologies are suitable for tracing data from creativity processes in interorganizational R&D projects, a two-stage literature review is conducted and relevant criteria for the discussion are derived. The procedure for the two-stage literature review is described in section 4.1. In section 4.2, criteria for the discussion in section 6 are derived from the characteristics of data from creativity processes and of interorganizational R&D projects (see section 2).

Two-stage literature review

For both literature reviews, the five common databases Taylor and Francis (Taylor and Francis Group 2021), IEEE (IEEE 2021), ACM (Association for Computing Machinery 2021), Springerlink (Springer Nature Switzerland AG 2021) and ScienceDirect (Elsevier 2021) are used. Both literature reviews were not semantic reviews because the focus only was on the appearance of the terms in the title and not on their distance from each other. The first part of the literature review focuses on which technologies are generally used for traceability. Here, the terms lineage and provenance are also included in the search strings since these are mainly used for tracing data in informatics. In total, 315 papers resulted from the first literature search, of which 247 papers were accessible. After sifting through their titles and/or abstracts, 114 papers remained. The full papers were then sifted, so that 74 papers remained at the end (see table 2). Table 2 gives an overview on the search strings and results of the first part of the literature review.

Table 2: Search strings and results of the first part of the literature review

Database	Focus on	Search strings	Search Results	Access to	Selection after sifting title and/or abstract	Selection after sifting full paper
Taylor and Francis	Publication title	traceability AND technology	53	20	7	6
		lineage AND technology	0	0	0	0
		provenance AND technology	3	2	0	0
IEEE	Document title	traceability AND technology	40	40	38	36
		lineage AND technology	2	2	0	0
		provenance AND technology	4	4	1	1
ACM	Publication title	traceability AND technology	88	83	27	6
		lineage AND technology	3	3	3	1
		provenance AND technology	30	26	20	8
ScienceDirect	Title	traceability AND technology	70	53	15	13
		lineage AND technology	3	1	0	0
		provenance AND technology	15	9	1	1
SpringerLink	Title	traceability AND technology	2	2	2	2
		lineage AND technology	0	0	0	0
		provenance AND technology	2	2	0	0
		Total	**315 Papers**	**247 Papers**	**114 Papers**	**74 Papers**

From the first part of the literature review 74 full papers result, which show different technologies for traceability. The results of this first part show, that the phases *capturing*, *tracking* and *storage* are necessary steps in a traceability process. Because most of the technologies mentioned in the 74 full papers can be assigned to these three phases. Moreover, these phases also appear in a typical traceability process in supply chain contexts (see Zerkte 2018). Hence, three of the four phases from the "dockable tracking cycle" of Schönhals et al. 2018 (see section 3) can be confirmed as necessary process phases in a traceability process.

Thus, the second part of the literature review is focusing on technologies in these three process phases. Moreover, only technologies for content and not for movements and/or locations were considered for the literature review. This is because for individual creativity artifacts the focus lies on the content and not on their geo location. From the second literature search, in total, 4116 papers resulted, of which 1165 papers were accessible. After sifting through their titles and/or abstracts, 188 papers remained. The full papers were then sifted, so that 64 papers remained at the end (see table 3).

Table 3 gives an overview of the search strings and results from the second literature review. In total from both literature reviews 138 full papers result which show different technologies for traceability per process phase.

Table 3: Search strings and results of the second part of the literature review

Database	Focus on	Filter	Search strings	Search Results	Filtered results	Access to	Selection after sifting title and/or abstract	Selection after sifting full paper
Taylor and Francis	Publication title		capturing AND technology	67	-	28	2	0
			tracking AND technology	134	-	45	7	2
			storage AND technology	158	-	64	5	0
IEEE	Document title		capturing AND technology	95	-	95	41	5
		Tracking, target tracking, object tracking, optical tracking	tracking AND technology	561	101	101	18	13
		Storage management, cloud computing, DRAM chips, flash memories, Big Data	storage AND technology	548	89	89	21	5
ACM	Publication title		capturing AND technology	121	-	121	33	8
		Research article	tracking AND technology	472	256	256	12	4
		Research article	storage AND technology	323	104	104	25	14
ScienceDirect	Title	Engineering & Social Science	capturing AND technology	546	81	54	6	1
			tracking AND technology	266	-	172	13	10
		Engineering & Computer Science	storage AND technology	712	201	27	4	1
SpringerLink	Title		capturing AND technology	1	-	0	0	0
			tracking AND technology	66	-	5	1	1
			storage AND technology	46	-	4	0	0
			Total	**4116 Papers**		**1165 Papers**	**188 Papers**	**64 Papers**

Relevant discussion criteria per process phase

From the characteristics of interorganizational R&D projects and of data from creativity processes which are shown in section 2 different criteria for discussing the resulting technologies can be derived. For data from creativity processes four criteria result, which can mainly be assigned to the capturing and tracking phase. From the intangibility of creativity data, the criterium **intangibility** results. This criterium considers that individual creativity artifacts can only be captured physically with difficulty or not at all. From an online, hybrid or offline data collection, the criteria **type of data** and **conduct of process** can be derived. The criterium type of data focuses on which kind of data results. These could be in text, voice or illustration. Moreover, with the criterium conduct of process it is considered whether the creativity process is conducted online and/or offline. Thus, these two criteria, like the criterium intangibility, can be assigned to the capturing process phase.

Furthermore, for tracing data on the respective person, personal data is processed, and thus European data protection becomes highly relevant. According to the regulation of the European Parliament and of the council are personal data "any information relating to an identified or identifiable natural person" (European Union Law 2016, article 4, (1). Processing these data is only lawful under certain conditions, for example, if a person gives consent, that his/her data may be processed for one or more specific purposes (European Union Law 2016). In this context data processing "means any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction" (European Union Law 2016, article 4, (2). Controllers and processors are among others responsible for the security of processing. This implies, for example, that personal data is pseudonymized and encrypted. Moreover, persons have different rights, such as the right to information which are provided and to access personal data, the right to rectification and erasure, the right of restriction of processing, the right to data portability or the right to object (European Union Law 2016). Thus, one very important criterium for discussing suitable technologies is **data protection**. This criterium can be assigned on the one hand to the tracking phase, since in this phase the meta information of the data is bundled with it and on the other hand to the storage phase, as the meta data need to be stored. Table 4 summarizes the above explained criteria-derivation-process for data from creativity processes and illustrates which phase of the traceability process can be assigned to these criteria.

Table 4: Derived criteria and assigned process phase for data from creativity processes

Characteristics of data from creativity processes (see section 2)	Derived criteria for discussion	Assigned phase of traceability process
Intangibility of IP	Intangibility	Capturing
Online, offline, hybrid data collection	Type of data (e.g., text, illustrations, voice, …)	Capturing
	Conduct the process (online and/or offline)	
Traceability to the respective person	Data protection	Tracking, Storage

For interorganizational R&D projects four criteria result, which can be assigned to the storage phase. Due to the partner heterogeneity of these projects, the criterium **accessibility** can be derived. Because each partner needs to have access to the resulting data to process them further. From a high opportunism risk and a lack of trust in these projects, the three criteria **transparency**, **tamper-free** and **storage type** can be derived. Because the data needs to be transparent to each project member so that everyone has the same knowledge base about the data after the creativity process. Moreover, project members need to be sure, that the data was not changed afterwards. Whether the resulting data are stored central or decentral is for the coordination in the project important. Table 5 summarizes the explained criteria-derivation-process for interorganizational R&D projects and illustrates which phase of the traceability process can be assigned to these criteria.

Table 5: Derived criteria and assigned process phase for interorganizational R&D projects

Characteristics of interorganizational R&D projects (see section 2)	Derived criteria for discussion	Assigned phase of traceability process
High partner heterogeneity	Accessibility	Storage
High opportunism risk, lack of trust	Transparency	Storage
	Tamper-free	
	Storage type (central/decentral)	

Resulting technologies from the literature review

From the two-stage literature review many capturing technologies result. In the **capturing phase**, for example, any kind of codes or sensors as well as RFID-technology are often used. Table 6 gives an overview of the resulting capturing technologies.

Table 6: Overview of resulting capturing technologies

Capturing technology	Literature reference
2D-code	e.g., Madleňák et al. 2016; Ding et al. 2019; Saikouk and Spalanzani 2016
QR-code	e.g., Dong et al. 2020; Tzoulis and Andreopoulou 2013
Barcodes	e.g., Chrysochou et al. 2009; Dong et al. 2020; Jiang et al. 2017; Madleňák et al. 2016; Tzoulis and Andreopoulou 2013
Wearable sensors	Jiang et al. 2017
Magnetic	Saikouk and Spalanzani 2016
Magnetic stripes	Madleňák et al. 2016
Punching or marking logs with paint	Tzoulis and Andreopoulou 2013
Synthetic DNA	Saikouk and Spalanzani 2016
Edible marking systems	Chrysochou et al. 2009
Smart fabric	Chan and Gollakota 2017
(Video) cameras	e.g., Chandra 2007; Ni et al. 2011
Microphones	Chandra 2007
Web-based environments	Arvaja and Pöysä-Tarhonen 2013
PC-Screenshots	Hanawa et al. 2014

Capturing technology	Literature reference
Wireless sensor networks	Ni et al. 2011; Jiang et al. 2017
Magnetic sensors	Lee et al. 2018
RFID-technology	e.g., Chrysochou et al. 2009; Ding et al. 2019; Jiang et al. 2017; Madleňák et al. 2016; Ni et al. 2011; Tzoulis and Andreopoulou 2013; Saikouk and Spalanzani 2016
Isotope ratio/ trace elements	Saikouk and Spalanzani 2016
NFC	Mainetti et al. 2013
Nano capsules	Saikouk and Spalanzani 2016
DNA fingerprint	Zhao et al. 2020; Tzoulis and Andreopoulou 2013
Digital pens	Song et al. 2006
Camcorder	Chandra 2007
Webcams	Krishnan et al. 2015
E-paper tags	Chrysochou et al. 2009
Optical Character Recognition	Fawzi et al. 2015; Madleňák et al. 2016; Tuganbaev et al. 2005
Screen capture	Zhen and Su 2010

For the **tracking phase** from the literature review, different technologies, such as unique identification marker (Sunindyo et al. 2014), fingerprint, facial or voice recognition (Madleňák et al. 2016), router ID (Qingshan 2012), machine ID (Shih and Yang 2019), hash (e.g., Dong et al. 2020; Jian-zhi et al. 2019; Shih and Yang 2019), data packet marking (Qingshan 2012), individual ID (Xiu and Muro 2017), and Fast IDentity Online (Park et al. 2019) result. For the **storage phase**, from the literature review, distributed storage (e.g., Lakshmi and Deepthi 2018; Yan and Long 2015), blockchain (e.g., Shih and Yang 2019; Jian-zhi et al. 2019; Dong et al. 2020; Mann et al. 2018), cloud storage (e.g., Lee et al. 2016; Zenuni et al. 2014) and relational storage (El-Aziz and Kannan 2012) result. For storing meta data, from the literature review result, for example, the applications Ariadne (Glavic et al. 2014), ProvenanceCurious (Huq et al. 2013), HIVE (Tan et al. 2020), Blockchain (Hasan et al. 2019; Mann et al. 2018), InterPlanetary File System (Hasan et al. 2019) or $PROV_{2R}$ (Stamatogiannakis et al. 2017).

Discussion

In section 6.1., the identified technologies are discussed for the phases capturing, tracking and storage by usage of the derived criteria (see section 4.2). At the end, in section 6.2., recommendations regarding suitable technologies for tracing individual creativity artifacts in interorganizational R&D projects are given.

Discussion of the technologies by usage of the derived criteria

The capturing technologies are discussed by usage of the criteria *intangibility, type of data* and *conduct the process*. Due to the intangibility of data from creativity processes many of the capturing technologies, such as RFID technology, barcodes, or sensors, are not suitable to capture these data. Because they need to be added physically on the item to be traced. RFID technology and sensors only could be used for motion capturing in a creativity process (Huang et al. 2019; Lee et al. 2018). Hence, from the literature review, only the following capturing technologies are suitable: Digital pens, microphones, screen capture, camcorder, webcams, (video) cameras, optical character recognition, web-based environments, and PC-screenshots. Some of these technologies, such as digital pens, cameras, optical character recognition or sensors, are already mentioned by Schönhals et al. 2018 for tracing non-verbal movements, written or sketched artifacts. However, they also show some other technologies, such as (3D)-scanning, which is also included in the discussion (see table 7).

The technologies, suitable for individual creativity artifacts, can further be discussed by the two criteria *type of data* and *conduct the process.* For example, digital pens are suitable to digitize text data in offline creativity processes. Moreover, screen captures, or a web-based environment are mainly possible with online creativity processes for capturing illustrations or text (see table 7).

Table 7: Discussion of capturing technologies

Criterium / Capturing technology	Conduct the process		Type of data		
	Online	Offline	Illustrations	Text	Voice
Digital Pen	○	●	○	●	○
Camcorder	●	●	◉	◉	●
Webcam	●	●	◉	◉	●
Camera	◉	●	●	●	○
Optical Character Recognition	●	●	○	●	○
Microphone	●	●	○	○	●
Screen Capture	●	○	●	●	○
Web-based Environment	●	○	◉	●	○
(3D)-Scanning	○	●	●	●	○

● = suitable; ◉ = partly suitable; ○ = not suitable

In general, conducting a creativity process online, also for example with collaboration tools, has great potentials, not only because of the current COVID-19 pandemic, but also because the written or sketched artifacts are already digitalized. Hence, only verbal and non-verbal expressions need to be captured. This simplified data capturing. Thus, interorganizational project members have many possibilities to capture individual creativity artifacts. However, whether these members frequently use these capturing technologies for their creativity processes, depends on the project culture. Project members need to be willing to document essential creativity artifacts, including those that were not generated during official creativity sessions and need to be honest concerning their origin. Then, project culture supports a complete, gap-free documentation and thus data capturing becomes legal resilient.

In the tracking phase the captured data are supplemented with meta information (see Schönhals et al. 2018). Hence, the individual creativity artifacts are assigned to the respective author, for example, by an individual ID, a hash, or the bundling of the data to a data package with an ID. In this phase, a correct assignment of the meta data to the creativity artifacts is for a legal resilient tracking essential. With the assignment mainly the elements “what” and “who” are considered. According to Ram and Liu 2009 there are further elements to include for provenance semantics, such as *when, where, how, why* and *which tool?* (Ram and Liu 2009). Thus, these elements are advantageous for a concrete traceability of the individual creativity artifacts to the respective authors. However, with the collection of these meta data and their connection to an individual creativity artifact, personal data are collected which need to be processed. According to article 32 (a) these data need to be pseudonymized and encrypted for processing (European Union Law 2016). Hence, there is a contradiction in this phase, since on the one hand the meta data need to be pseudonymized and encrypted for processing and on the other hand these data need to be readable to trace the individual creativity artifacts to the respective authors. Thus, there are legal hurdles in the tracking phase regardless of what technology is used.

In the storage phase, the individual creativity artifacts as well as the belonging meta data are stored. There are different technologies which can be used for storage. Table 8 shows the discussion of the storage technologies by using the four criteria *accessibility, transparency, tamper-free* and *storage type*.

Table 8; Discussion of storage technologies

Criterium / Storage technology	Accessibility	Transparency	Tamper-free	Storage type	
				Central	Decentral
Distributed Storage	●	●	○	○	●
Blockchain Technology	●	●	● (if public)	○	●
Cloud Storage	●	●	○	●	○
Relational Storage	●	●	○	●	○

● = applies; ○ = does not apply

From the discussion results that a public blockchain is the best solution compared to the alternatives. Because it is the only storage technology which is tamper-free. Hence, when using alternative storage options, a four-eyes-principle is important so that the data cannot be tampered. However, there are legal hurdles in terms of data protection. Because the meta data need to be stored pseudonymized and encrypted, but still need to be readable to trace the individual creativity artifacts to the respective authors. Pseudonymization “means the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person” (European Union Law 2016, article 4 (5). Hence, in the storage phase there is the difficulty of where to store the additional information which can be used to identify a person. If these data remain with one person, there is again a trust-issue. Thus, the key for decrypting the data needs to stay with the respective person so that he/she decides on the possibility of identifying him/her. Hence, the respective person needs a kind of “passport” to identify himself/herself.

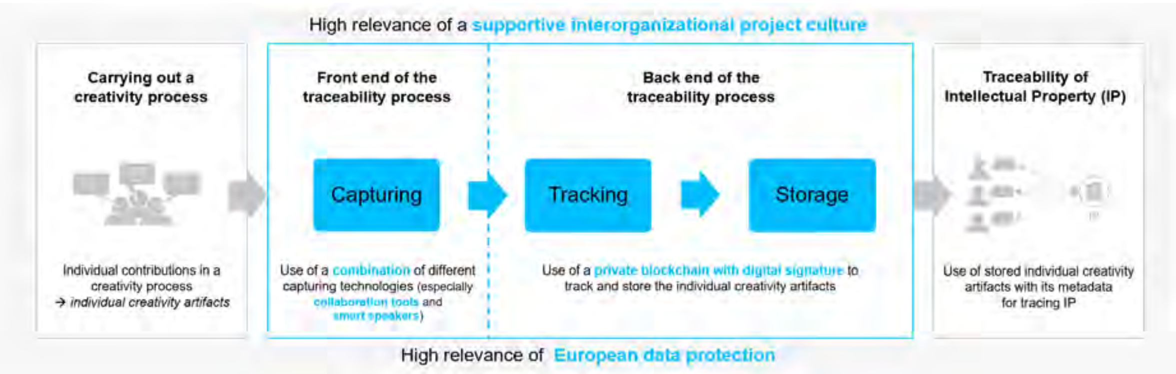
Recommendations on technologies for tracing IP

From the discussion, the following recommendations can be given. **In the front end,** for the capturing phase, there is a combination of different capturing technologies suitable so that data can be collected in text, illustration, and voice. This could work, for example, with digital pens, cameras, microphones, or collaboration tools. Especially collaboration tools, such as Miro (Miro 2021), Mentimeter (Mentimeter 2021) or Conceptboard (Conceptboard 2021) have a great potential since the data is recorded digitally from the beginning. Hence, only verbal and non-verbal expressions need to be captured additionally. For capturing verbal expressions Artificial Intelligence has a great potential. Because with the use of smart speakers, such as Alexa (Amazon 2021), Siri (Apple 2021) or Google Assistant (Google 2021), verbal expressions are recorded and can be easily processed by Artificial Intelligence. However, the usage of the capturing technologies depends on the interorganizational project culture. Project members need to be willing to document essential individual creativity artifacts, including those that were not generated during official creativity sessions and need to be honest concerning their origin. Then, project culture supports a complete, gap-free documentation and thus data capturing becomes legal resilient. Hence, a project-culture-aware management (see Dieterich et al. 2021) is important, with which a culture based on supporting values can be developed.

In the back end, for the tracking and storage phase, a public blockchain turns out to be the best option. Because this is the only mechanism which includes important provenance elements such as *what, who* and *when* and offers a tamper-free storage. However, an interorganizational R&D project is a temporary organization closed to public where the transactions can only be validated within this organization. Hence, a private blockchain is the recommended option, even though it could be tampered. That's why the relevance of a supporting project culture is also evident in the tracking and storage phase. With the use of a private blockchain, all interorganizational project members become "miners". Thus, a supporting culture needs to ensure that the decision which individual creativity artifacts are correct transactions and thus are entered into the private blockchain must be made by all. This way, no one feels disadvantaged, and everyone has an equal chance to contribute. Furthermore, the use of the blockchain also supports a cooperative project culture, since no one can subsequently say that he/she was involved in the invention, when he/she was not, because he/she was one of the miners who approved the transaction. Hence, with a supporting project culture a private blockchain becomes tamper-free. Moreover, a major topic in the tracking and storage phase is European data protection. In the tracking phase, it is important that each project member gives consent to the tracking of his/her individual creativity artifacts. Furthermore, pseudonymization and encryption is essential. Here, keys for decrypting the meta data must remain with the respective person so that he/she decides on the possibility to identify him/her. Hence, in the storage phase, with the use of this kind of technologies, the additional information for identifying a person remain as well with the respective person. Data protection is especially for blockchain technology crucial. Because since project members have, for example, the right to rectification and erasure, there is a direct contradiction between data protection and immutability of a blockchain (see Peitz 2020 for a detailed consideration of the blockchain technology regarding data protection).

Based on the above recommendations, the traceability process in interorganizational R&D projects (see Fig. 1) can be adapted. Fig. 2 illustrates that in the front end the use of a combination of different technologies, especially the use of collaboration tools and smart speakers is beneficial. In the back end, it illustrates that a private blockchain with digital signature is most suitable. Moreover, Fig. 2 shows, that an IP-traceability processes in interorganizational R&D projects should be embedded in an environment with a supportive interorganizational project culture and respected European data protection.

Figure 2: Adapted and embedded IP-traceability process in interorganizational R&D projects



Conclusion, limitations, and future research

This paper takes a holistic view on an IP-traceability process in interorganizational R&D projects, as a particular Open innovation mode, aiming at showing different technologies which can be used in the front and back end of a traceability process (see Fig. 1) and discussing these technologies in terms of their suitability for data from creativity processes in these projects. To achieve this goal a two-stage literature review on different technologies in the context of traceability was conducted. Then, criteria were derived from the characteristics of data from creativity processes and of interorganizational R&D projects, with which the resulting technologies were discussed. At the end, recommendations regarding suitable technologies for tracing individual creativity artifacts in interorganizational R&D projects were given.

From a technological point of view, the discussion shows that tracing individual creativity artifacts in interorganizational R&D projects is feasible in many ways. In the front end, independent on the technologies used in the back end, different technologies, such as digital pens, microphones or cameras can be used to capture the data. Especially collaboration tools are beneficial when conducting a creativity process online, since then most of the creativity artifacts are already digitalized. Only non-verbal and verbal expressions need to be captured additionally, for example by smart speakers. In the back end, a public blockchain turns out to be the best option since it is tamper-free. Hence, the use of blockchain technology in Open innovation, as it is shown in previous studies (e.g., de la Rosa et al. 2016; Schönhals et al. 2018; de la Rosa et al. 2017), can be confirmed. But in future studies, a specification on which kind of blockchain is used should be given.

However, the discussion particularly shows that a supporting project culture is the predominant aspect for traceability in the context of IP. So is a private blockchain the recommended option in the presence of this culture, as it makes it tamper-free. Then, the features of a private blockchain also strengthen the targeted cooperative innovation culture in interorganizational R&D projects (see Dieterich et al. 2021). Hence, a project-culture-aware management (see Dieterich et al. 2021) is a key to develop and maintain this project culture and thus to achieve interorganizational project success. Then, the set-up and maintenance of the traceability system stands up to a cost-benefit analysis and becomes legal resilient. Furthermore, when using technologies, such as blockchain for tracking and storage, European data protection is essential. It is important, that each project member gives consent to the tracking of his/her individual creativity artifacts and that the data are pseudonymized and encrypted. The keys for decrypting the meta data should remain like a passport with the respective person so that he/she decides on the possibility to identify him/her.

However, there are as well some limitations which need to be considered. The discussion of the technologies builds on the literature which was identified by the two-stage literature review. The review was focused on the above common five databases. Further databases were not included in the review. Moreover, there was a constraint in the accessibility of the literature in the databases. Thus, other researchers may come to a different literature base to work with.

The given recommendations can be seen as a starting point for future research which, for example, could put these into practice. For concrete implementation possibilities, it is important to consider a supporting project culture and European data protection. Moreover, future research could develop a concrete concept on how tracing data from creativity processes is possible in compliance with European data protection.

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Topic »AI an New Service Development«

10.1
List of Papers

- **Testing Perceived Quality of AI-based Smart Services**
  Jens Neuhüttler, Sibylle Hermann, Walter Ganz, Dieter Spath (Fraunhofer Institute for Industrial Engineering IAO, Germany)

Testing Perceived Quality of AI-based Smart Services

Jens Neuhüttler, Sibylle Hermann, Walter Ganz, Dieter Spath (Fraunhofer Institute for Industrial Engineering IAO, Germany)

Challenges in the Development of Smart Services

The ongoing developments in the field of artificial intelligence (AI) are considered as core drivers of growth and innovation for services (cf. Roth & Oks 2020). For example, machine learning methods can help to attenuate the field of tension between individualization and automation that exists in the provision of services (cf. Bruhn & Hadwich 2020). This potential is particularly relevant for smart services, which comprise data-based and individually configurable service packages consisting of intelligent technologies, digital services and physically rendered services (cf. Bullinger et al. 2017a). Smart services are provided on the basis of data collected by networked physical objects. Analysing these data and combining them with other data generates information that permits comprehensive conclusions about the status of objects, their usage and the application-specific environment. They facilitate the development and provision of digital and physical value-added services adapted to the actual needs of customers in a given situation. In this context, methods based on artificial intelligence play an essential role in various respects: On the one hand, they may be used for automatic extraction of information from large volumes of data or the identification of new findings that are not obvious to humans (cf. Wahlster 2017). At the same time, machine learning provides a basis for automated or even autonomous systems that can take charge of the provision of services fairly autonomously, e. g. in form of physical or digital robots (cf. Neuhüttler et al. 2020, cf. Wirtz et al. 2018). Notwithstanding the potentials outlined, current studies show that more than 50% of new smart service offerings launched fail as early as in the first year after their market launch (cf. Leiting & Rix 2020).

One of the reasons considered for this is a lack of concepts, methods and tools to develop smart services systematically (cf. Spath et al. 2014). Tried and validated methods of service engineering focused on the development of "traditional" services do not sufficiently consider essential characteristics of smart service systems such as development within ecosystems, increasing automation or new digital forms of interaction and are therefore only useful to a limited extent (cf. Böhmann et al. 2018). Accordingly, it is about customizing or even redesigning these to facilitate a systematic design of digital service systems. For this reason, new approaches for the development of smart services have been proposed in the past few years (cf. Jussen et al. 2019), the development phases and tasks of which match fairly well. The common characteristic of these approaches is an iterative and incremental procedure where prototypes are developed in a repetitive process and tested jointly with customers or users to explore potentials for improvement for the subsequent phases of development. Hence, testing is considered to be critical for success and highly relevant in these approaches to avoid undesirable developments at an early stage and prevent later failure in the market. However, none of the approaches developed provides a comprehensive description of the procedure or the methods and tools suitable for testing smart services.

Another reason that may explain early failure is a lack of understanding of the customers' perceptions of the quality of smart services (cf. Maglio & Lim 2016), although knowing the essential expectations is the basis for a systematic and quality-focused approach in the development of smart services. Traditionally known drivers and models of quality must nevertheless be verified with a view to their portability particularly on the background of the use of AI in smart service systems (cf. Bock et al. 2020). One issue is to find out which ones of the dimensions known are modified by the use of AI and which new aspects gain in importance, for example, in various forms of AI-supported interaction. Research is still in its early stages in this regard and yields hardly any knowledge about the expectations of potential customers (cf. Ostrom et al. 2019). A conceptual framework for quality assessment of smart services proposed by Neuhüttler et al. provides a relevant basis which has been extended to include AI-specific aspects (cf. Neuhüttler et al. 2019a). However, this approach also lacks a specific description of how the conceptual framework can be used precisely in the testing phase of smart service engineering to date.

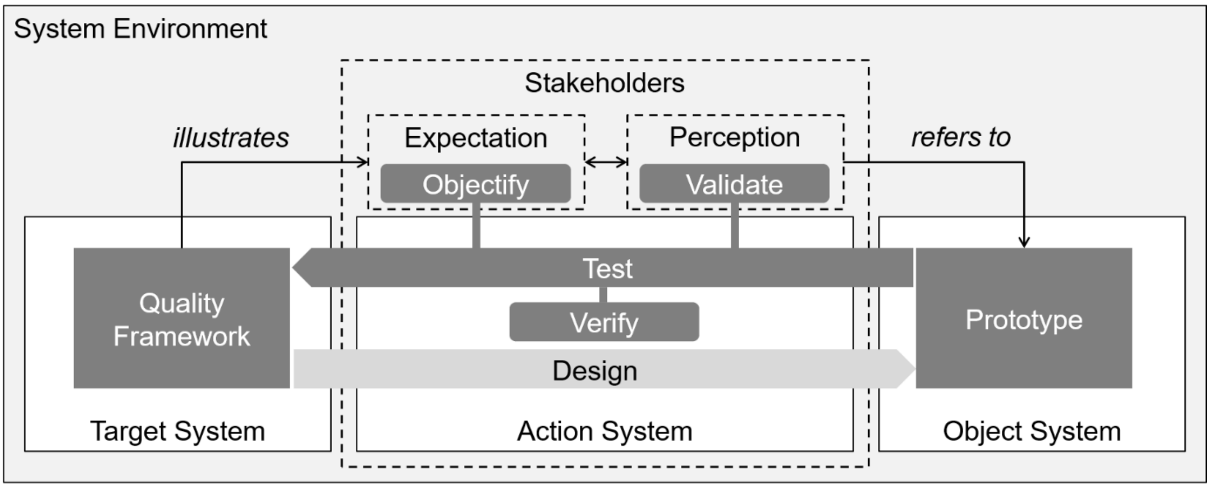
This is where the present contribution ties in by proposing an approach for quality-based testing of smart service systems and describing its implementation by way of two use cases at the Stuttgart Airport. In a first step, the relevant elements of a quality-based test are identified and correlated with each other. This is followed by a description of the two use cases and the procedure model for testing AI-based smart services at Stuttgart Airport.

Testing Approach for Smart Services

Testing during the Development of Smart Services

Figure 1 illustrates the development process of smart services as the transformation of a target system into an object system utilizing an action system (cf. Albers et al. 2016). The target system describes the desired condition of a smart service based on known requirements, framework conditions and properties and increasingly detailed and extended in the course of development. The object system comprises the description of all documents and artefacts produced as partial solutions in the course of development. The action system is understood to involve all activities, resources, processes and methods used within the framework of development. The fundamental development tasks include the design, i.e. designing a state of development in terms of a prototype on the basis of the knowledge available in the target system. On the other hand, this state of development must continuously be checked against the target system which represents testing.

Figure 1: Core elements of the quality-based testing approach for smart services coloured in black (source: own illustration referring to (Albers et al. 2016))



Testing involves three essential tasks: Verification makes a comparison of the prototype developed with the requirements specification resulting from the target system. In most cases this is done using objective criteria and may be performed by in-house experts. The other testing tasks, i.e. assessment and externalization, constitute validation in the narrower sense and require the integration of external stakeholders. In the development of smart services, not only customers and users but also partners and other decision-makers need to be considered. The assessment test task addresses the subjective perception of the stakeholders regarding a state of development presented to them. The third task of testing is externalization, i.e. matching the subjective expectations with the target system that is subject to development with the aim of obtaining a basis for design with maximum validity.

In the following sections, particularly assessment will be viewed as a core validation task of testing in the development of smart services. In this context, the perceived quality resulting from comparing the subjective perception with the expectations of a test person is in the focus of assessment. Figure 1 also shows that performing a quality-based test requires three essential elements: In the object system, a prototype of the smart service is required that can be subjected to assessment by the stakeholders. With a view to facilitating a systematic assessment involving the relevant stakeholders, a suitable procedure model as well as a methods and tools base are required in the action system. The third element is a representation of the target system which can be utilized as a structuring element of assessment and should generate repeatable findings that are as targeted as possible for the further development process. The conceptual framework for smart service quality is used for this purpose with the intention to assess the matching of expectations and perceptions and thus the perceived quality. The two elements of prototype and conceptual framework are explained in more detail in the following sections. The procedure model is presented in chapter 4.

Prototypes and Innovation Labs

As a consequence of the intangible and integrative nature of smart services the question arises of how stakeholders can be involved into a development process in a useful way. In this regard, prototypes play an essential role, since they enable stakeholders to experience the current state of development and thereby facilitate an early assessment of the characteristics and functionalities (cf. Blomkvist & Holmlid 2010). Since prototypes can be used across all phases of development, they can have different degrees of maturity: In early phases of conceptual design, less mature prototypes are frequently created which have a relatively low functionality and fidelity of representation. Along with the more advanced phases of development, the maturity increases and the prototypes come closer to the final version of the smart service in terms of complexity and performance capacity. The perceived value of smart services results from the integration of activities and resources of the various parties within the use process (*value-in-use*) and from their embedding into a specific application context (v*alue-in-context*) (cf. Neuhüttler et al. 2019a). To develop prototypes which permit valid conclusions about the perceived quality and potentials for improvement, prototypes must therefore also make it possible to experience the use process and application context in addition to the artefacts. Accordingly, service prototypes usually include the following elements (cf. Razek et al. 2018):

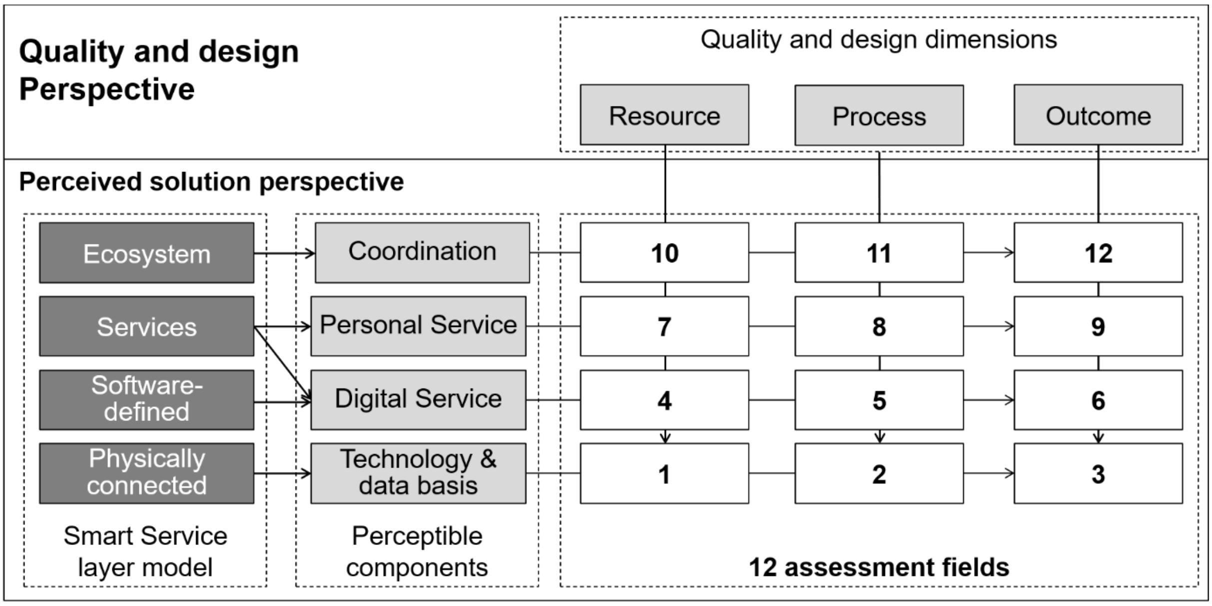
- Stakeholders: Test persons who assess the prototype and other persons involved in the test such as colleagues and external parties.
- Interactions: Interactions between stakeholders and/or between the test person and the provider's artefacts.
- Artefacts: Descriptions of the visible, tangible or simulated elements of the smart service to be subjected to assessment (e.g. objects, visualized data flows, front-ends etc.).
- Test environment: Describes a typical environment in which a smart service is delivered.
- Other context factors: This is finally the attempt to simulate cultural or social factors that may influence the perceived quality of the smart service or take them into account in the description of test scenarios.

Service labs play an important role for testing because of the numerous different components of smart service prototypes. They provide a physical space in which different technologies (e.g. virtual reality), resources and methods (e.g. in a service theatre) can be used to simulate the provision of a service and its environment and include many different components of prototypes. Hence, labs are a protected test environment in which various components of a prototype can be modified and the resulting change in the perception of stakeholders can be assessed. Other advantages are the repeatability of tests under identical conditions and the reliability of test results achieved by a controlled environment (cf. Burger et al. 2012).

Conceptual Framework of Quality as a Basis for Assessment

With a view to structuring the perceived quality in the development of smart service systems, Neuhüttler et al. 2019 have proposed a conceptual framework which can be used, for example, to facilitate a systematic assessment of prototypes within the scope of testing (cf. Neuhüttler et al. 2019a). In a first step, the smart service development object is structured regarding its content to be able to identify specific handles for improvement. This procedure is based on the finding that the overall quality of a service is made up of the sub-qualities of its individual service components (cf. Bruhn et al. 2010). The horizontal axis of figure 2 represents structuring along the structure, process and outcome design dimensions, which are used for characterizing services in service engineering and also for quality assessment (cf. Donabedian 1980).

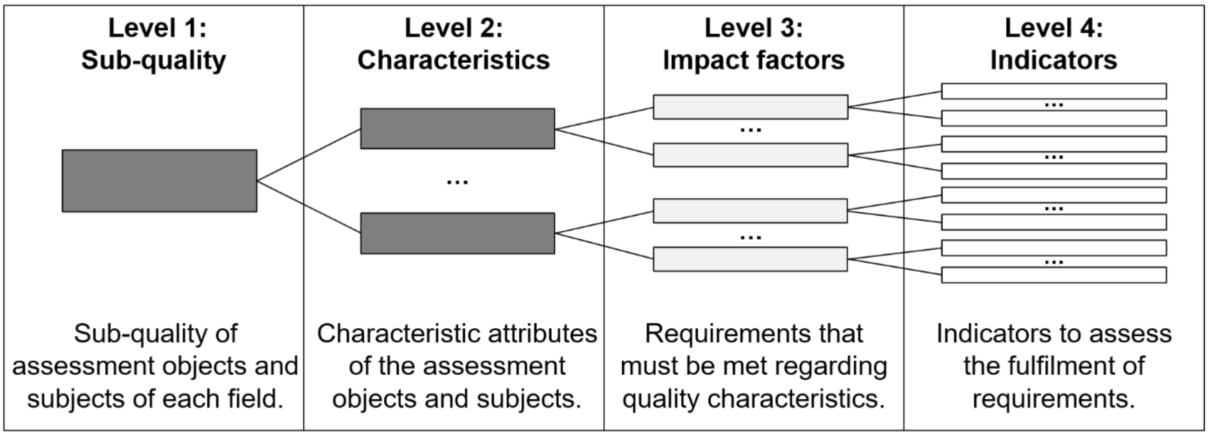
Figure 2: Derivation of 12 assessment fields for smart service systems (source: own illustration based on (Neuhüttler et al. 2019a))



In this way, links are created to existing quality models and also to the methods and models of service engineering with the aim of establishing a conceptual framework that is compatible with practical use. Along the vertical axis, the conceptual framework is structured by the perceivable service components of a smart service system that are derived from the well-known layer model (cf. Bullinger et al. 2017b). This includes the intelligent technologies of physically networked objects, digital services as well as services provided by persons. Since smart services consist of different service components and are provided jointly by several parties, the coordination of the various contributions and parties involved plays an important role and has been considered in the conceptual framework. Unfolding these two dimensions produces 12 fields of assessment, the sub-qualities of which can be assessed by the stakeholders within the scope of a test.

In a second step, the abstract construct of sub-qualities has been operationalized by deconstruction to facilitate quality assessment of specific smart services with stakeholders. For this purpose, the sub-qualities were translated into empirically tangible and assessable indicators for the test at various levels. Figure 3 shows the different levels of operationalization based on the sub-quality of an assessment field (level 1). This describes the degree to which the quality characteristics of objects and subjects assessed match the subjective requirements in the perception of users (cf. Leimeister 2020). Hence, it is therefore necessary to first identify the objects and subjects that users can perceive within the 12 assessment fields (cf. Bruhn et al. 2010). The subsequent level 2 describes quality characteristics of the objects and subjects assessed, i.e. properties inherently assigned that can be used for assessing the perceived quality. Quality characteristics form the interface between quality assessment within the scope of the test and the identification of specific potentials for improvement of the state of development since they show the requirements to be fulfilled for which characteristics. The quality impact factors shown at level 3 represent sets of requirements for characteristics demanded by users that can be verified directly by a more detailed sub-division according to specific assessment criteria (level 4).

Figure 3: Schematic representation of operationalization of sub-qualities of the 12 assessment fields



This operationalization procedure can be illustrated by the example of assessment field 5: It addresses the process quality of digital services in the smart service system. For example, the assessment of the sub-quality at level 1 addresses the use of the service by the test person, the integration of additional data into the service or the algorithms on which the service is based. The quality characteristics identified at level 2 comprise, for example, the *interaction friendliness* of the digital interface, the *integratability* of the service into one's own thinking patterns and workflows or into an existing digital ecosystem as well as the *adaptability* of the service to specific applications and findings from the current data available. Another quality characteristic is the perceived *control* since collection and exchange of possibly sensitive data via digital interfaces are often perceived to happen in a non-transparent and risky way. On the one hand, it addresses a test person's perceived capability to actively influence the process and the outcome of the service. On the other hand, continuous collection and utilization of data for personalized value propositions and offerings may cause the impression that the user himself is under surveillance or control (cf. Breidbach et al. 2019). At level 3 of the conceptual framework, the perceived control of a digital service is characterized by the quality-determining factors of *transparency*, *traceability*, *accountability*, *controllability* and *convenience* of use. If the intention is to give users a feeling of control, for example, it is necessary to fulfil specific requirements regarding transparency by disclosing fundamental information about the data used, the intentions of algorithms used or the core factors influencing automatic decision-making (cf. Shin & Park 2019). However, transparency is insufficient to increase traceability particularly in AI-based smart services which use blackbox algorithms (e.g. convolutional neural networks) for decision-making and requires additional measures (cf. Rai 2020). For example, the concept of explainable artificial intelligence (XAI) can be applied in this context; it uses simple interpretable explanation models to enable gradual traceability of explanation variables, explanation processes and decisions. At level 4, the conceptual framework includes indicators that can be used, for example, for assessing the degree of fulfilment of the *traceability* requirement. These are statements which test persons can confirm or reject on a multi-stage answering scale. Sample indicators are:

- Automatic decisions of the service match my intuition.
- I know core factors influencing the decision-making.
- I know which data are used in decision-making.
- I understand how the service gets to its decisions (e.g. suggestions).
- The digital service delivers calculable results.
- Decisions remain calculable for me even though machine learning is used.
- The complexity of data processing is reasonable and proportionate for the application.

Even though similar terms are used, it becomes clear that the conceptual framework of smart service quality is not an empirically validated quality model like SERVQUAL with fixed quality dimensions and assessment criteria (cf. Parasuraman et al. 1988). As a consequence of the essential characteristic of smart services, i.e. the individual service configuration and the large number of service variants derived therefrom, such a model could only be used in very specific cases within the scope of a test. Rather, it is about selecting those assessment fields, characteristics, quality-determining factors and criteria available in the conceptual framework which are relevant for a specific test within the scope of development of smart services. The relationships between the individual components of a quality-based test are outlined in the following section.

Interrelations of presented Components

There is a close and logical interrelation between the components of a quality-based test of smart services identified and characterized in the sections above. Figure 4 illustrates this interrelation by way of three different modes of testing: concept test, lab test and pilot test. In very early phases of development, it is useful to have the concept of a smart service assessed by the relevant stakeholders within the scope of a concept test. Usually there is no fully differentiated prototype available yet in such a case, but rather a verbalized or visually developed format (e.g. service blueprints or storyboards). Accordingly, concept tests rather tend to be useful for the assessment and selection of different concept variants (e.g. regarding the degree of automation of a smart service) or for the collection of ideas and requirements. The conceptual framework may be used here at level 2 (cf. figure 3) to facilitate systematic assessment and collection of requirements along the quality characteristics described there.

Within the scope of a lab test, the test persons are presented a current state of development in a laboratory environment. This requires that at least some of the components of the prototype have reached a higher degree of maturity with regard to fidelity of representation and functionality to be able to achieve a meaningful assessment and identify specific actions for improvement. Non-functional components may be simulated accordingly in a laboratory environment. Different levels of the conceptual framework are used depending on the specific degree of maturity of the prototype components; for example, the assessment can be made for some service components on the basis of the quality-determining factors while detailed indicators may be used for other components. Since there are significant differences regarding the development cycles among the individual comp onents of a smart service, using different levels makes it possible to adapt the assessment.

Figure 4: Interrelations of components in different types of testing Smart Service

Testing types	Concept test	Laboratory test	Pilot test
Objectives	▪ Selection among concept variants ▪ Requirement analysis ▪ Recognizing advantages and disadvantages	▪ Detailed evaluation of components ▪ Identification of potentials ▪ Preference determination of alternatives	▪ Evaluation of Smart Service under real conditions ▪ Estimation of the potential for success
Prototype maturity	▪ Low degree of maturity ▪ Simple verbal or visual presentation ▪ No functionality	▪ Different degrees of maturity of components ▪ Simulation of non-functional or missing components	▪ High degree of maturity ▪ (Almost) complete functional range ▪ High level of detail
Framework usage	▪ Use at the level of quality characteristics ▪ Weighting of the characteristics	▪ Different levels, depending on maturity of prototype ▪ Mostly level of fulfilment of determining factors.	▪ Use of detailed quality indicators ▪ Variable use depending on the interest in the findings

A pilot test describes the use of an almost fully functional prototype in true detail with a selected range of test customers in a real-world service provision setting. This makes it possible to assess the quality of the smart service in detail and broken down to the level of the individual criteria. The three testing modes differ with regard to the insights achieved, the expenditure involved and the potential of saving costs later.

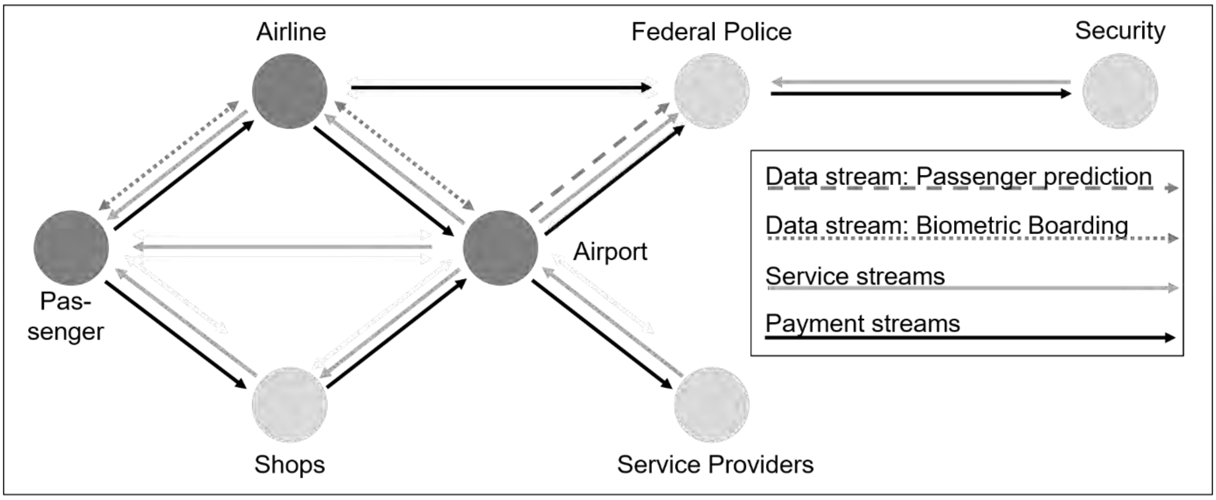
Exemplary Application at Stuttgart Airport

The use of the components outlined for the quality-based test is illustrated below by means of two applications of smart service development located at Stuttgart Airport.

Stuttgart Airport as a Smart Service System

One of the main objectives of an airport is to ensure that air traffic operations run as smoothly as possible and make the infrastructure available that is necessary for this purpose. The tasks directly related to air traffic (aviation domain) include management of taxiways, runways, passenger clearance and the transport of baggage and passengers between apron and terminal. The non-aviation domain covers, for example, construction, operation and maintenance of runways and technical facilities, optimum management of office and shopping areas, restaurants and car parks as well as internal services, airport security and business communication. As an infrastructure provider, the airport operating company supports and coordinates the activities of many different parties forming part of the airport service-providing system. The most important customers of an airport are the airlines, followed by the businesses operating on the airport campus. However, there is usually only an indirect business relationship with the passengers. The following figure 5 provides an overview of the major groups of stakeholders within the airport service system.

Figure 5: Stakeholders and value-exchange streams of an airport in the use cases



The solid arrows between the parties reflect the core service and payment flows. The dotted arrows mark the data flows for the biometric boarding application. The dashed arrow indicates the data flow in the AI-based passenger prediction application. Both applications are presented below.

Biometric Boarding Application

Facial recognition technology was used for the first time in passenger clearance at Atlanta International Airport at the end of 2018 (cf. Delta Airlines 2018). After the successful launch in Atlanta, it was initially used on a trial basis at numerous airports worldwide, for example, in Sydney, Ljubljana, Amsterdam, Athens and Hong Kong, just to name a few. Other projects are under preparation, such as at Stuttgart Airport. The use of AI for facial recognition and identification technologies makes it possible to design passenger clearing as a fairly much document-free process. As a prerequisite, passengers must first register and consent to the biometric procedure. When registering, the passenger’s face is scanned and matched with the photograph in the official identity document. When the person scanned can be identified as the one on the photograph, the person is checked in and a virtual boarding card is produced. From then on, a glance into the camera will be sufficient for a person to be identified at all stations until entering the aircraft. The introduction of biometric identification offers advantages for all parties involved according to the International Air Transport Association: Passengers, airlines/airports and security authorities. For passengers, the processes at the airport would become quicker and more convenient since searching for and putting away booking confirmations, identity documents and boarding cards would be eliminated. Airports and airlines would work more efficiently since several minutes would be saved per aircraft in the boarding process. In addition, fewer check-in desks and therefore fewer employees would be required. Moreover, since facial recognition makes it more difficult to travel with a false identity, the work of the security authorities would be easier.

Despite stated advantages, the use of facial recognition technologies in passenger clearing processes is not without controversy. There is discussion about data security and data safety, the reliability of facial recognition and the actual added value for the passengers. With the registration for the biometric procedure, a set of highly sensitive personal data is input into the computing systems of private or semi-public international corporations. Critics see three particular risks involved: First, data loss and possibly identity theft could occur if the data are not properly protected on the systems of the airlines and airports. Second, there are fears that the companies themselves might misuse the data, for example, for marketing purposes or to optimize their service offerings. Third, there are concerns that biometric processes – once they are introduced and accepted in air traffic – could be propagated to other domains such as rail transport or access to public buildings. Another issue of criticism are ethical concerns, since facial recognition works less reliably with people of colour, particularly with dark-skinned women. Apart from that it is questioned whether the biometric process actually offers any significant added value for the passengers. Eventually the convenience and time saved in passenger clearing is bought by additional procedures required for registration. On the background of this discussion, the question arises of what is the attitude of the passengers themselves towards the biometric customer journey and which demands they make regarding its design. With a view to exploring this issue, the conceptual framework for quality assessment described above is used for the envisaged design at Stuttgart Airport. The intention is to assess the service quality and determine factors that are particularly important for acceptance on the part of the passengers.

AI-based Passenger Prediction Application

Optimizing passenger flows and reducing waiting times at the various service stations (e.g. security check or baggage check-in) are some of the core tasks to raise the perceived service experience of passengers. This relies on comprehensive knowledge about the current situation at the airport, on the basis of which action can be taken and workflows and activities can be adjusted. For this reason, Stuttgart Airport uses the Passenger Tracking System developed by XOVIS AG. It is based on optical 3D sensors mounted to the ceiling of the airport building which can identify persons in an anonymous mode and track their movements. An image recognition software is used to obtain key indicators for monitoring and controlling passenger clearance such as, for example, the current number of persons present, their distances among each other, the length of queues or the duration of process cycles. Key indicators and service levels can be coordinated individually with the airport and visualized in a dashboard for the staff. Whenever certain threshold values are exceeded (e.g. average time spent in the queue at the security check), the staff is alerted and can take action accordingly, such as open additional security check stations. At the same time, specific notices informing about additional security check stations and the anticipated waiting time can be used to control passenger flows. However, the options for action are limited in case of exceeding thresholds ad hoc, since opening additional security check stations requires additional personnel. For this reason, XOVIS AG pilots an AI-based prediction function as a supplement to its digital services. Based on history data and current passenger information from the airport operating system, the number of passengers arriving is predicted for 24 hours in advance and recommendations are given to optimize staffing at the security check stations. A fundamental requirement for successful implementation is the personnel's trust in the abilities of the prediction service and the recommendations generated. In addition, the personnel should not have the impression that the service curtails their freedom of decision or even replaces specialized skills and competencies. Finally, an effective interaction between humans and the technical system should be designed by visualizing and integrating the information accordingly into existing thinking patterns and workflows. For this reason, XOVIS AG are currently performing a pilot test for the new functionality together with Stuttgart Airport with a view to assessing acceptance and identifying scope for improvement.

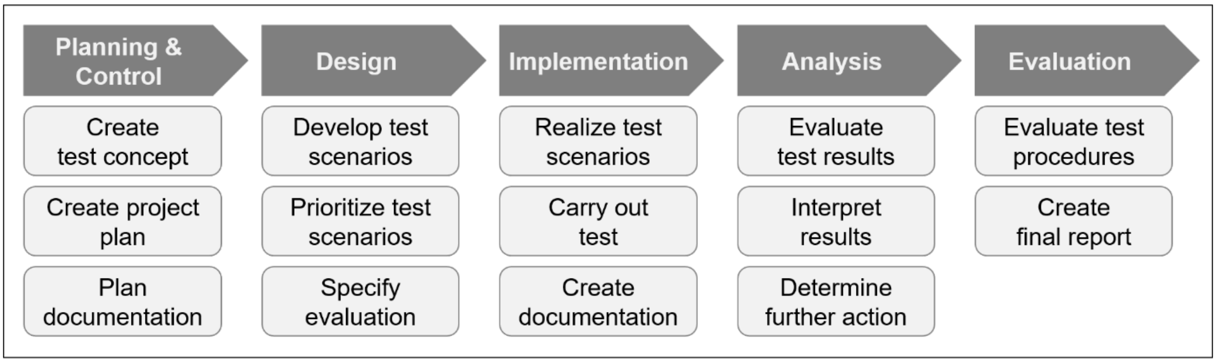
The two applications described illustrate two different types of tests where different test persons and prototype maturities exist. The following sections describe the procedure of a quality-based test in the context of the two applications.

Description of a Quality Based Test Procedure at Stuttgart Airport

Procedure Model

The Fraunhofer IAO uses a reference model which specifies the required tasks and a basic sequence to facilitate a systematic approach for quality-based testing of smart service systems. This structured approach is intended to avoid that individual worksteps are done incidentally, double work is done or earlier errors are repeated. The phases of the reference model shown in figure 6 are based on the fundamental test process of the ISTQB (International Software Testing Qualifications Board).

Figure 6: Reference procedure of quality-based testing of smart services



This approach has been chosen as a basis since it has become widely popular in practice and fairly much matches the test tasks for service development identified within the scope of a business survey (cf. Burger et al. 2012). It is customized with a view to the particular characteristics of smart service system development at the level of activities to be provided and the related support methods and structuring aids. Although the test tasks grouped according to phases are arranged in a sequential order in the reference model and basically rely logically on one another, they are performed in overlap and sometimes in parallel in practical application (cf. Spillner & Linz 2019). The following sections describe the goals and activities of the various test tasks in more detail in the context of the two sample applications at Stuttgart Airport.

Phase 1: Planning and Control

In the planning and control phase, the initial task is to develop the test concept which defines the framework conditions for reliable and smooth performance of all subsequent activities. A test concept describes the test object, the test goals and the test procedure which determines other activities (cf. Spillner & Linz 2019).

The test object represents the core subject of the test project and delimits it precisely (cf. Witte 2016). For this delimitation, the smart service components to be considered need to be selected first. The conceptual framework may be used here to facilitate structured decision-making. Figure 7 presents typical test objects and subjects from the twelve assessment fields the test team supports as a basis for discussion and decision in the selection. For example, in the sample application for AI-based passenger prediction, different service components of the smart service system could be addressed, ranging from the sensing equipment to services provided by persons. However, the test team decided to focus on digital and outcome-related test objects emphasized in figure 7.

The second task of concept development is the definition of test goals that reflect the desired outcome of the test. Test goals may be, for example, confirmation or rejection of test hypotheses, a certain assessment value or the identification of options for improvement. In addition to the test goals, the general test procedure is also defined, i.e. the assessment of a development type or a comparison of different variants. Along with the test goal and the test procedure, the criteria for the test end are also defined; they describe when a test has been performed successfully or not and is thereby terminated. Moreover, the relevant stakeholders of a smart service are analysed and the group of test persons defined. This can be supported by stakeholder maps or buying center analyses. For the AI-based prediction service, for example, the identification of options for improvement was in the focus within the scope of a pilot test. The assessment was done by personnel of Stuttgart Airport acting as test persons. In contrast, the biometric customer journey involves assessing different service variants and passengers are addressed as test persons.

Figure 7: Exemplary testing objects and subjects of smart service systems

Smart Service components	Dimensions		
	Resource	Process	Outcome
Coordination	▪ Ecosystem partners ▪ Resource integration	▪ Task sharing ▪ **Process Interfaces**	▪ **Functional benefit** ▪ **Additional value**
Personal Service	▪ Frontline Employees ▪ Servicescape ▪ Technical equipment	▪ Personal interaction ▪ Integration in customer sphere	▪ Personal relationship ▪ Process result
Digital Service	▪ IT-Infrastructure ▪ **Front-End** ▪ Additional data sources	▪ **Use of digital service** ▪ Data Integration ▪ **Algorithms**	▪ **Information** ▪ **Recommendations** ▪ Triggered actions
Technology & data basis	▪ Product basis ▪ Intelligent Technologies ▪ Communication-Infrastructure	▪ Use of networked physical products ▪ Integration into the usage environment	▪ Collected data base ▪ Process outcome

In addition to creating the test concept, the *planning and control* phase also involves creating a project plan for the test project in which the timeframe, the resources required and the roles of the test team are defined. The third essential task is to initiate a documentation and control process defining the continuous review of activities performed in comparison with the planning as well as the events to be documented (cf. Baumgartner et al. 2018). Although the activities of the documentation and control process begin in the first phase, they usually extend across all phases of the test project.

Phase 2: Test Design

In the design phase, the test concept is specified in more detail and operationalized for the subsequent phases. In a first step, this involves developing test scenarios to be used as a basis for performing the test and assessing the current state of development with the various stakeholders. In this regard, test scenarios must be designed in such a way that they create situations for test persons that are as similar as possible to the later smart service delivery situation and thus allow qualified assessment. The following relationship exists between test scenarios and the components of a service prototype described in section 2.2: For the description of test scenarios, relevant components of the prototype are used which are required to generate realistic situations and valid results depending on the test goals and the test procedure. However, it is also possible that requirements result from the test goals regarding the functionality or degree of detailing of a prototype that it does not yet have because of the current state of development. In this case, it is necessary to define specific requirements for the development of the prototype from the test scenarios or describe the simulation of additional components using suitable methods and technologies.

Nevertheless, the prototypes customized for the test scenarios should not require too much individualization with a view to safeguarding efficient test performance and allowing deduction of implications that are suitable for generalization. Moreover, the components of the prototype do not necessarily all have the same degree of maturity, depending on the development logic and phase. The integration of the elements in a suitable and assessable prototype which can be realized efficiently at the same time and the iterative matching with the requirements of the test scenarios are among the most complex and at the same time most important steps (cf. Neuhüttler et al. 2019b). Usually, it is not possible to realize all test scenarios with stakeholders for reasons of time and capacity. For the prioritization of the test scenarios thereby made necessary, various methods of service engineering and existing documents can be used. For example, the relevant delivery processes can be visualized from the perspective of the provider (e.g. with service blueprints) or the user (e.g. with customer journey maps) and subjected to structured analysis to obtain and prioritize relevant test scenarios (e.g. interactive situations). In this context, the focus is on the contact points between users and service options of the provider (persons, objects, user interfaces), since any inconsistencies or errors occurring at this point cause a particularly negative impact on the perceived quality. Potential sources of problems can be assessed and prioritized with regard to their probability of occurrence, probability of discovery and their effects using a schematic assessment method based on Failure Mode and Effects Analysis (FMEA). An alternative approach is the use of a Design Structure Matrix (DSM). This supports the analysis of effect relationships in complex systems, where individual test objects are assessed with regard to their interrelations (cf. Browning 2001). In this way, service components with a high effect relationship with other components can be identified, any defects of which would significantly impact the perceived quality of the system as a whole.

The third step in the design phase addresses the specification of the assessment basis for the test scenarios, where the assessment level of the conceptual framework for quality assessment is defined depending on the test goals and the degree of maturity of the prototypes used (cf. figure 3). In addition to selecting an appropriate viewing level, the test team defines the quality characteristics, quality-determining factors or individual assessment criteria to be addressed. The modular and configurable nature of the conceptual framework makes it possible to assess also components of different degrees of maturity together in a structured way in one go or scrutinize individual components in more detail, depending on the focus of interest. In this way, it is possible to reduce the number of test scenarios to be implemented and safeguard an efficient process. The fundamental approach for selection is evident in the example in section 2.3. For example, to assess the AI-based prediction service at Stuttgart Airport, the user interface and the information content are assessed in detail using assessment criteria from level 4 (cf. figure 3). In contrast, other test objects such as algorithms and the impact on the overall result are assessed under the concept of fulfilment of requirements at level 3.

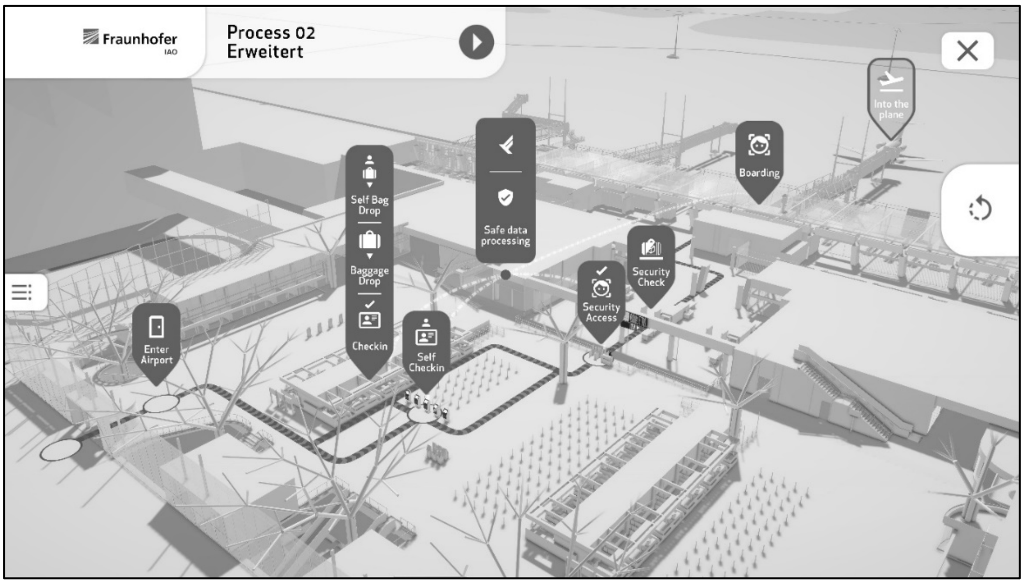
Phase 3: Implementation

The implementation phase comprises all activities for final preparation and implementation of the previously designed test scenarios as well as the documentation. This involves, for example, creating questionnaires, customizing the test scenarios, preparing the lab environment as well as inviting and briefing test persons. The collection of relevant test data is one of the most important tasks in this phase. In addition to obtaining direct feedback using questionnaires, other data may also produce new findings or confirm or invalidate direct assessments. This includes, for example, data collected using intelligent test technologies such as smart glasses (to track individual eye movements) or fitness trackers (to measure heart frequencies and excitement of test persons) (cf. Neuhüttler et al. 2019b). The preparation of test scenarios for the Biometric Customer Journey sample application is described in more detail below.

Traditionally, the customer journey for air travel involves the following steps: Booking, travel to airport, check-in, possibly baggage check-in, boarding card check, security check and boarding. This may also include staying in the lounge, shopping or the consumption of food and beverages at a kiosk or in a restaurant. When entering the airport building, passengers first go to the check-in desk of the appropriate airline unless they had already checked in online. At the desk, they say their name and destination or present the booking confirmation and possibly the identity card or passport. The airline employees at the desk search for the booking in the reservation system, assign a seat and issue the boarding card. If the passengers want to check in their baggage, they can have this done at the desk at the same time. They place the piece of baggage on to the belt and have a voucher tagged to their boarding card. When boarding time approaches, the passengers go to the boarding card check. Subsequently the passengers pass the barrier towards the security check. After passing the body scan and baggage scan performed by the Federal Police or security service provider, the journey leads to the gate. The boarding card and sometimes also the identity document are checked again there by the airline personnel. Subsequently the passengers can pass to the aircraft directly or to the apron bus and finally enter the aircraft. Person and baggage check-in may alternatively be done at self-service stations. There, passengers have to enter the same data as at the check-in desk.

In order to test the perceived service quality, three variants of the biometric customer journey were modelled in BPMN and subsequently visualized in the form of interactive 3D models by the Solid White digital agency. The first process variant corresponds to the flow planned for the pilot project. Here, biometric identification is only used for the boarding card check and at a self-boarding gate. The second extended process variant comprises the stations of the pilot phase and, in addition, the self-bag-drop, i.e. baggage check-in at an automatic station. Figure 8 shows a schematic visualization of the customer journey for this extended process variant. The labels indicate individual touch points of the customer journey. Clicking a label opens a visualization of each sub-process.

Figure 8: Overview of the customer journey visualization in a 3D prototype



The third and more futuristic variant is a vision of the future. Here, the biometric data are permanently stored after registration and will be available from then on at all airports. In this variant, registered persons are routinely scanned and identified whenever they enter an airport. If a matching booking exists, the check-in occurs automatically. Push messages on the smartphone direct passengers to the terminal with the shortest waiting time for the security check. Passengers receive notices telling them to which gate to go and when to set out to be there in time. Neither documents need to be presented nor data input anywhere. A face scan is sufficient for identification. In addition to the stations of the customer journey, all three process variants also show the data flows, since it is safe to assume that data handling is an important quality-determining factor. Figure 9 shows a screenshot from the registration process at a common use self-service kiosk (CUSS automatic station) operated jointly by various airlines.

Figure 9: Check-in and registration for the biometric procedure at a CUSS station

The scene depicted is an animation and shows in an endless loop how the passenger is prompted successively to place the boarding card and identity document into the machine and have his face scanned. You can see the scanning process and the notice that the data are saved securely in the system of the airline. For quality assessment, one specific set of questions was selected from the conceptual framework of the quality for smart services for each process variant and each touch point and customized for the framework conditions of the test scenario. For the sub-process of 'Check-in and registration for the biometric procedure' shown in figure 3, for example, the following aspects were considered to assess the sub-quality of field 1 (cf. figure 2):

- The CUSS machines have an attractive appearance.
- The machines are easy to find.
- I feel free to choose from different service variants (with or without acquisition of biometric data).
- A sufficient number of face scanners are available.
- Structural arrangements make sure that my privacy is sufficiently protected.
- I am aware of the functions of the CUSS station.
- The data acquired are in a plausible relationship with the value proposition.
- I can see for which purpose the data are used and for what they are not going to be used.

The implementation of the test is planned in several different stages. First, the visualized test scenarios will be applied with test persons in the ServLab, the service lab of the Fraunhofer IAO. In the next step, the tests are planned to be carried out with real passengers in the real environment of Stuttgart Airport. Finally the 3D visualizations can be utilized for the introduction of biometric boarding, for example, in the form of explanatory videos. An abstracting assessment of the smart service, e.g. at level 2 of the conceptual framework, may also be performed here and implemented on a permanent basis.

Phase 4: Analysis

The fourth phase comprises analysing and interpreting the test results on the basis of the test records and filled-in questionnaires. The results of the various test persons are initially summarized and analysed for each test scenario depending on the degree of detailing required. Subsequently, the assessment results for individual service components are analysed across the various test scenarios to obtain significant knowledge about options for improvement. In addition to analysing the customer assessments, this step may also include the experience and opinions of the test persons as well as other test data.

In the test interpretation, the results are compared with the test end criteria defined. This also includes analysing the reasons for any deviations between the desirable results and the assessments. This leads to three basic options for the further procedure: In the first case, the results from the quality assessment of the smart service prototype are satisfactory and the requirements for another development phase fulfilled. The second case occurs if the quality of test planning and implementation was insufficient and the results obtained are not sufficiently meaningful to be able to make a decision. Hence, the test must be repeated and the problems eliminated. In the third case, the team identifies options for quality improvement during the evaluation and decides that the development level of the smart service needs to be revised. The information and recommendations are fed back to the appropriate development teams depending on the scope of the service components affected (e.g. personal service, digital service, technology and data or coordination).

Phase 5: Evaluation

The final phase involves the evaluation of the test procedure to facilitate continuous further development and customization in terms of a continuous improvement process. The evaluation includes an analysis of both the feedback from the test persons and the meta-data from the test such as, for example, the duration of individual activities, the number of changes made to test scenarios or deviations between planning and implementation (cf. Spillner & Linz 2019). Usually this is done on the basis of the documentations defined in the course of test control. Once the test procedure has been evaluated, the last activity consists in preparing a final report which contains an overall documentation of the activities, results and recommendations for action identified as well as the evaluation of the test procedure and will be made available to all stakeholders and/or archived.

Summary and Outlook

This article presents an approach for quality-based testing of smart service systems. The essential elements of the approach include prototypes for the visualization of the state of development, the conceptual framework of smart service quality as well as a procedure model which describes major goals, tasks and supporting methods. The practical implementation of the approach has been illustrated by way of two applications operated at Stuttgart Airport. It has been possible to show that the test approach can be used at different development levels and for different types of smart services because of the configurable conceptual framework of quality assessment, which includes different service components and levels of detailing. The two aspects of quality management and testing in development have been considered jointly in this article, thereby closing an existing gap. However, research on this topic is still only at its beginning. One specific starting point is the application of this approach in different industries and with different variants of smart services, where patterns and relationships of relevant quality aspects can be found and utilized as recommendations for design in the development. In addition, the intention was to study the role which the quality-based testing approach can play for consistent safeguarding of quality standards in complex value networks. Setting and revising uniform quality standards for smart services, for example, also offers an opportunity for differentiation to businesses. Finally it should be noted that the conceptual framework of smart service quality should be further developed on the background of changing social values and that more social, ethical and environmental characteristics should be included in the assessment in the future. This is particularly true with regard to the propagation of learning systems and the associated expectations to be considered regarding fairness and transparency of algorithms.

Furthermore, it will be crucial to better understand the limitations of current AI programs (e.g. the barrier of meaning) (cf. Mitchell 2019). This will help avoid unrealistic expectations that can negatively influence the perceived quality of smart services.

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1 1
Topic »Data based Service Products«

11.1
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Impact of climate change on banking organizations and emergence of new services

Karim Elia Fraoua, Christian Bourret (Université Paris Est Marne-La-Vallée, France), Kamel Haddad (BNP, USA)

The issue of climate change is increasingly urgent to deal with and populations are increasingly aware of this issue and its challenges, particularly economic, which also affects the notion of biodiversity. This climate change generates increasingly important economic costs for society as a whole, but also problems in the functioning of organizations and businesses linked to the availability of infrastructures that can be impacted by these climate changes. Some of these costs are caused by extreme weather events, such as hurricanes or forest fires, but also by flooding with increasingly extreme new ones causing infrastructure shutdown.

There are also chronic meteorological events, such as the rise in sea level or the rise in temperatures which are more and more visible and which cause dysfunction of the structures of electricity distribution or water availability, including to ensure the continuity of the richness of biodiversity, which is increasingly threatened. This physical risk can lead to the destruction of infrastructure, a disruption of the supply chain, or a change in consumption habits, which will profoundly affect the lives of citizens.

After the Paris Agreement in 2015, many countries strengthened their policy of transition to a low-carbon economy, and companies will have to face increasingly stringent climate regulations, which will impact the lives of citizens. The Task Force on Climate-related Financial Disclosures (TCFD), has published a reference document for companies to better inform investors, insurers and other stakeholders about their climate profile. These regulations result in lower income and increased household spending.

This new risk, known as transition risk, could significantly affect the ability of companies or individuals to meet their financial obligations and banks could be led to poorly assess their solvency. This will therefore lead financial institutions to imagine new services in order to be able to better manage this prudential risk. Indeed, there is the credit risk which is the risk of default on a debt, which can result from the fact that a borrower does not make the required payments. Credit risk remains the most important risk for banking institutions to manage. This is underlined by the Network for Greening the Financial System (NGFS), which stresses that "climatic or environmental criteria are not yet sufficiently taken into account in internal credit evaluations or in agency models [...] credit".

It should be remembered that the main activity of the bank is credit and deposit. In carrying out this mission, it must guarantee the security of deposits and risks related to credit management for its customers. Several types of credit exist, from the least risky to the more risky. The issuance of credit is linked to the growth of the economy, ranging from home loans, to business loans. In addition, banking activities have multiplied, but there is still an important factor, namely risk taking. This risk-taking translates into gains and losses, the difference of which must be sufficient to allow the sustainability and growth of banking activity.

In order to prevent these risks from jeopardizing the economic health of countries, and following the various excessive crises, regulators have put in place a number of measures to ensure that banks implement prudential measures. The Basel Committee, created in 1974, imposed the so-called Basel agreements to which all banks had to comply with ratios measuring the debt ratio with the nature of the debts by imposing de facto soundness tests, including the one that is required. current usage says the Stress Test.

Debts are placed on the financial market through certain instruments and de facto the emergence of this new risk linked to the transition will also impact the banks' market risk which is itself measurable through the Value. -At-Risk (VaR). VaR represents the maximum potential loss of an investor on the value of an asset or a portfolio of financial assets which should only be reached with a given probability over a given horizon. VaR can be viewed as a quantile of the distribution of profits and losses associated with holding an asset or a portfolio of assets over a period of time.

The rest of this work will be based on an in-depth analysis of the situation through an in-depth reading of the literature and on interviews with those involved in the analysis of this new type of risk and the systems that are being put in place.

We will also analyze endogenous factors such as credit needs, growth analysis, changes in temperatures, etc., but also exogenous factors such as transition risks which will make it possible to measure uncertain financial impacts of a positive or negative nature. on the capital structure and which are the result of regulatory and economic policies. This transition risk is introduced with a factor ranging from 0 to 1, with the optimal number being a transition to a carbon emission level requiring near-zero emission, and 0 being a stability of the current trajectory. We will thus see, according to the recommendations of future COPs, the changes in regulations and their impacts on the evolution of climate risk.

The introduction of climate risk becomes complex to model in order to better situate VaR on this given horizon, and consequently the famous prudential risk linked to climate change, and consequently the mobilization of capital for banks to cover this risk, which affects bank profitability and which by impact is passed on to consumers across society. The presence of the cost of banking is found in almost all transactions that take place every day in the economy.

It is therefore necessary to resort to data sciences to complete the panoply of tools available to banks to assess this risk and to be able to predict the next situations in order to better insure their cover or simply to withdraw from certain financing because they will be too risky and uninsurable. Data science can play an important role in assessing this risk as closely as possible for borrower profiles, whether business or private, in order to better adapt the credit supply to climate risk.

From an economic intelligence perspective, we will highlight how the inclusion of data on climate change contributes to the inclusion of this new type of risk in actuarial analyzes and in the insurance business and will lead to the emergence of new professions or functions corresponding to the offer of new services or services to users, whether they are individuals, companies or organizations.

This work will show the interest of tools from Datasciences such as Deeplearning, which by integrating a multitude of endogenous and exogenous factors can allow the implementation of an important decision-making tool, adapted to each profile. borrower and will thus allow financial institutions to reduce the role of climate risk in prudential rules.

Service innovation in Platform Firms from the perspective of economic theories

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Abstract

Platform firms (PFs) facilitate a connection between producers and consumers, which is nothing new in social and economic relations. But in today's information revolution, innovation means the accumulation of producer and consumer data. Processing data allows PFs to obtain new values from information patterns on two or more sides of the market including, where applicable, from their own market products.

The aim is to explain the PFs from the standpoint of different economic theories, such as the institutionalization of competition, the theory of innovation evolution, the neoclassical theory and the information theory. The PF's salient features are two or multi-sided markets, the concentration of value, the impact from the information network position as well as the degree of its maturity.

A description is formulated of different interventions from state and civil society organizations, or mixed arrangements, which vary with growth and therefore with the diffusion phases of the PFs' innovations.

Some lines of a research agenda of economic theories are proposed to develop either the PFs' potentialities and mitigate the negative impacts of their economic concentration resulting from the winner-take-all (WTA) approach, based on the growing number of sources of value extraction, the variety of the applications and the exclusivity agreements. A discussion on how to regulate the protection of private information is also proposed.

Key words: Platform firms, oligopoly, information networks, private information, economic theories.

Background and problem statement

Platform Firms, PF, are business models which are part of the information revolution. From this point of view, they are interconnecting groups of users that generate value. Following are some definitions of PFs.

"Markets with platforms can be broadly defined as markets where the interaction between

at least some participants is facilitated and managed by an intermediary. Managing this

interaction can take many forms; the most obvious ways are setting prices for participation

or usage or setting participation levels." (Belleflamme & Peitz, 2018).

More specifically relating to the internet, "Online platform refers to an undertaking operating in two- or multi-sided markets, which uses the Internet to enable interactions between two or more distinct but interdependent groups of users so as to generate value for at least one of the groups" (European Commission, 2015).

Or, looking at it from a broader perspective, digital platforms "are characterized by providing the infrastructure to intermediate between different user groups, by displaying monopoly tendencies driven by network effects, by employing cross-subsidization to draw in different user groups, and by having a designed core architecture that governs the interaction possibilities" (Srnicek , 2016, p. 27).

There are dominant online platforms that have integrated across business lines such that “they both operate a platform and market their own goods and services on it. This structure places PFs in direct competition with some of the businesses that depend on them, creating a conflict of interest that platforms can exploit to further entrench their dominance, thwart competition, and stifle innovation” (Hahn , 2019).

When antitrust procedures target these structures, they fail to detect the problem. “Neglecting structural remedies results in both substantive harms and institutional misalignments—effects that are especially pronounced in digital platform markets” (Hahn , 2019), and problems when selecting the **relevant market,** which is prone to being monopolized.

“In this manner, selling more to one group influences demand by the other group. Often, the way platforms attract suitable participation is by offering discounts to the harder-to attract group at the expense of the more ready-and-willing group”. (Ward , 2017).

"A firm can raise prices above the competitive level without losing so many sales that the price increase would be unprofitable" (Ward , 2017).

“We recommend that further consideration of the need for regulation of online platforms should start by attempting to more precisely define the most **pressing harms to businesses and consumers**, and then consider the extent to which these concerns are common to all online platforms, sector-specific, or specific to individual firms.” (House of Lords, UK Parliament, 2016).

In light of these wide-ranging impacts, both positive and negative, on the economy and society, concerns about **regulation** are raised quite often by governments and other organizations. But how to respond is still unclear.

However, “regulators are confronted with the fact that with the rapid pace of change and innovation on the Internet, regulatory initiatives are often rendered irrelevant almost as soon as they are proposed” (Claffy & Clark, 2014). This could be linked to the fact that the Multi-sided Platforms, MSPs, are themselves "private regulators", because they have to define access to interactions around the platform, applying “combinations of legal, technological, informational and other instruments (including price-setting) to implement desired outcomes” (Boudreau & Hagiu, 2008).

Given this uncertain environment, a working hypothesis is proposed with an eye on economic theories. From that starting point, we can discover what possibilities there are to help explain PFs, or at least to reveal the limitations inherent in this new type of company (Table 1) and come up with some ideas that would merit further development.

Examples of the different purposes of Platforms Firms

Table 1. Type of Platform Firms (Source: European Commission, 2015.)

Type of Online Platform	Example
General search engines	Google, Bing, Baidu
Specialized search tools	Google shopping, Kelkoo, Twenga, Google Local, TripAdvisor, Yelp
Location-based business directories or maps	Google or Bing maps
News aggregators	Google News
Online market places	Amazon, eBay, Allegro, Booking.com
Audio-visual and music platforms	Deezer, Spotify, Netflix, Canalplay, Apple TV, Disney+
Video sharing platforms	YouTube
Payment Systems	Paypal, Apple Pay
Social networks	Facebook, LinkedIn, Twitter, Instagram
App stores	Apple App Store, Google Play
Collaborative economy platforms	Airbnb, Uber, Taskrabbit, BlaBlaCar

Objectives

The first objective is to highlight the possibilities and limitations of understanding the Platform Firms' business model on the basis of theoretical capabilities developed by different economic theories.

The second is to propose some critical theoretical issues that need to be resolved in order to achieve a better grasp of the PFs' characteristics and economic impacts.

Methodology

An assessment is conducted of the main economic theories and approaches based on 1) the historical relationship between economic theories and technological revolutions; and 2) a general appraisal of their objectives, methodology and ideology. The theories being considered are classical, Marxist, neoclassical, evolutionary and institutionalist. The approaches are structuralist, dependency, economic cycles and organization (as business models).

Looking at the period when economic theories were developed, the context in which production takes place could clarify their main content. A historical-logical organization of the work components in the productive process, and how they tie in with the technological revolutions underway, would help to relate them to the period in which the specific economic thinking was developed.

Those approaches and theories can be grouped along ideological lines or by the manner in which the technological object is highlighted and their methodology.

Consequently, contrasting the economic aspects of emergent PFs with the theories - objectives, methodology and ideology – can shed some light on the possibilities and limitations of explaining those aspects[9]. This exploratory study is a point of departure and offers some findings that could be helpful in further discussions.

Results

1. As mentioned above, the economic theories can be grouped by ideology, the way in which the technological object is focused on and by their methodology (Table 2).

1.1 Ideology is present in economic theories in an implicit or explicit way. The first ideological group consists of theories relating to the socioeconomic problems of well-being, such as classical theory, Marxism and structuralism, and the dependency theory to solve underdevelopment, with different definitions and analysis, ranging from the search for causes of change, overcoming the system, or alternatives to the current socioeconomic structure.

The second ideological group comprises those that replicate the functioning of capital and productive efficiency, mainly the neoclassical theory and the organizational approach. Similarly, the cyclical approach can be brought into play when elaborate countercyclical policies are established.

[9] "It is not possible to know whether standard economic models apply to multi-sided platforms without explicitly considering the existence of multiple customer groups with interdependent demand [as the] the applied antitrust economics literature does not apply directly to multi-sided platforms" (Evans & Schmalensee, 2013).

The evolutionist and institutionalist theories are situated between the two, since they examine both the demands of well-being and policies to emulate practices for innovation and competitiveness.

1.2 Looking at how to approach technology, i.e. the technological object, some theories focus on the relationship between inputs and outputs of production: neoclassical theory, structuralist theory, organizational theory and to a certain extent the classical theory in its analysis of machinery as a cause-effect phenomenon.

Others focus primarily on the working process. In this group are found the Marxist, evolutionary and classical theories under the principle of the division of labor. Organization theory deals with the management processes. In the case of Platform Firms, data are processed by algorithms. "Big data are perfectly excludable; indeed, they are excluded from the very individuals (the users of the platforms) from whom the data are collected (usually without payment but often in return for 'free' services) and also from competitors and would-be competitors, suppliers to the platforms, government and the general public." (Hu , 2020, p. 25).

One aspect of the technological object is the diffusion of the product on the market, which is implied by the theory of long cycles (boom and bust), via the diffusion of new technologies. The dependency theory, which contrasts diffusion in the center versus the periphery, and structuralism, which relates to the technology gap, could provide "the opportunities for learning and the higher the potential technological spillovers from which the periphery may benefit.. if the periphery builds up the required absorptive capabilities—which includes indigenous R&D, education and training, policies for encouraging more technology-intensive industries, and support to public and private institutions engaged in innovation and diffusion of technology" (Porcile, 2021). This is compatible with the very centrality of the diffusion of products and processes found in the evolutionary theory. The neo-institutionalist theory can also be considered here, since it implicitly touches on diffusion with the concept of negotiation costs when referring to the rules that regulate transactions on the market. Marxist theory uses the concept of product realization on the market that is part of the circulation of capital.

1.3 From the point of view of method, theories are classified into two large groups. On the one hand are those that perceive science and technology as an endogenous process, that is, explained within the same theory: classical Marxism based on dialectical materialism, structuralist theory, technological management and evolutionary theory. The neo-institutional theory could also be included, since it raises a question about the origin of institutions, their development and performance, and those linked to the same technology, which implies an internal explanation of the same theory. The peak of a cycle is explained by the maturity-saturation of economic gains of a certain technological paradigm, while the trough is a result of political and institutional changes required for the diffusion of new disruptive technologies.

On the other hand are those theories in which technology is exogenous, mainly the neoclassical theory, as an external factor, and the dependency theory that considers that technology is transferred to the periphery from the central countries. Such a gap is in part overcome by structuralist policies as mentioned above: R&D and learning capabilities.

2. A focus on the technological revolutions in progress would be worthwhile and concerning them to the period of specific economic thought relating to work. This is done by historically observing the changes in the components of the productive process in question.

2.1 Classical economic theories arose at the beginning of the industrial revolution (1776-1847) when manufacturing was organized around artisanal production processes. Therefore, it was a transformation from a land-based economy to an industrial one, when the centrality of the division of labor was conceptualized, which led to increased commercialization and the substitution of manual labor by machines. Labor productivity was driven by the invention of the machine tool, which involved moving tools from craftsmen to machines. This change in quality triggered a technological trajectory, which combined tools and increased speed and greater precision when machines were in control.

2.2 Dialectical materialism, or Marxism, coincided with the first stage's full industrialization (see 2.1), demonstrating that work was the source of value and was exploited by capital. Innovation is a necessary result in order to obtain relative surplus value by lowering the value of the means of subsistence and extraordinary profit by securing a temporary monopoly on innovations. The second stage, from 1848 to 1939, featured the incorporation of energy to drive machinery, the basis of mass production. Energy allowed an industrial relocation of natural sources (water and rivers) through the transmission of electrical energy; and, secondly, the steam engine revolutionized transportation – railways and shipping - facilitating an increase in trade and later, the automobile with the internal combustion engine was introduced.

2.3 The neoclassical economic theory emerged in 1900. It proposed the productivity of both labor and capital, without differentiating between them in production, with a distribution of profit according to their marginal productivities. Although the neoclassical theory does not include welfare topics *per se*, the pioneer welfare economics authors used neoclassical concepts to build some thoughts relating to welfare. For example, Pigou and Coase used the marginal cost in both private and social spheres, to explain why externalities can have such a negative or positive impact on social welfare. Pareto's optimal equilibria is on the same track.

However, Keynesianism asserts there is a need for state participation to solve the multiple "market failures" caused by the distribution of income, and the need to provide communications, energy and R&D infrastructures.

2.5 The neo-institutionalist theory is rooted in the neoclassical theory that recognizes that there are also costs arising from negotiations or transaction costs, mainly in big assets (firm's ownerships) and those related to knowledge as technology and intellectual property. There is a cost of negotiation between users and others in the organization, which is in charge of the rules that are often set by the State.

Hence, these aspects can be incorporated in all other theories, taking account of their own ideas. Because information runs like a river through negotiations, transaction costs are especially low with PFs.

2.6 The evolutionary theory proposes to explain, via technology and innovation and their diffusion, the range of changes in the economy, absorbing the economic impacts of computing, starting with the chip in 1972. Therefore, the evolutionary theory focuses on the scientific-technological revolution, RCT (from 1968), which includes the introduction of the productive component of information as a new factor of production and science is more linked to production. Therefore, machinery is transformed into digitally controlled machines and energy is converted into energy systems through information and communication technologies, ICTs, optimizing the interrelation of sources of energy and its distribution. The automation of work impacts the worker, who is transformed from simply being part of it to supervising and controlling it.

In parallel, the chemical industry started down a path of increasingly direct application of scientific knowledge to technologies. This affected all the work components, in particular the very object of work, the product, which is transformed by chemistry and the broader and deeper knowledge of materials[10].

With the advent of RCT a new kind of craftsman appeared, a scientist who controls the process of work around knowledge. Alongside these two events, a contradictory evolution occurred: the decreasing participation and marginalization of work and the revival of productive and creative capacity in the scientific worker. Then a new phase began, in which all the components of the work process were transformed, of which the PF business model was a part.

[10] The creation of research and development (R&D) in chemical laboratories dates to the 1941 to 1965 period in Germany.

Table2: Economic theories: Ideology, Object and Methodology

Aspect	Theory& approaches / Item	classical	Marxist	neoclassical	evolutionary	institutionalist	structuralist	dependency	economic cycles	organization (business models)
Ideology	Welfare	x	X				x	x		
	Efficiency			x	X				x	X
Object	input-output	x		x			x			
	working process	x	X		X	x				X
	Diffusion		X		X	x	x	x	x	X
Metho-dology	exogenous static			x			x	x		X
	endogenous dynamic	x	x		X	x			x	

Source: the author

3. Some economic problems are not covered, or only partially so, by economic theories such as the information revolution, services and the related general traits of the Platform Firms, PFs. Therefore, some proposals are presented below to extend or modify some concepts, firstly those related to the services and information revolution and, secondly, to highlight PFs (see Table 3).

3.1 Classic theories. It is quite obvious that classical theories did not address those recent economic problems, however some concepts could be broadened to understand them. Ricardo's focus on machinery could be expanded to ask the question: What is the machinery of informatics? The computer, and in a broader sense, the information systems that encompass, of course, a new set of tools built by hardware and software. Therefore, the classic point of technological unemployment is located in both industrial and service workers. In addition, the valorization process requires a reconceptualization in light of the service economy. Therefore, the classic technological unemployment issue is, nowadays, affecting industrial as well as service employees. Also, the valorization process needs a reconceptualization given the state of the service economy.

3.2 Marxist economic theory now has the challenge of incorporating information as an essential production input. Therefore, a service generates value as well as surplus value. As in the case of goods, services can be productive, or part of capital or unproductive, or part of luxury consumption. Users or consumers, more often in services than in goods, can be part of this valorization process in the digital chain. Consequently, services could push up capital gains in different ways (countertendencies).

3.3 Neoclassic Theory. Since most countries are becoming service economies - that is, more than half of employment comes from services - information is increasing its share as a factor of production, but it is missing from the theory in two aspects 1) the range of economic impacts, and 2) its very nature that it is not a rival good, rather, it accumulates and develops through the exchange between multiple users and consumers. So, until now, there are some models that include knowledge in the production function, but it is not enough, since in addition the new business models are not yet endogenized by theory.

Platform Firms (PF) As mentioned before, a platform firm is a service provider of online intermediation, in social and economic relations comprising online search, e-commerce, social networks and cloud computing services, between different agents for the exchange of goods, services or information over the Internet (Nielsen , Basalisco, & Thelle, 2013). All exchanges involve information and data processing.

Accordingly, there is more value creation thanks to a massive reduction in transaction costs, but at the same time there is huge value concentrated in the multi-sided PF, which controls the distribution of the valorization process between producers, consumers and other agents.

Therefore, a PF implies a distribution of resources (classic theory) and risks. The PF's networking allows it to generate surplus value even though the capital and workers are located outside the PF, i.e. the supply and demand agents. (Marxist theory).

Capacity, based on intensive innovation, allows the PF to profit from the "network effect" optimized by the application of algorithms that process its object to transform: the flux of data. The network effects tend to create oligopolies, at the same time that the PF's marginal costs tend to fall to zero. The optimal resource configuration is to maximize the external linkages and minimize the internal costs (neoclassic theory).

This economic environment results in the concentration of PFs. Of the world's 100 biggest PFs, the US has 68 and China 27, and in a distant third place, Europe has 3, so it is a critical international concentration issue. The 15 largest PFs account for 75% of the world market (Ács, Szerb, Song, Komlósi, & Lafuente, 2020).

The PFs' disrupted technology in different areas creates barriers and also the possibility of entrant gateways (Evolution theory). PFs bring about a drastic fall in transaction costs for producers and consumers, which in parallel causes a high concentration in market value either in the sectors or regions (institutional theory) (Corona-Treviño, 2018).

The situation is contrary to the PF's regulation to foster innovation and to limit economic concentration and protect individual data[11].

Conclusions

One of the difficulties in understanding contemporary platform companies lies in the fact that economic theories have lagged behind phenomena, especially in the wake of economic crises. Such is the case of the economic problems that have arisen in tandem with the informatics revolution in which PFs are embedded.

However, the characterization of PFs could focus on them first as a production unit system, or even better as an ecosystem, in which there are multiple participants linked and grouped by common interests in multiple-sided markets that are regulated by the PF.

Therefore, MPFs have a complex life cycle with multiple break-even points - that is, when they begin to generate positive returns - in one market that is interdependent from other markets. Encouraging the entry of new PFs would require a broad policy that would alter the landscape in sectors where they are highly concentrated (evolutionist*).

[11] The negative impacts emerging from the ways in which big data are being used are associated with, rather than caused solely by, big data, including massive collection of personal data by the giant platforms without the targets' authorization (Hu , 2020).

* This theory could be related with the referred subject.

In this framework, regulation would take the form of meta-regulation that would provide guidelines to those self-regulated PF ecosystems with the aim of mitigating certain negative social impacts and fostering further innovation based on disruptive technological advances.

The economic theories could devise a cross-development of their main concepts: division of labor (classical*) and the nature of the input data and the output service (neoclassic*). Furthermore, research is required to explain the reduction of transaction costs by PFs and to detect their sources (institutionalist*). This reduction in transaction costs or generating an external capital as in the collaborative economy, could be considered as countertendencies to increased gains (Marxist*).

Network effects must be studied as a complex and dynamic network (informatics*). By their very nature, data, information and knowledge are intangible and non-rivalrous. However, big data, collected, stored, used and systematically controlled by the PFs, are vital to preserving their competitive advantages and their expanding performance in both scale and scope.

Table 3 Economic Theories: Developments to cover new problems: Information, Services and PFs

THEORY	OBJECT	CONTEXT	NEW ECONOMIC PROBLEMS			Knowledge Society
			Diffusion of information technologies (1990-->)	Services	Firms	
Economics	**Technological**	**Origen& Development**	**informatics**	**Innovation**	**Platform Firm PF**	
Classic	Tools	Industrial Revolution First Phase (1776-1847)	computation techniques	Service worker numbers are greater than production workers and are increasing. Therefore, work valorization process needs to be redesigned.	The PF implies a re**distribution** of resources and risks.	Multifunctional workers
	Machinery		Computers and Information systems		Value concentration through the intermediation of multi-sided PFs. New social problem: the social distribution of welfare.	Knowledge: International Division of Labor, IDL
Marxist Dialectical-Materialism	Competition between firms impact positive technology diffusion	Industrial Revolution Second Phase (1848-1939)	Surplus value is generated by **Information**.	There are productive and unproductive innovation services for capital.	PFs are an intermediary that controls the distribution of value between producers, consumers and other agents.	Knowledge Co-operation: Knowledge value is multiplied by its wider applications.
	Science and technology and their relation with the **work process**		Service workers generate value	Service users are part of the valorization of capital in the digital chain. They often function as countertendencies	The PF networking allows it to generate surplus value as the capital and workers are the demand and supply agents.	Knowledge organization is collective and complex
Neoclasic – **Micro**	Technical Change	Diffusion of the Industrial Revolution (1900-)	Information costs	PF is an intermediation on multisided markets. The optimal resources configuration is to maximize the external linkages and minimize the internal costs.	**Network effect is optimized by the application of** algorithms.	Research and development and diffusion of the ICTs.

	Oligopoly	Black Box: input-output		Principal-agent approach on asymmetric information	Information is a factor which does not depreciate by using it. So the economic nature of the factors of production must be handled differently, instead of being equal to capital.	**The network effects tend to create** oligopolies**. PF marginal costs** tend to zero.	Endogenous model of knowledge and environment.
	Macro	Production function with endogenous technological change		Knowledge: Production Factor	Must countries are becoming dominated by the Service economy.	The concentration of PFs in US and China, and less in Europe is becoming an international issue.	Sharing mechanisms to reduce the concentration of knowledge in certain countries
Evolutionist		Technology Processes	After 1973 Crisis: Diffusion of Schumpeter Thinking	ICT's path dependency and routines	Awareness of the increased of the innovation service: KIBS	The disruptive technology in different areas creates barriers and also entrant gateways. PF's life cycle is complex with new equilibrium cost points.	To foster opportunity windows in the product and service cycles: Tacit and codify.
Institutionalist		Technology Transaction's Rules of law	R. Coase "The Nature of the Firm" (1937)	Information and transaction costs	Regulation uses services certifications	PFs drastic fall in transaction costs for producers and consumers results in a high concentration of market value.	Regulations on the knowledge flux to boost technology diffusion
		Organizations for R&D	XXI Century	Diffusion of information technologies from 1990	Participation of the users-consumers in innovations.	Contradictory PF regulation between fostering innovation and protecting individual data.	Entrepreneurship knowledge culture to applied science and technology

Source: the author
Note: Color cells are characteristics included in the theories. White cells are proposals for theory development related to contemporary problems

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ScooP: Concept for a nationwide multi-operator platform for e-scooters

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Introduction

E-scooters are a growing Mobility as a Service (MaaS)-concept and an important addition to urban mobility. Many of the daily routes could be driven e-scooters (Gruber & Wiederwald, 2019). According to the literature review by Şengül and Hamid (2021), "E-micromobility has the capability to be used for all trips which are less than 8 km, consisting of 50 to 60 percent of total trips in China, the European Union, and the United States" (p. 17) and most commonly e-scooters are used for commuting or fun/leisure. A study of the DLR shows that e-scooters in Germany are mainly used in the evening and at weekends, as well as a leisure activity. Nevertheless, according to the authors, there is a substitution potential for car trips. (Gebhardt et al., 2021). Under the right conditions, e-scooters have the potential to contribute positively to the mobility revolution.

Since June 2019, e-scooters are also allowed to participate in German road traffic and providers of e-scooter rental services are allowed to set up their vehicles (Elektrokleinstfahrzeuge-Verordnung - eKFV, 2019/6). Since then, e-scooters have become an integral part of many German cities. Simultaneously, the number of negative headlines in German media is growing and, with it, the need for a regulated market. A recent newspaper article summarises this as follows: "It is not uncommon for the e-scooters to be parked or discarded in the middle of the pavement after use, becoming dangerous trip hazards or obstacles, or they end up somewhere in the bushes and flower beds. Even worse: more and more often, e-scooters are discarded in waters." (Euler, 2021) E-scooters standing in the way are a dangerous obstacle, especially for people with visual impairments (Schwär & Orosz, 2020). The number of accidents involving e-scooters is increasing. Experts of the German Road Safety Council (Deutscher Verkehrssicherheitsrat, DVR) and the inspection company DEKRA demand additional rules for e-scooters to ensure driving safety. For example, providers should reduce the speed of the e-scooters during the first three rides of a user. This is to ensure that novice drivers can get used to the e-scooters. The experts also recommend automatic speed reduction in bad weather or at night (dpa, 2020). Due to the rapid market ramp-up, it was impossible to adapt the urban infrastructure to the new mobility offer. In addition, it was overwhelming for cities and municipalities to define regulations such as contracts, interfaces for data exchange, and rules for use. On the other hand, e-scooter providers are confronted with new legal, personnel, and technical requirements in every city. The establishment of uniform conditions would be a simplification on both cities and providers. Furthermore, it is important to develop concepts that enable the safe and satisfying use of e-scooters. However, in order to advance micromobility, a number of challenges need to be addressed and the cooperation between cities and sharing providers needs to be strengthened. Previous experience in the field of mobile parking has shown that a multi-operator platform can improve the cooperation between cities and different operators (in this case of electronic payment systems providers). The smart parking platform defines itself as a "service-oriented advisor and partner to municipalities when it comes to introducing, setting up and maintaining the new payment system" (von Beust & Coll. Beratungsgesellschaft mbH & Co. KG). All relevant operators of mobile parking services are active on the platform and agreed to fulfil some basic requirements, e.g., data protection. Following this example, we have initiated ScooP – a joint research project between Von Beust & Coll. Beratungsgesellschaft, the TraffGo Road GmbH and the Fraunhofer Institute for Industrial Engineering. The research project is partly funded by the Federal Ministry of Transport and Digital Infrastructure (BMVI) as part of the mFUND initiative. The aim of the research project is to conceptualize a service platform that will regulate administrative, legal, and (data-)technical standards for the cooperation between cities and municipalities with e-scooter sharing providers.

Purpose of Research

Sustainable integration of micromobility into urban transport concepts can only succeed in cooperation. According to recent reports, an intensified political and public discussion regarding the handling of e-scooters can be observed. A report published in the FAZ in September 2021, says: "The cities are declaring a fight on them - but the providers have shown themselves unimpressed so far.". Even though e-scooters have been allowed on the roads in Germany since 2019 and in the USA since 2017, they are still a rather new mobility option. This results in many unanswered questions and the public discussion is not based on scientific evidence (Gebhardt et al., 2021).

This leads us to the assumption that it is important to create a basis for the orderly cooperation between cities and providers and to improve scientific evidence in this field. The aim of our research project is to strengthen the cooperation between cities and providers, considering the interests of all stakeholders.

In this paper, we answer the following research questions:

1. How do city or municipality representatives perceive the cooperation between them and e-scooter sharing service providers?
2. What challenges do municipality and city representatives see in regard to e-scooters?
3. Is there a need for an independent entity to support the cooperation between cities and e-scooter providers?
4. What requirements do cities and e-scooter providers have for such a multi-operator platform as an independent entity?
5. How could a multi-operator platform be designed?

Methodology

In the period from March to May 2021, qualitative interviews with municipal representatives were conducted as part of the ScooP project. In preparation for the interviews, an analysis of the state of the art was conducted, which focused on the current state of research as well as on a search for documented examples of municipal practice in dealing with the introduction of e-scooters. Subsequently, a semi-structured interview guide was designed, and we started to contact potential interview partners. The interview partners received the interview guide in advance to be prepared for the interview. The interviews were conducted digitally via MS Teams. The guide served as an orientation for the interview but there was an option to include further interesting questions and descriptions of examples from municipal practice.

In total, municipal representatives from 15 German cities were interviewed. The duration of each interview was approximately 45 minutes. Subsequently, the interviews were transcribed and analysed in a structured manner. Regarding the size of the cities interviewed, representatives from large cities with more than 1.5 million inhabitants were interviewed as well as representatives from medium-sized cities with about 50,000 inhabitants. In three of the cities surveyed, there were no e-scooters at the time of the interview. The interview guide focused on the current situation regarding e-scooters, legal, (data) technical, and organizational requirements for a multi-operator platform, and the contribution of e-scooters to current or future mobility concepts.

Results

State of cooperation between cities and providers from the perspective of the cities

Communication between providers and cities

In the interviews with municipal representatives, it became clear that most of the communication with providers works well to very well. In most cases, the cities have a central contact person from each provider. Only one municipality stated that communication difficulties arose due to a constant change of contact persons. Overall, the relationship was described as cooperative.

Communication between providers and users

Opinions differed on how to deal with complaints from the public. I The assessments of how to deal with complaints from the population make it clear that the providers respond promptly to the information from the population. However, it was also frequently mentioned that citizens cannot reach anyone on the hotline numbers offered and spend long periods on hold. It sometimes happens that citizens address their complaints directly to the contact persons in the municipalities, who, however, are not responsible for this.

Commitment agreements

The majority of municipalities have initially regulated their cooperation with providers through so-called voluntary agreements. These define organizational and technical regulations. In the interviews, it was often pointed out that the agreements were created basing on the template of other cities and minor city-specific adjustments were made. For most cities, the agreements are publicly available for viewing on the websites of the municipalities. The majority of interviewed municipalities reported that the e-scooter providers accept the rules.

In addition to the interviews, we analysed the current legal basis. With the "Elektrokleinstfahrzeugeverordnung" (eKFV) from June 2019, the prerequisites were created for e-micromobility-vehicles to enable their participation in German road traffic. This applies to smaller vehicles with electric drive that have a steering or grab bar, such as e-scooters and Segways (Elektrokleinstfahrzeuge-Verordnung - eKFV, 2019/6). Primarily, this regulates technical requirements such as maximum speed, power limits, and minimum road safety requirements. Each vehicle requires a general operating permit or individual operating permit as well as a valid insurance plate. However, the eKFV does not constitute a regulatory framework for the deployment of e-scooter fleets by e-scooter sharing providers So far, there is no nationwide standardised regulation for the deployment of e-scooters in German cities and all efforts to establish them have been unsuccessful. For example, a request of the state of Berlin to modify the German Road Traffic Act was rejected in the spring of 2020 when it was voted on the issue in the Bundesrat (upper house of the German parliament). The amendment should include that parking of e-micromobility vehicles and bicycles requires a permit if done for commercial purposes (Weimer, 2020). Instead, each municipality currently sets its regulations, which vary slightly depending on the interpretation of the respective road law of the federal state. In principle, depending on the city, either semi-binding contracts or rather non-binding declarations of intent are made with the e-scooter providers or they require a so called "Sondernutzungerlaubnis" (special-use permit).

It is legally controversial whether the commercial installation of e-scooters is a special use that requires a permit or whether it is public use that does not require a permit (Wissenschaftlicher Dienst des Bundestages, 2020). There are different assessments of this by the administrative courts (OVG) of the federal states. Recently, the OVG Münster decided that the station-independent placement of sharing bikes in public traffic areas constitutes a special use and not a public use (*Mietfahrräder dürfen in Düsseldorf nicht im öffentlichen Straßenraum abgestellt werden.,* 20.11.2020). In response to this, municipalities in NRW and other federal states are increasingly granting "Sondernutzungserlaubnis" instead of agreeing voluntary agreements. Comparing different agreements, they always address similar issues, e.g. road safety, parking of e-scooters, redistribution and maintenance of e-scooters as well as data exchange (Stadt Heilbronn; Stadt Stuttgart, 2020).

Nevertheless, the providers find a heterogeneous landscape of regulations, resulting in difficulties to access the complete market.

Administrative and legal challenges

Municipality and city representatives reported various challenges related to e-scooter sharing services. The most frequently mentioned challenges are the parking behaviour of the users and the compliance of no-parking zones. The GPS inaccuracy of the e-scooters was also commonly mentioned in this context. This inaccuracy often leads to difficulties in complying with no-parking zones or specially designated parking areas. The parking of e-scooters in contravention of the rules is equally problematic. E-Scooters are a source of danger for other road users, especially when they are parked at bus stops, in the middle of sidewalks, or bike paths (Figure 1).

Figure 1: Parked e-scooter is blocking bike path. (© Fraunhofer IAO, Janika Kutz)

The lack of sanctioning options is also a difficulty in dealing with misbehaviour of the users. In most cases, cities do not yet have the possibility to intervene effectively.

Another challenge frequently mentioned by the municipal representatives is the data exchange and data management between them and e-scooter providers. Often, the cities receive simple descriptive PDF reports from providers which are not suitable for further analysis. At the same time, there is often a lack of resources within the cities to organise data exchange via a „Mobility Data Specification (MDS)“ interface. Small to medium-sized municipalities often do not have the necessary data and personnel capacities.

Further, the transfer of information on temporary no-driving and no-parking zones for e-scooters is also described by the interviewees as time-consuming because they have to contact each provider individually. Also, some interviewees said that there is no possibility to check whether the temporary no-driving or no-parking zones are marked in the user app in time.

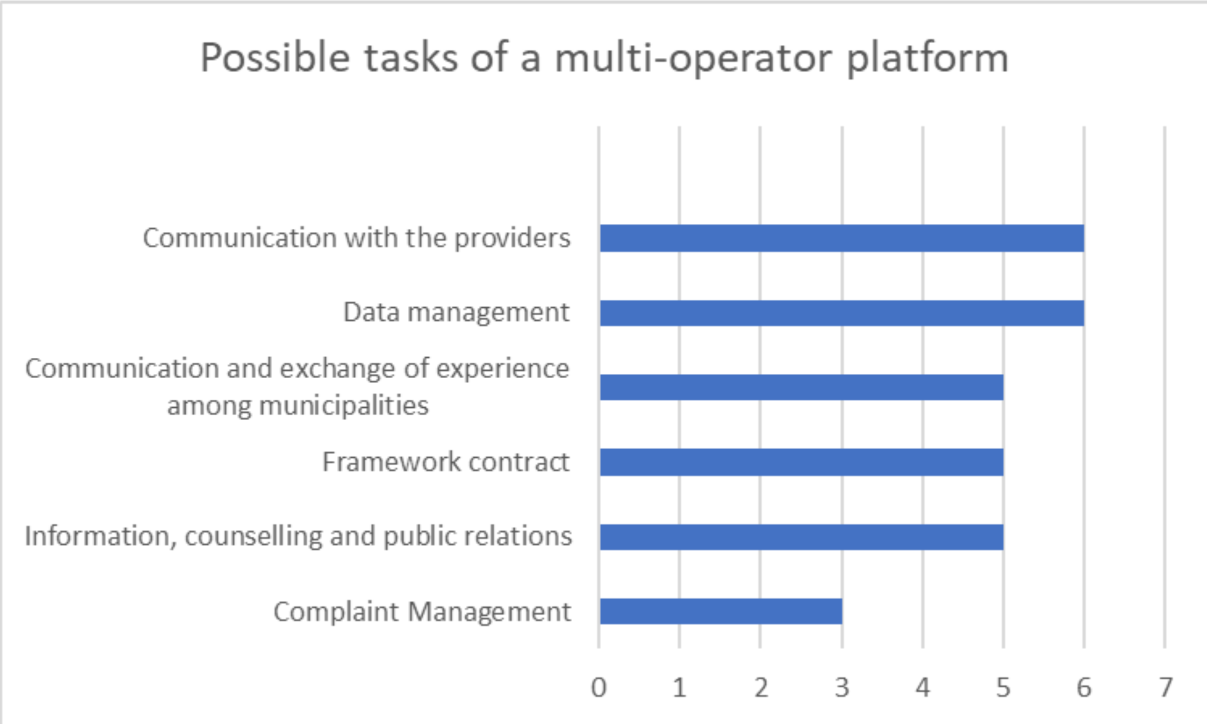
In addition, some cities described that there is currently no active exchange of experiences between cities. One of the reasons for that is different applicable national laws. However, due to different laws of the federal states, this would only make limited sense.

Respondents of two medium-sized cities that do not currently offer e-scooters pointed out that lack of space is a major challenge. They do not have parking space available, which makes the launch of e-scooter sharing services more difficult.

Is there a need for regulatory and operational support?

As a result of the challenges described above, most interviewees expressed a desire for support. This applies both, the legal level, and the organisational level, but also when it comes to dealing with data. Figure 2 shows the areas in which municipalities most often wish support from a neutral entity.

Figure 2: Possible tasks of a multi-operator platform



A big advantage of the platform would be a controlled communication with the providers as well as with other municipalities. The workload could be reduced due to a regulated exchange of experiences and information about the latest developments on the topic of e-scooters. This could also lead to more uniform regulations in the field of micromobility in future. Furthermore, the interviewees mentioned that the platform should also support cities while introducing e-scooter services. A standardized contract (framework contract) available via the platform would be helpful for many cities as well. Especially, if it were a contract that regulates the exchange of data between providers and cities. In particular, central data management is perceived as very helpful. This could include the bidirectional data exchange, support in analysis and evaluation of data as well as data security. Our research and the results of the interviews clearly lead us to the assumption that there is a need for regulatory and operational support.

A multi-operator platform as a solution for the challenges?

As a solution for the different challenges, we develop a concept of an independent platform where cities and providers can exchange their data. The multi-operator platform addresses the needs of both the deployment and operational phase of e-scooter sharing in cities. In the deployment phase, the lack of legal regulations leads to a patchwork of documents and procedures when e-scooters are introduced in new cities or municipalities. The providers need to deal with new regulatory documents for each new location. As the first service, the platform will provide a highly standardized contract or declaration of intent (depending on local requirements) for the operation of e-scooter fleets. This contract will be developed in collaboration with both cities and operators so that it can be quickly accepted as a valid standard by all relevant partners.

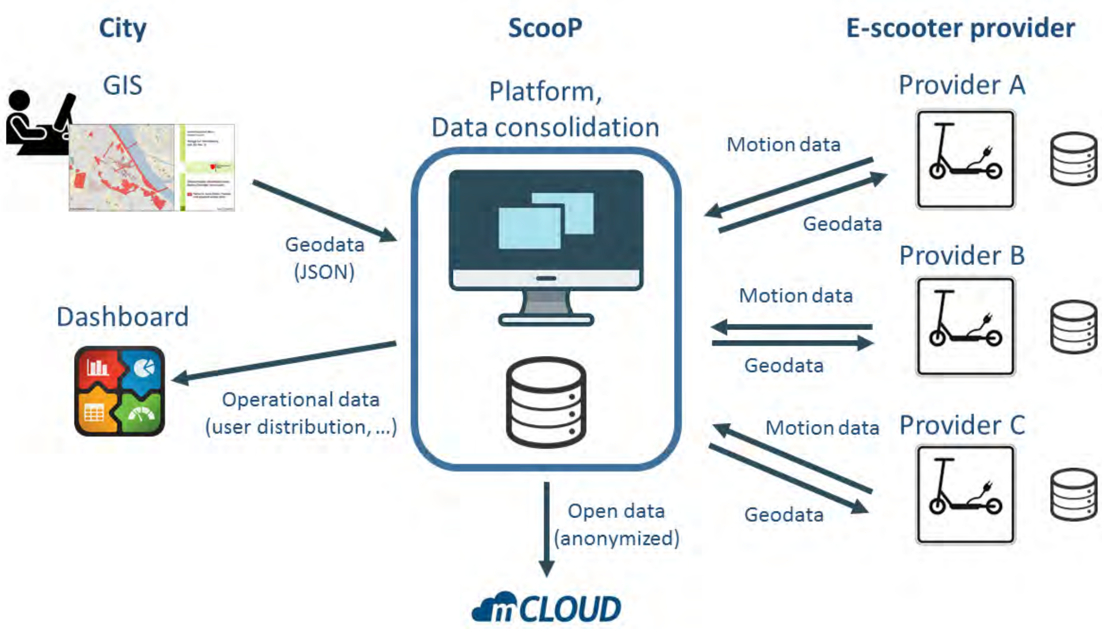
On the part of the cities, in addition to the contractual regulations, the processing of geodata is of great importance. These are created for example with a GIS system and are to be shared with operators in the platform in an automated manner (to the day). The geodata are currently collected by municipalities with varying degrees of digitization and then processed by operators and enriched with their own information. Mainly, these are the geodata on e-scooters and data on business areas, hubs, parking areas, no-parking zones, reduced speed areas, no-driving zones, etc.

Basically, geodata of the zones are polygons describing the respective zones. If necessary, time restrictions and other metadata are also supplied. Also, the cities must adapt the boundaries of the zones from time to time, or they must implement temporary restrictions, for example for demonstrations or construction sites.

GeoJSON is a suitable format for such information, as it is a relatively parsimonious data format for exchange. The data can be easily exchanged through web interfaces. Therefore, the project will define a unified geospatial data model that will be used to exchange the data. This enables the cities to act even more flexibly on changes in geodata.

To provide an initial insight into the system architecture, Figure 3 shows the data flows (simplified) between the main stakeholders, i.e. cities, e-scooter providers, and the multi-operator platform (ScooP).

Figure 3: System architecture and data flow of the multi-operator platform (simplified)



In addition to the generation of geodata, the processing of operational data on a macroscopic level is important for monitoring the providers. For example, it must be recorded how many e-scooters each provider operates in the city. Statements about the use of e-scooters, e.g., trip lengths and durations are also important. Such motion data are collected on the part of e-scooter providers and evaluated internally. Accumulated motion data is usually delivered back to the cities or municipalities in monthly reports via e-mail. However, the frequency of data recording and transition is not uniformly regulated. The precision of the GPS transmitters is also unclear.

The newly developed data exchange standard MDS (Open Mobility Foundation, 2021) is designed specifically for the needs of the shared mobility economy like e-scooters, bikes, and car sharing. We aim to use this standard in the development of the platform. We plan to make consolidated data stocks available to third parties via the mCLOUD (BMVI, 2021) - a research platform for open data in the field of mobility and related topics, operated by the BMVI.

The aggregated statistical data are not particularly comprehensive and are usually delivered via e-mail. API interfaces for daily retrieval are currently not provided. Project aimsto agree on standardized data content with the operators, which will provide machine-readable data via API interfaces that can be evaluated across operators on the part of the municipalities. It is to be examined whether, in addition to aggregated data, data on individual trips with route progress can also be available. This data would be much more comprehensive and allow corresponding evaluations.

Another service the platform could provide is a ticketing system for complaints. Currently, complaints are communicated between cities and providers by e-mail or phone. A standardized ticketing system would make the tracking of user complaints easier. Also, it would be possible to extract statistical information on user complaints and fixing the problems.

Discussion and further need for research

After evaluating the various interviews and discussions, the exchange between providers and municipalities proved to be partly difficult. On the one hand, there is an industry that has only been active in Germany for two years and is characterised by a high degree of predatory competition due to a continuously growing number of providers. They would like to see appropriate framework conditions, in some cases even regulations that, however, should not have the tone of a ban. On the other side there are municipalities that have the ambition to achieve a mobility change, but for them it is difficult to create the necessary infrastructure (e.g. parking spaces, construction of cycle lanes) and framework conditions at the same pace as micromobility. After various discussions with municipalities and providers, as a neutral partner, we try to establish the exchange between all stakeholders on a meta-level via the concept of a multi-operator platform. Our aim is to support providers and municipalities in gaining a better understanding of the respective situation of the partner. To support cooperation, the multi-operator platform also creates contractual, organisational, and technical standards that consider the needs and requirements of both, municipalities and providers. The basis for this is a uniform framework contract that can be individualised for each municipality. In addition, contractual regulations regarding data exchange are also considered.

Unfortunately, it has not yet been possible to get in touch with all e-scooter sharing providers. In general, they were rather cautious about exchanging information. Nevertheless, we have now been able to intensify our exchange with a few providers. Now, it is possible to take their needs into account for the further conception of the platform concept. A joint workshop with municipalities, providers and users will be held to validate and evaluate the platform concept. In addition to the cities and providers, e-scooter users are a key factor for the success of the offer. To get a better understanding of the user requirements, surveys will be carried out, evaluated, and compared to the previous findings in the further course of the project.

It also became clear that it is important to inform municipalities about the potentials of targeted use of mobility data. As this offers e.g., the possibility of unleashing potential to what extent e-scooters can usefully supplement and expand the existing mobility offers - especially in public transport. It must also be ensured that providers make their data accessible. The platform can act as a link between cities and e-scooter providers. Its task is to receive, consolidate and, if necessary, convert data. It is also the task of the project to evaluate and optimize the methodology of data processing (preparation, anonymization, etc.). The platform will therefore offer standardised interfaces for data and geodata. At a later stage of development, the platform could also provide tools for evaluation. If the platform is launched successfully, it will be quite conceivable to expand the offer for other sharing services in the field of micromobility such as e-bikes and cargo bikes.

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Evaluation of job performance as an instrument to measure gender equity in access to public employment in Colombia and Data Analytics

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The purpose of evaluating job performance in the Colombian State is to assess the contributions of the public servant selected by merit contest in the fulfillment of the entities' objectives, through work commitments previously agreed upon with the evaluator.

The Labor Performance Evaluation is defined as "An objective and permanent management tool, aimed at assessing the individual contributions and the behavior of the evaluated person, measuring the positive or negative impact on the achievement of institutional goals", and is regulated by Law 909 of 2004, Decree Law 760 of 2005, Decree 1083 of 2015 and Agreement 617 of 2018 of the CNSC.

The National Civil Service Commission -CNSC-, as a Colombian public entity, responsible for the administration and monitoring of the careers of public servants, with the exception of those with a special character of constitutional origin, designed the system and application of evaluation of the job performance called EDL-APP.

The fact of systematizing the Labor Performance Evaluation (EDL) process has facilitated the flow of information between the CNSC and the entities that it administers and monitors, and the use of the EDL-APP tool has encouraged the active participation of the actors of the process.

- Identified benefits of using the EDL APP tool, such as:
- The capture, storage and processing of data.
- The simplification and streamlining of procedures.
- The generation of valuable information.
- It facilitates the management of the CNSC in the face of the EDL process in all the entities that adopted the standard system.

In this way, the implementation of the EDL application has not only facilitated the issuance, access and treatment of information in all State entities, but has also allowed the development of the process in a more agile, efficient and environmentally responsible way.

The characterization of the information registered in the EDL-APP application is based on a data analytics exercise, which allows us to understand the behavior of the information registered by the different actors that participate in the evaluation process (more than 160,000 users registered in the system, between heads of staff, evaluators and evaluated). Analytics, through the systematic use of data or statistics, allows the interpretation and communication of significant patterns in the data, which allows making assertive decisions in the management of human talent and giving value to the data.

The psychometric analysis is based on the analysis of the textual contents derived from the agreements registered in the EDL-APP application, which is shown from the functional commitments and the behavioral competencies agreed in the system, which allows defining groupings of these commitments from the textual content through common elements.

For the analysis, a tokenization is carried out, which consists of a "process of substituting an element of sensitive data with a non-sensitive equivalent, called a token". In it, text vectors are presented to operate mathematically on the set of textual content, in order to find proximity through artificial intelligence algorithms.

Tokenization is carried out through the itoken function of the tex2vec package that operates in R, therefore, the factorial analysis of the main words and actions, understood as vectors, leads to obtaining the main content axes and explanation of the variability of the set of functional commitments.

With the foregoing, a segmentation of the work commitments of public servants is established, based on the functional commitments and on the behaviors associated with the behavioral competencies agreed in the Work Performance Evaluation, which allows generating correspondence analysis of the textual content to identify the main axes of these, the explanatory contents of the public servant's commitments, as well as an association map related to the commitments, hierarchical levels, types of entities, names and grades of jobs.

For the processing of the commitments as text strings, we started from the database generated in the EDL-APP, which was refined excluding the repeated and test records. Consequently, the database for the psychometric analysis contains 4,691,666 records that groups the agreement of commitments of the administrative career servers and in the probationary period evaluated in the annual periods 2019-2020 and 2020-2021.

The EDL-APP, in addition to having the purpose of registering the qualifications obtained by the people chosen under the merit contest system, allows obtaining information on age ranges, gender and the predominant hierarchical level to which the selected people enter through the meritocracy.

According to said statistical report, and with the report presented by the CNSC's Administrative Career Directorate, generated in 2021, it was identified that, for the care, professional and advisory levels, the majority of people who enter on merit to public jobs in Colombia, they are women, which shows that the merit contest system contributes to the eradication of neighborhoods and nepotism, as well as eliminating gender barriers to access to public employment.

EDL-APP as a source to analyze data that generates value

The data era has arrived to revolutionize the world and understand its usefulness as a source of information and generation of value propositions to organizations, allowing them to make decisions that lead to improve processes for the benefit of customers, users, employees, and in general of the so-called stakeholders.

In accordance with the above, the CNSC, in order to give value to the data recorded in the EDL-APP, and through the Power BI tool, generated a data structure, focused on its analysis.

In this sense, when the Power BI tool consumes the source called EDL-APP, the data reported in said APP is stored in a database (PostgreSQL) and from it, when connecting to the Power BI tool, it starts the extraction, transformation and loading (ETL) process by storing the information in a Datawarehouse.

Subsequently, the stored data is converted into information that is classified, ordered and quantified, this allows the components of the performance evaluation to be measurable, in order to identify gender and age, both of the servers who enter the administrative career for overcoming their probationary period, as well as for those who already have rights and remain in their employment, obtaining at least a satisfactory qualification in their performance.

The data converted into information allowed the CNSC to obtain as a more relevant result, the fact that, by merit, women have greater access to career jobs than men, as shown below:

LEVEL OF EMPLOYMENT	WOMEN	MEN
ASSISTANT	29.321	26.394
PROFESSIONAL	22.477	16.974
ADVISOR	349	323

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Return on Investment - Digital Value Creation in German SMEs

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Abstract

Digitization is key for staying competitive. Using data analytics requires financial resources to create value. As these resources are more limited in small and medium sized enterprises (SMEs) and analytics use cases and best practices are not well known, the purpose of this qualitative study is to investigate how SME managers are adding value and achieving a measurable return on investment (ROI) by using big data and data analytics. The measurement of economic value, the ROI associated with the use of data analytics technologies by SMEs is presented and discussed to construct a model designed for analysing the monetary benefit of data analytics adaption by SMEs. The study reviews a range of literature and models relating to data analytics impacts in SMEs and further focuses on in-depth qualitative research on digital transformation in German SMEs to explore the usage of data analytics and measurements of the added value and return. By inductively performing a multiple-case study at German SMEs, the researcher provides evidence to determine the usefulness of data analytics in SMEs. 15 participants of executive-level SME leaders who had the authority to approve the implementation of analytics technologies in their organization have been interviewed in individual semi-structured interviews to gain an understanding of their experiences. The study provides a rich overview of added values, benefits, and ways how SME can make use of a variety of ROI opportunities when implementing data analytics. Five driving values are revealed: increased revenue, improved customer and employee satisfaction, efficiency, and productivity. In addition, the case studies prove 13 significant positive ROI in numerous use cases where data analytics solutions are implemented to improve revenue or to cut costs. The weighted ROI average in this study is 15,3. Thus, most of the investments are highly worthwhile with a fifteen-times return of investment.

Keywords: Digitization, Data Analytics, SME, Added Value, ROI

Introduction

With a rapidly growing trend in today's businesses, innovative digital approaches influence organizations in all industries extremely. Digitization and data analytics is a megatrend in its early days, jeopardizing existing business models and promising extensive opportunities simultaneously (Bleicher & Stanley, 2016). The digital transformation of industries forces companies to rethink their business models due to its disruptive impact. This change has a rigorous effect on company's performance and economic growth as supply chain processes can be enhanced through the use of digital technologies such as data analytics (Iddris, 2018; Loebbecke & Picot, 2015; Tarutė & Gatautis, 2014). In order to make effective decisions, firms need to understand the significance, the benefits and return of digital innovations such as big data and analytics solutions (Bleicher & Stanley, 2016; Chen, Chiang, & Storey, 2012).

SMEs have been recognized as the bedrock and a dynamic driving force for various economies, playing an essential role for the development of a country. It is often emphasized that SMEs are responsible for most of the innovation, employment and growth in national economies such as Germany (Bouwman, Nikou, Molina-Castillo, & Reuver, 2018; Higón, 2012; Matthews, 2007). They provide a fruitful research basis as they represent over 99% of all companies located in Europe (Lopez-Nicolas & Soto-Acosta, 2010). Today, SMEs are not fully exploiting the potential of digital technologies as they miss resources such as personnel capacity, skills and funding (Bouwman, Nikou, & Reuver, 2019; Goerzig & Bauernhansl, 2018; Li, Su, Zhang, & Mao, 2018). Esselaar, Stork, Ndiwalana, and Deen-Swarray (2007) argue that the prime constraint to adopt digital innovations remains too high investments and usage costs. Especially when companies are very small and entrepreneurs work in a non-digital field, they often do not see a reason to digitize and implement solutions such as data analytics. SMEs do not want to deal with these as they need their time to focus on their core business.

In a nutshell, SMEs are still struggling and missing guidance on realizing additional value and benefits by digitizing their business (Barann, B., Hermann, A., Cordes, A.K., Friedrich, C., Becker, J., 2019).

Especially due to their lack of financial resources, support, know-how and strategy mindset in terms of digitization, an assessment of a possible digital ROI is relevant for SMEs to verify whether a digital technology such as data analytics is increasing company performance or not. This could guide SME managers towards digitization and lead to an overall higher acceptance of digital solutions. (Bouwman et al., 2019; Cenamor, Parida, & Wincent, 2019; Nguyen, 2009).

Given this interest, the aim of this multiple case study is: (i) to investigate how SMEs are adding value and creating a return by using data analytics technologies, (ii) to identify the drivers of a company's successful digitization strategy, (iii) to suggest a measurement model of economic value SMEs can achieve and to determine the return of investment (ROI) associated with the usage of analytics by SMEs, and (iv) to analyse research gaps and directions for potential further research. The body of the paper is structured as follows. First, the existing literature and theoretical understanding of big data, data analytics and value creation are presented and discussed. The following section provides a description of this study's methodology and data collection approach. The findings of six illustrative cases are presented, discussed, and synthesized next. Finally, the contributions are highlighted and several reasoned managerial guidelines and potential avenues for future research are presented. A conclusion completes the paper.

Theoretical Background

Digitization and Data Analytics

As Schumpeter stated, innovation is the key to value creation, generating growth in companies and the economy (Schumpeter, 1942). In recent decades, innovations tended to coincide with digital transformations. Using new technologies such as data analytics and implementing digital transformations have led to broader development benefits with significant effects (Galindo-Martín, Castaño-Martínez, & Méndez-Picazo, 2019; Loebbecke & Picot, 2015). Analysing the literature, digitization originally describes the conversion of analogue to digital information and processes in a technical manner (Negroponte, Harrington, McKay, & Christian, 1997). Digitization is further known as the implementation of digital technologies offering technical elements such as hardware or software (Cenamor et al., 2019) to improve or disrupt business models, processes as well as products and services (Denner, Püschel, & Röglinger, 2018).

Big Data and data analytics are typically characterized by a "focus on very large, unstructured, and fast-moving data" (Davenport, 2014, p. 10). Big data is defined as extremely large data sets in volume, velocity, variety and veracity (Chen et al., 2012) and can be obtained from diverse sources such as CRM systems, social media, web logs, competitors' websites, household hierarchies, government sites, e-commerce sites, click stream, customer reviews, and other open sources (Chen et al., 2012; Fan, Lau, & Zhao, 2015). Data Analytics can be seen as an evolution of earlier concepts and terms such as "online analytical processing", "decision support" and "business intelligence" (Davenport, 2014; Rouibah & Ould-Ali, 2002). This study includes the concept of big data analytics to analyse and interpret any type of digital information. The technical and analytical advances in data analytics that largely define the feature set of today's digital products and services are critical to the development for SMEs and entrepreneurs (Loebbecke & Picot, 2015).

Through the effortless access to a large pool of information and sophisticated data analytics, SMEs may, for instance, analyse the interdependency of online and buying behaviour of users to customize and tailor advertisements and thus increase overall demand. To give an example, comparing their inventory stock data and weather data, Walmart discovered that their customers frequently bought Pop Tarts in addition to flashlight and battery purchases, when a hurricane approached. This insight allowed them to adjust their stocks accordingly in advance of a hurricane and thereby better serve for their customers' demands. Thus, incremental enhancements to SMEs business models through increased digitization and big data analytics is opening up new opportunities, values and unlocking new economic potential (Loebbecke & Picot, 2015).

Value Creation and Measuring the ROI

Any potential investment initiative needs to be able to answer a valid question stated by the investor: "What is the value returned by the respective investment?". Thus, carrying out an investment is mainly based on the investors' expectations regarding the returned value (Lin, Huang, & Zeelenberg, 2006). Investments in digital technologies and analytics solutions to perform a digital transformation in SMEs make no exception to this rule, as the business performance strongly depends on the ability to measure the own business efficiency (McIntosh, Culley, Mileham, & Owen, 2001). As mentioned before, the adoption of data analytics in SMEs leads to important benefits and added values, but without a set of measurements, there is no proof that the digital technologies were well chosen and efficiently implemented in the SME's value chain.

However, evidence of the ROI of digital investments has been far from conclusive (Dehning & Richardson, 2002; Melville, Kraemer, & Gurbaxani, 2004). In literature, the impact of digital investments on the organisation as whole has frequently been measured using variables such as market share, market performance, productivity growth and cost reduction (Bharadwaj, 2000; Das, Yaylacicegi, & Menon, 2010; Liang, You, & Liu, 2010). Nevertheless, a precise measuring standard of the digital ROI, especially for SMEs, is immature. This lack of a measurement leads to the impossibility of proofing that the investment resulted in a profit or loss (Mangiuc, 2009). McCann and Barlow (2015) also point out that calculating this ROI can be a complicated task but any company which fails to do so will jeopardize its ability to demonstrate the full rewards of its technology usage.

Thus, even if the need to measure the results of digital solutions is widely accepted, the evaluation and measurement method is still subject to debate as it has been traditionally challenging. The difficulty to financially quantify the added value to the SME by a certain technology such as data analytics is a major drawback. A simple measurement model could demonstrate that the received benefits by the adopted technologies can be assessed in monetary values. Such a model could become a solid starting point for the analysis and measurement of a digital ROI. A possible pathway could be to design and build a model respectively an applicable set of metrics for the evaluation of the costs and benefits of the technology adoption (Mangiuc, 2009). The traditional equation used to compute and measure ROI as a percentage is:

$$ROI = \frac{(investment\ gain - investment\ cost)}{investment\ cost}$$

Synoptically, when measuring the return of an investment, some benefits are more easily measured than others (McIntosh et al., 2001). As mentioned before, those benefits that are easy to quantify and define are called *hard benefits* (Blanchard, 2011; Crawford & Pollack, 2004; McCann & Barlow, 2015), *financial or tangible benefits* (Blanchard, 2011; McCann & Barlow, 2015) as well as *monetary benefits* (Tarutė & Gatautis, 2014). However, not all values and benefits are measurable directly. In literature, these are considered *strategic benefits* (Tarutė & Gatautis, 2014), *non-financial* or rather *intangible* (Blanchard, 2011; McCann & Barlow, 2015) as well as called *soft benefits* (Crawford & Pollack, 2004).

Research Methodology

Case Study Design

The researcher intends to investigate the return of a data analytics within SMEs. Main objectives are to understand special use cases and tools for SMEs to identify value creation and added benefits as well as their costs. The outcome of the case study will answer the precise research question: How can small and medium sized enterprises benefit of using data analytics and create a positive return on invest? To analyse this topic and calculate a digital ROI, the case study will answer several sub questions such as: How does analytics can improve internal processes to increase efficiency and lower operating expenses? How do data solutions support to satisfy customer needs and improve customer experience? How does data analytics lead to a positive ROI?

As this topic is novel and represents a relatively current notion in scholarship, this paper employs an exploratory research design through a multiple case study. Case studies are recommended in exploratory research as they are "revelatory" for research, provide rich data and allow the investigation of contemporary managerial challenges (Yin, 2018). They are suitable to examine a broad and complex topic, when theory is rare (little is known) and the context is significant (Dul & Hak, 2007; Eisenhardt, 1989). According to (Yin, 2018), case studies are suitable when a "how" or "why" research question is asked about a contemporary set of events over which the researcher has no or little control. Moreover, qualitative case studies are increasingly used for building new theory based on data analysis (Beverland & Lindgreen, 2010; Saunders, Lewis, & Thornhill, 2019). This approach is preferred as the researcher not only observes but is deeply involved in the actions within the investigation area (Eisenhardt, 1989; Yin, 2018).

Case Selection

Following the SME definition of the German Institute for SME research (IfM Bonn, 2020), two criteria were applied in the database search: staff headcount below 500 employees and annual turnover below 50 million euro. The empirical data stems from six SMEs based in Germany that implemented and use analytics technology which have shown solid evidence of strong growth and innovation. The relatively high number of companies in the sample lowered the sample bias, in the sense that it reduced the risk that included companies were more technologically savvy than those that did not participate in the study. In turn, this allowed the analysis of a wide and representative group of SMEs headquartered in Germany. Table 1 lists the research sites compared to number of employees and annual revenue. It also provides a brief description of their digital transformation under study to give rich familiarity with each case and accelerate cross-case comparison (Eisenhardt, 1989).

Table 1: Anonymous Overview of Participating SMEs

Firm	City	Industry	Products	Size (in 2019)	Brief descriptions of SME's digital transformation under study
N1	Cologne	Manufacturing	file destruction and shredding, scanning and archiving of sensitive data	75 employees, 9 million p.a.	Founded in 1985, N1 started offering data protection-compliant destruction of files and sensitive information carriers with a nationwide presence in Germany. In 2011, the family-owned company changed it's brand and paper-heavy business model that worked for decades. Driven by the digitization and decrease amount of paper, the market and technology leader had to add further digital services such as document scanning, archiving of data and digitally signage of contracts. Today, the award-winning company digitizes 60 million documents in a year making 20% of the total revenue with it.
N2	Gelsenkirchen	Manufacturing	industrial packaging for the transport of goods	70 employees, 8,5 million p.a.	N2 was founded in 1947. The family owned business is producing safe and stable industrial packaging units for the dispatch of large-volume goods on an area of 15.000 sm. Being a reliable partner in Europe for the automotive, glass and steel industry, N2 has decades of experiences in producing wood packing systems. However, it started the digital transformation with employing a CDO in 2016. The B2B company wants to become a 90% digital business in the future and stop using paper in the office and production line.
N3	Darmstadt	Manufacturing	high-performance lithium ion battery systems	284 employees, 47 million p.a.	N3 started out of a university research group in 2008. Going public in 2018 at the Frankfurter stock exchange, N3 is gaining ongoing market share due to its specialisation of large lithium-ion-based operating systems for vehicles. Being one of the most innovative companies in Germany, the leading manufacturer is a pioneer in digitizing its value chain. This year, N3 expanded in the US building an identically constructed production plant via AR instructions due to entry restrictions for specialist during the COVID-19 lockdown.
N4	Cologne	Retail	table, living and decoration products	490 employees, 50 million p.a.	N4 was founded in April 1999 . When it started to enter the digital sector with an online shop in 2007, revenues increased by 7% yoy. In 2015, the company slid into the red due to loss-making business, but turned the business from insolvency to a digital and marketing driven company. Today, N4 is being celebrated as digital pioneer and asked as consultant in the retail industry. Well known as brand and second largest furnishing chain in Germany, it increased its revenue by 20% during the Covid-19 lockdown only due to its online business.
N5	Taucha	Retail	fashion wear and style counselling	280 employees, 39 million p.a.	Founded in 1832 and still family owned in the sixth generation, N5 is one of the largest fashion retailer and style consultancy in Central Germany. In 2012, the Saxon multi-label branch started with an online shop to firstly increase the customer rate in it's stores. Today, the award-winning company increases its online revenue by 30% yoy and also developed its on consultancy and logistic app. To consequently pursue its digital strategy and transform its stationary core business with 16 branches the company founded its own digital IT subsidiary.
N6	Düsseldorf	Retail	innovative mixed spices from all over the world	85 employees, 20 million p.a.	N6 started to disrupt and revolutionise the dominated spice industry by offering more than 150 innovative, global spice mixes. Founded in a student shared flat in 2012, it firstly sold its spice mixes in the B2B sector to restaurant owners and businesses. In 2014, N6 started a multi channel strategy, by selling via an online shop, retail chains and a strong online community. Today, N6 is the largest digital spice company in Europe, making 65% of revenue online. The data driven company is known by one in four.

First, the researcher visited more than fourteen SMEs that have initiated or have shown interest in implementing analytics technologies in their value chain. Based on these preliminary meetings, the researcher purposefully sampled six players that are especially relevant due to their development and utilization of big data geared towards growth and maybe also rewards as best practice example. None of the participating SMEs were competitors. Furthermore, these businesses have been chosen for illustrative purposes, meaning that the researcher wants to offer real-life cases that support the logic of the presented concepts (Kumar, Stern, & Anderson, 1993; Siggelkow, 2007). The initial screening of each company took approximately one day per SME.

Data Collection

The researcher draws the results primarily from in-depth interviews, along with support from online media, expert discussions, direct field observations, documentary evidence, archival records, and workshops (see Table 2). The use of different sources permits triangulation, allows for internal validity and underpins the research results (Jack & Raturi, 2006; Yin, 2018). Lasting between 40 and 135 mins (52 mins on average), the interviews (15 in total) were conducted between May and November of 2020 via telephone, were recorded on audio files and later transcribed in spreadsheets. Before the interview, the researcher familiarized with each case by studying the company's website and consulting online presentations, news articles and videos featuring the company in question. The interviewees have been the decision makers in their companies such as owners, senior manager (whoever is in charge), and CEOs with extensive expertise in the subject area and who had participated in the analytics adoption decisions within their business.

Issues discussed during an interview that needed additional clarity were followed up by the interviewers later. Data from 15 interviews was triangulated by examining company websites, visits of the SMEs (where possible due to the SARS-CoV-2 pandemic), industrial databases, press releases and press interviews. This allowed for a more in-depth perspective on the digital return of the analysed SMEs. In total, 13h of interviews were conducted, which were transcribed in more than 110.000 words. Table 2 shows an overview of interviews conducted, the delineation of the personal and organizational characteristics of the interviewees and other sources such as official websites, brochures, and presentations, published news articles, online videos, field observation and physical artifacts.

Table 2: Data Collection & Overview of Interviewees

Firm	Interviews	Interviewee Function	Other
N1	3	Head of Digital Sales, CEO, CDO	a, b, c
N2	2	CEO, CDO	a, b
N3	2	Head of IT, CDO	a, b, c
N4	3	Head of IT, CEO, CDO	a, b, c, d, e
N5	2	Head of IT, Head of Marketing	a, b, c, d
N6	3	Head of IT, Controlling & Online Marketing	a, b, c, e

Other: a) official website, brochures and presentations, b) published news articles
c) online videos, d) participant/field observation, e) physical artifacts

Data Analysis

After data collection, a within-case analysis was performed including a detailed description of all six cases to allow the researcher to familiarize with each case before beginning to identify common themes among the case (Eisenhardt, 1989). The researcher described the analytics adoption in all six SMEs in terms of the tools and approaches used, the adoption, the growth after the implementation as well as the costs and returns. These reports were then given to the respondents to ensure the accuracy and validity of the findings. Subsequently, a cross-case analysis was conducted using a pattern matching logic (Beverland & Lindgreen, 2010; Eisenhardt, 1989).

Based on the theoretical background, the Gioia method (2013) was used for iterative data analysis. This method is inductive in nature and allows to continuous and systematic combine empirical data and theories (Dubois & Gadde, 2002). Three data analysis steps were undertaken:

Step 1: This analysis is comparable to Strauss and Corbin (2003) notion of open coding (Gioia et al., 2013). First, the researcher repeatedly read the interview transcripts to capture the informants' senses and conducted in vivo coding and compiled the initial coding table afterwards. The coding was double-checked by another peer-researcher of his chair. All divergences were resolved through discussions until agreement was reached. Finally, a set of first-order concepts that represented informants' views of what was going on in each case setting (van Maanen, 1979) was derived.

Step 2: With a second order analysis, the researcher found theoretical interpretations for the first order concepts derived in Step 1. Step 2 is iterative in nature as it included repeated comparison and contrast to the first-order themes and comparing extant literature to themes from the derived concepts. As a result, the second-order themes became the notions the researcher used to “explain the patterning of the first-order data” (Van Maanen, 1979). As the second-order themes emerged, the researcher tried to aggregate and distil the second-order themes even further into aggregate dimensions. According to Gioia et al. (2013), this is when the research transited from being inductive to being abductive in that “data and existing theory are now considered in tandem” (p. 21). For the purpose of this research, the author was open to use concepts identified in previous research to summarize the second-order themes and aggregate dimensions, a practice also incorporated by Pan and Tan (2011). The data structure presented in Figure 1 highlights the first-order concepts, second-order themes and aggregate dimensions derived from both steps. The findings section includes more information on representative quotations for the first-order concepts and second-order themes.

Step 3: In the last step, the researcher builds a process model on the dynamic interrelationships between second order and aggregate dimensions to create a comprehensive storyline that can help to make sense of the digital return the researcher observed. Based on these findings, a pattern emerged of digitally created ROI for SMEs.

All in all, construct validity, which refers to choosing appropriate operational measures for the studied concepts, was ensured by data triangulation and by continuing non-stop chains of evidence on the methodical choices (Eisenhardt, 1989; Gibbert, Ruigrok, & Wicki, 2008). The researcher further ensured internal validity, namely the act of presenting causal relationships through explanation building and addressing rival explanations in the discussion section (Yin, 2018). External validity, which refers to the generalisability of research results, was established by analysing a substantial number of six cases. Reliability, namely the degree to which the exact method used in this paper leads further researchers to the same results, was ensured by thoroughly documenting the research process, including case study protocols and a case study database (Yin, 2018).

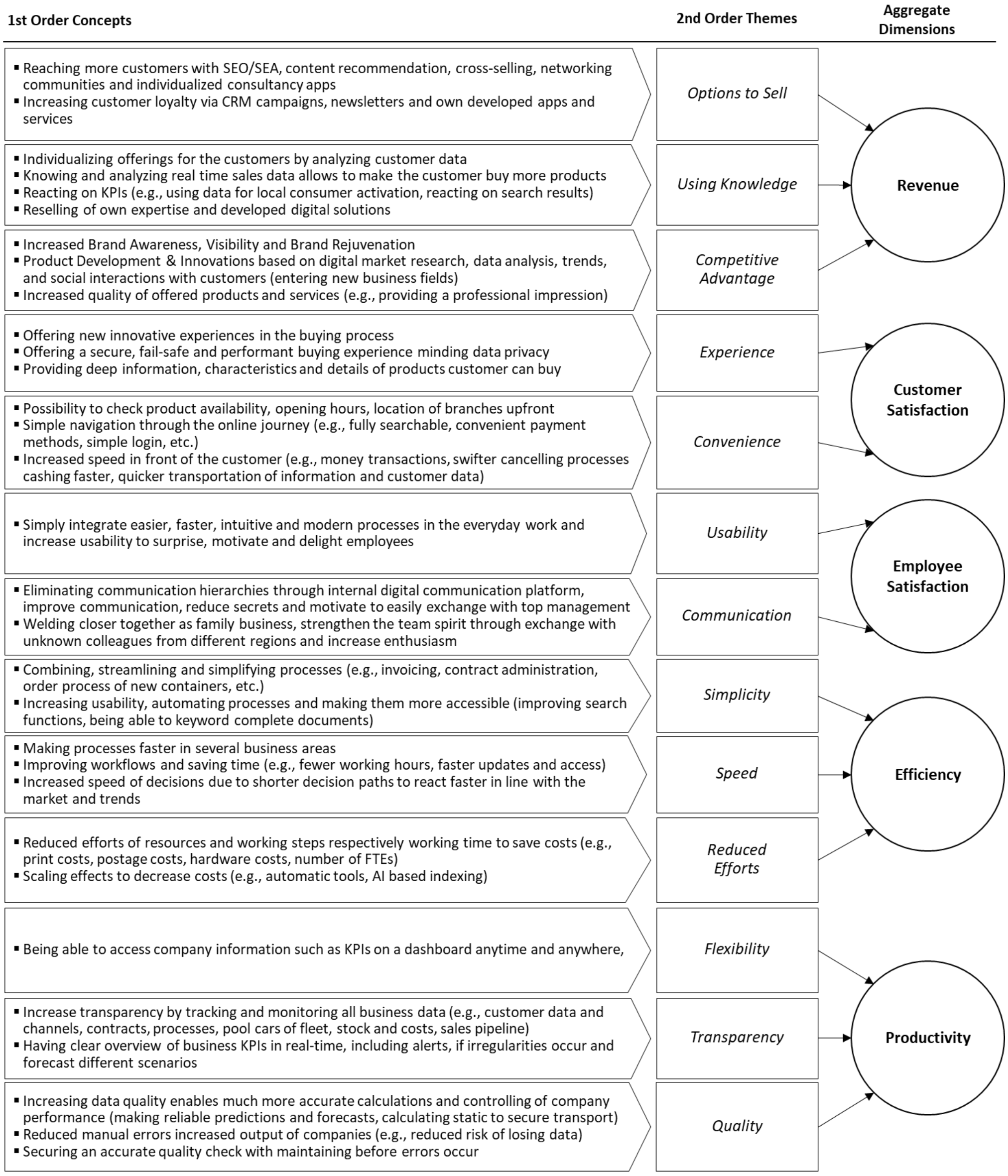
Findings

In this section, the authors describe the observed attained values and benefits that have helped the SME managers to generate their digital ROIs and increase company performance. The participating SME managers were aware of the significance of business enhancement through data analytics. They all used big data and analytics in different areas in their company and know the returning benefit and value added (see Figure 2). Whereas the primary overall goal of all participating SMEs was basically the same: reducing costs and increasing revenue, the SMEs application foci aimed for different sub-goals and activities to achieve these sub-goals, as it can be seen in Figure 2.

Digital Value Creation

An extensive analysis of the data collected resulted in the generation of key values and returns: Figure 1. The categorization of these provided a structure to examine the central research question. Overall, the added values and benefits found by this analysis are increasing revenue, customer and employee satisfaction, efficiency, and productivity. The findings are summarised in Figure 1.

Figure 1: Study results structured in line with Gioia et al. (2013)



Increasing Revenue

The analysis shows that for SMEs increasing revenue is one of the most important objectives in terms of using analytics. It provides the opportunity to increase *options to sell* SME products. The option to contact customers via newsletters in analyzed buying rhythms and even optimized delivery times of mailing to improve the opening rate increases sales, as faced by numerous SMEs. Additionally, SME managers mentioned reaching more customers with Search Engine Optimization and Advertising (SEO/SEA) e.g., *Google AdWords*, content recommendation and videos, social media posts to get in contact, following cross-selling and offering fixed appointment bookings for their stores. One SME explained that it even secured its revenue during the lockdown phase of COVID-19 using an analytics-based consultancy app and sending packages to customers to generate revenue despite shop closures. Commonly, the interviewees perceive that it is important to increase customer loyalty via CRM campaigns. To give an example, one of the SMEs increased customer retention with valuable feedback by implementing a *WhatsApp*-Community to get food trends and product requests out of the own community within 24 hours.

Moreover, several companies indicate to *use* their gained *knowledge* based on customer data to raise revenue. The findings stress that the SME managers individualize the online shop for customers by analyzing their data. Two of the SME managers emphasised that their system automatically filters products according to customers' needs and interests, as shown by the following citations: *"We use data to develop tailormade individual offerings and consult the customer in the best way." (N5), "We want to be able to address customers more directly on our website, to address them more individually. My impression is that people appreciate that. And the corresponding figures also indicate that they do. And that a vegan, for example, does not get advertising for barbecue or meat spices. That is simply taken for granted and should not happen in the future." (N6)*

Furthermore, knowing and analyzing real time sales data allows the SMEs to make the customer buy more products. The interviewees derive recommendations and predict forecasts on historical developments by analyzing buying rhythms, successful posts, and products as well as sales figures. This finally leads to the possibility to react on KPIs and making retaining offers. The CEO of N4 revealed that if something is wrong with the turnover, he can immediately react and lower the prices, while the SME manager of N6 goes one step further by stating: *"Statistically speaking, if a customer has not bought for 365 days, then 90 percent of them will not buy again. These are the things we have determined. So, in the end, after 340 days: Hey, we have an offer for you. Don't you want to buy something again?"*

Hence, using knowledge based on data analysis helps to improve revenue. It appears that the SME managers also use their data for local consumer activation or react to search results on their website. Finally, two SMEs point out that they even benefit from reselling their own expertise and developed digital solutions to other companies in their industry. The award-winning SME N4 is even requested as consultant as they have been recognized as a digital pioneer in their industry and even clearly grown their revenues during the Covid-19 lockdown phase.

Additionally, the analysis has shown that digital technologies such as analytics lead to an increased *competitive advantage* and therefore to more revenue. SMEs can benefit from a higher brand awareness, increased visibility, and brand rejuvenation. A N5 manager described the situation as follows: *"We have rejuvenated ourselves in the last three or four years. Thank goodness for that."* The CEO of N1 adds*: "We use data to remain competive or to open up new, completely new business areas".* Thus, another value in terms of competitiveness is the possibility of agile product development and innovation creation based on digital market research, data analysis, and social interactions with customers, as highlighted by several SMEs. The interviewees call attention to this opportunity, namely that new ranges of products, characteristics and product designs are developed based on taste profiles, personas, trends, and interactions with consumer. This data analysis supported by algorithms finally lead to interesting and promising new products and therefore a higher turnover. N6 for instance, launched an avocado topping mix after measuring an increment avocado post in social media and created an Oatmeal spice through social interaction with customers. Both mixes were sold out immediately after launching. Finally, numerous interviewees further share their experiences of what digitisation can achieve in terms of quality of offered products and services. This is reflected by N2, that achieved superior cut results due to a saw blade analytics software. Additionally, N1 improves service and product quality by scanning documents with OCR and indexing them with AI.

Increasing Customer Satisfaction

In addition to increasing the revenue, the companies also strived to satisfy their customers. More specifically, the analysis revealed two themes of increasing customer satisfaction with digital technologies: *experience* and *convenience*. It appears that many SMEs implemented a product information system to provide deep information, characteristics, and details of products during the buying process of certain goods and increased reliability of the product availability with automated ERP and stock tracking systems. Paired with a secure, failsafe and performant buying experience with respect to data privacy (e.g., staying anonymous in the buying cycle), SMEs therefore increase the customer experience. Today, even the digital tracking of store traffic during the pandemic is taking the fear of visiting the shop and thus increases the customer experience, as N5 highlighted.

Another aspect revealed through this analysis is the increased *convenience* for customers when entrepreneurs implement big data technologies. First, all retailing SMEs the researcher studied, provided the opportunity to check product availability. Second, all customers benefit from a simple navigation through the online journey, for instance a fully searchable portfolio and content, convenient and secure payment methods as well as a simple single-sign or partner log-in for buying products as easy as possible. Third, SMEs use analytics technologies to increase speed in front of the customer as swifter transportation of information and customer data is possible. Thus, faster money transactions, for example in the situation of cancelling articles, allow SME manager to offer convenient payments by simply transfer money back via interfaces. Moreover, quicker check out processes and reduced cash outages are applied.

Increasing Employee Satisfaction

The findings stress that employee satisfaction can also be significantly improved by using analytics in SMEs. An increasing *usability* of tools and processes derives as aspect that makes the job and work easier and more comfortable. During the interviews, all SME managers acknowledged that they increased the employee satisfaction and motivated them through easier, partly automated processes. By providing intelligent dashboards, modern and faster software as well as easy-to-use and intuitive tools for employees, the SME managers delight and consequently motivate their employees. An interviewee of N5 mentioned an increased usability in addressing customers by providing employees BI dashboards with customer data to address them accordingly. In N4, employees are operating the cash system nearly blindly as it simply works with an intuitive data software and touchpad. Even an automatic data key to open the pool car and checking in via an automatic fleet management was outlined by the CDO of N3.

Increased Efficiency

The analysis has also shown that data analytics tremendously drive the efficiency, and therefore performance of a company. Most of the participating SMEs were aware of the enhancement of business processes through big data technologies. It even appears that the SME managers often invested primarily for efficiency reasons. Here, three main drivers of an increase in efficiency revealed. First, *simplicity* increases as many processes become easier, automated, and streamlined. To some entrepreneurs, the goal was simply mapping systems together, reducing steps in processes, increasing usability as mentioned before and making processes more accessible. Here, respondents of N3 stated that they omitted essential steps in the invoicing process, for instance through automated invoice software. The system recognized invoices formats automatically and manually inserting becomes obsolete. Similarly, N5 simplified the order purchase process using BI dashboards to find documents *"with the push of a button"*.

Second, digitized processes facilitate a higher *speed* in every business area. This is reflected by all companies, which had successfully transformed processes to make them more modern, faster, and finally improved workflows to save working time: *"… with the analytics system, we can assure that you get your offer much faster" (N2) or "… [the automatic warehouse] definitely saves time." (N6).*

These citations show that SME managers become much faster and reduce time-consuming processes. They benefit from quicker processes in the purchasing department, in the automatic warehouse, direct transfers of stock information. Here, the system announces shortages in stock and helps to replenish stocks in branches just in time. Furthermore, the SME managers perceived an increase in their decision-making speed by comparing real-time KPIs based on BI dashboards. It appears that they can even take better decisions with available analytics.

Third, several interviewees point out the benefits of *reducing efforts* with analytics solutions which in turn leads to a higher efficiency. Commonly, the interviewees described lowered efforts in their value chain: N5 reduced working steps and meeting time to collect and present KPIs. This is automatically done by the BI tool, today. N4 benefit from an accounting tool, where invoices are automatically booked. Likewise, N5 reduced efforts with making calls and appointments by simply introducing an automatically appointments booking for guests. While a manager of N2 emphasized that they decreased the waste of cutting wood with a data optimization software for saws. In turn, this leads to a cost cutting of 15%.

Additionally, the possibility of scaling effects due to data analytics cannot be neglected when it comes to reducing costs. Here, N6 adverts with influencer marketing and profits of a scaling effect by implementing an automatic influencer tool. In the words of the manager at N6: *"The influencer at the end of the month can draw an evaluation himself. That means that it doesn't really matter to us now whether we work with 10 influencers or 500, because the effort is the same. What you can scale endlessly. And you don't necessarily need an employee for it anymore"* Similarly, N1 reduced efforts through implementing AI-based indexing to cluster and allocate information types when scanning documents. This was stressed by the CEO of N1: *"AI is getting better and better. […] [All documents] that come into our company are directly pre-sorted via AI."*

Increasing Productivity

Finally, the analysis shows that the usage of analytics also leads to an increase in productivity for SMEs. Again, three main foci can be revealed. First, several companies indicate that they are much more *flexible* through analytics solutions such as being able to work remotely and access all relevant company information on dashboards to check the performance or relevant KPIs (e.g., sales figures, stock levels, etc.) immediately helps the SMEs to work in a more productive way.

Second, the use of big data increases the overall *transparency* of the SMEs business operations. By tracking and monitoring customer data and channels, contracts, processes, sales pipelines, and costs in real-time, all SMEs increase their productivity as they can react immediately. For instance, N5 build its own data-hub to increase transparency of customer data (e.g., size, preference, buying cycle) and order processes to use this knowledge to make their customers product recommendations. Similarly, N2 has a clear overview of all orders that are currently being processed. Thus, colleagues can always take over directly if a salesperson drops out, having everything needed and do not have to familiarize with each case. This also leads to an increase of reliability. The same company also relies on a scanning system that relates to the ERP in the production to know the exact number of resources used. Hence, the system can control the parts lists and the manager gets real-time reports of the stock. In an equal way, N5 included an algorithm in their tracking system to alert if irregularities occur. Consequently, the management can forecast different scenarios and knows in detail when bestseller products must be reordered. The CEO of N5 revealed: *"In the dashboards we see all current bestseller figures with product images. Meanwhile we have a reorder rate of 30% during the season, because we can now tell a supplier exactly in which quota and at which time, we need bestseller articles."*

Third, and closely associated with the previous theme is an increasing *quality* as faced by numerous SMEs. Five interviewees mention that data quality enables much more accurately calculations and controlling of company performance. To give an example, N6 analyses the buying rhythms of customer and historical data to predict in high accuracy when customers will make their second or third purchase accordingly. Through this, the company can determine how many new customers can be generated at what point of the year with the amount of maximum effort with an increasing reliability. Additionally, the management permanently knows the acquisition costs of new customers as these costs fluctuate over the year.

Besides the increased data quality based on data analytics, the use of it also reduces human, manual errors and therefore consequently increases the output of the company, as mentioned by several SME managers. A respondent of N2 admitted that miscount amounts of resources they used in the production are reduced. N2 further uses a calculation software to automatically calculate the static of wooden boxes and packaging materials to secure transports and reduce risk that boxes break. Finally, quality can also be improved via optimization software in the production line to maintain plants before error occurs or accordingly coordinating certain gluing times and charge over processes as stated by the CDO of N3: *"I think it is mainly to make your processes as secure as possible. For example, that you have certain gluing times and then the changeover process follows and to coordinate this accordingly, there is a system that supports it digitally and also does predictive maintenance."*

Return on Investment

As mentioned in the beginning, any potential investment, especially in an analytics technology or solution, should bring a measurable return. The SME performance strongly depends on the ability to measure the own business efficiency, which has strong relevance especially for SMEs due to financial bottlenecks in many cases. The presented findings above demonstrate various benefits in all kind of business operations. However, as previously mentioned, direct measurable evidence is lacking and there is no KPI-based proof that the analytics tools were well chosen, efficiently implemented in the SME value chain and finally worthwhile.

When it comes to the digital ROI, the findings show that most of the interviewees are purely interested in benefiting but did not make the calculation before investing. To some entrepreneurs, the goal was initially simple: They needed a certain benefit in a specific case requesting a direct effect. The ROI was not calculated, neither evaluated if processes really improved. Some managers stated: *"We are simply too small, which I could say we have such a full cost view." (N1), "Well, we haven't even thought about the financial thing yet. The main thing is to get rid of mistakes." (N2), "I did not have time to draw up a ROI, I must say that in all honesty. We were actually driven by this deadline pressure and we had to create a solution" (N3)*

It appears that SMEs invest in data analytics for different reasons such as company growth, increase quality, deadlines, or lifestyle factors to feel innovative instead of evaluating if the solution is worthwhile. At least some managers became aware of this lack of knowledge in regards of the measurable return during the meetings and started to reflect that a ROI is important to analyse, which was conveyed through statements such as: *"It was interesting from my perspective to ask myself these questions. Sometimes you notice that it is helpful […] to ask yourself the question what we actually do." (N6)*

The analysis of the before mentioned values and benefits demonstrates that not all analytics technologies have a direct financial computable value. The ROI is specific to the individual solution. However, there are a lot of scenarios in each SME for which a concrete ROI is computable as concrete numbers for gains and costs are available. The analysis reveals that a financial measurement is mainly possible in the cases of 1) *increased, added or new revenue* and 2) *saved costs due to reduced working* time.

ROI based on increased revenue

As presented in the previous findings chapter, an increase in revenue can be regarded as gain of a certain solution. Ergo, a ROI is computable and attributable to a certain solution by comparing the revenue increase with the acquisition costs. An example can be found in N6. The SME switched from OOH campaigns to Google *AdWords* campaigns. Using this solution, the managers were able to track revenue and costs of each digital campaign for acquiring new customers. Spending 10 euros for each new customer in marketing budget makes the case profitable as the company generates 35 euros revenue with each increment average shopping basket of new customers. Thus, the ROI turned out to be 2,5.

A much higher ROI based on increased revenue was generated by N3 in using the analytics platform Xing Business Pro for 800 euros license fee a year. Here, the salespersons of N3 were able to contact three prospects a week and check the response rate. In 2019, the company achieved an order of 40.000 euros purely by a proposed Xing contact and benefited tremendously of this solution. The ROI is 49 (see Table 5).

Another valid example of a digital ROI based on increased revenue is enhanced through the new analytics system implemented in the value chain of N3. This system writes an invoice or revises an offer by one click and consequently increases the data quality rate. As the company sells 50.000 development hours a year, an increase in 10% in quality is equal to an increase of 10% billed hours that have been forgotten before the system was integrated. 5.000 hours that are sold more to an hourly rate of 80 euros, increased revenue by 400.000 euros a year. The company invests 2.000 euros a month for the ERP software, which results in a ROI of 15,67.

ROI based on reduced working time

In most of the cases, reduced working time due to the usage of analytics solutions is the gain of the digital investment. Thus, in this situation a ROI is simply measurable. SME managers measure the working steps and time needed in the analogue process and compare it with the period the intelligent process takes. For instance, N4 implemented a smart disposition system in all stores to evaluate the inventory and sales data fully automatically. Afterwards, it calculates store delivery of two and a half thousand items every night on its own. This saves two working days in each store as the staff does not do calculate deliveries manually. N4 invested 300.000 euros in the development of the software, paid 100.000 euros implementation costs and must afford 800 euros server costs per month. Despite this investment, the company profits of a 29-fold ROI. According to the CEO, the system has paid itself off after six months.

Likewise, N5 developed their own app based on a BI dashboard. This app supports the store managers in checking sales KPIs each Monday morning and therefore reduces working time of a minimum of four hours per week in the evaluation process. An investment of 160.000 euros was needed to develop the app. However, the company reduced personnel costs significantly as store managers costs 25 euros per hour and are required in 16 branches. This results in an overall ROI of 1,6.

Finally, another analytic solution used by N4 is the OCR scanning software *ePost Scan* to automatically scan, analyse, index, and forward the incoming mail via PDFs to employees. The manual distribution of daily mail took two hours per day, involved one employee, and costed consequently 2.000 euros salary a month. The digital process charges the company 400 euros a month, needs 5 minutes instead of two hours a day and results in a positive ROI of 4.

The following Table 3 shows further scenarios and lists an overview, where a concrete ROI is calculable in all six SMEs. The computed average digital ROI is 15,3. However, the median (M=15,17) should be taken into consideration to compare and evaluate the different ROIs as there are a few special cases with a very high and low ROI distorting the average value.

Table 3: ROI Computation

Case Sites	#	Digital Solution	Derivation	Computation of ROI for Digital Investment Projects*	ROI
N2	1	Optimization Software	**G:** reduced costs for wood due to saw optimization: 10.000€/y **C:** invest in saw optimization system: 3.000€	$x = \frac{(10.000€ + 5y - 3.000€)}{(3.000€)}$	15.67
	2	Smart ERP System	**G:** saving working time 900€/d = 225.000€/y **C:** ERP system 30.000€ implementation[1] & 5.000€ license fees/y	$x = \frac{(900€ * 250d * 5y) - (30.000€ + 5.000€)}{(30.000€ + 5.000€)}$	31.14
N3	3	Xing Pro Business	**G:** 40k € revenue through order via Xing account, **C:** 800€/y fee for licenses	$x = \frac{(40.000€ - 800€)}{(800€)}$	49.00
	4	Analytcics ERP	**G:** 10% not forgotten 0f 50.000h sold/y due to ERP = 5.000h sold more x 80 Euro/h = 400.000€, **C:** costs for ERP 2.000 €/month	$x = \frac{(400.000€ - 24.000€)}{(240.00€)}$	15.67
	5	Smart Invoicing	**G:** Personnel costs of 5.122€/m reduced by 50% = 2.561€ x 12 = 30.732€/y costs saved, **C:** SW costs 9.500€	$x = \frac{(30.732€ - 1.900€)}{(1.900€)}$	15.17
N4	6	ePost Scan	**G:** savings of 2h/d working time for scanning daily mail = 2000 €/m, **C:** ePost Scan costs 400 Euro/m	$x = \frac{(2.000€ - 400€)}{(400€)}$	4.00
	7	Disposition Tool	**G:** saving 2 days working time in each store = 16hx35€x100stores = 56.000€/w x4x12 = 2.688.000€, **C:** investment of 300.000€ software+ 100.000 Euro implementation costs + 800€ server costs/m	$x = \frac{(2.688.000€ * 5y) - (400.000€ + 12 * 800€)}{(400.000€ + 12 * 800€)}$	31.81
	8	Accounting Software	**G:** saving working time 2hx35€/d = 17.500€/y, **C:** costs for accounting tool 25.000€ implementation* + 80€ server costs/m	$x = \frac{(17.500€ * 5y) - (25.000€ + 12 * 80€)}{(25.000€ + 12 * 80€)}$	2.37
N5	9	BI Purchase Dashboard	**G:** reduced working hours for purchasing labels: 12h x 35€/w x 60 labels x 2 (twice a year) = 50.400€/y, **C:** implementation costs for the BI Dashboard: 20.000€*	$x = \frac{(50.400€ * 5y - 20.000€)}{(20.000€)}$	11.60
	10	ISTA-App	**G:** reduced working hours for KPI check of store managers: 4h x 25€/w x 16 stores = 83.200€/y, **C:** costs for ISTA-App: 160.000€ Implementation & Development*	$x = \frac{(83.200€ * 5y - 160.000€)}{(160.000€)}$	1.60
	11	BI Consultancy Dashboard	**G:** secured 10% of the revenue during Covid-19 lockdown: 325.000€ instead of 0€ revenue, **C:** costs for consultancy dashboard: 20.000€	$x = \frac{(325.000€ - 20.000€)}{(20.000€)}$	15.25
N6	12	ERP	**G:** increase in revenue due to avoided loss of bestseller during the weekend: 52x1000ordersx4€ each= 208.000€ revenue, **C:** costs for the ERP: 50.000€/y	$x = \frac{(4€ * 1000 * 52) - (50.0000€)}{(50.000€)}$	3.16
	13	SEA Analytics	**G:** revenue with the average shopping basket: 35€ **C:** acquiring costs: 10€/customer	$x = \frac{(35€ - 10€)}{(10€)}$	2.50
				Ø ROI	**15.30**
				Median	**15.17**

[1]Assumption: Lifetime of investments = 5 years (Bundesfinanzministerium 2020) For reasons of simplification, net present value calculations are not taken into account.
[2]Assumption of 250 working days a year
G = Gain, C = Cost, y = year, d = day, h = hour, w = week

Discussion

Two prime research questions were addressed in the present paper. The first one (RQ1) considers how retail and production SMEs digitize their business based on analytics to create digital benefits, while the second

(RQ2) regards the path how these benefits can be measured and lead to a positive return on investment. This section provides a discussion of the two questions and a ROI calculation model. Concerning the first research question, the empirical results reveal the following dimensions of digital value creation: 1) increased revenue, 2) increased customer satisfaction, 3) increased employee satisfaction, 4) higher efficiency, and 5) productivity.

The findings illustrate a prime focus on cost cutting (increase in efficiency and productivity) as well as an increase of the overall revenue, while customer and employee satisfaction seems more to be added by digitizing SMEs value chains. Here, the present results highlight a more nuanced perspective from the interviewees in terms of reducing costs, being faster, more flexible, and simplifying processes when digitizing. In addition, SMEs primarily strive for more options to sell products, using their knowledge of customers and try to expand their competitive advantage to increase their revenue. In terms of cost cutting, these findings go in line with the literature, as a focus of efficiency and effectiveness as well as cost reduction can be found in numerous sources (Bayo-Moriones, Billón, & Lera-López, 2013; Müller, Buliga, & Voigt, 2018; Pulka, Ramli, & Mohamad, 2018; Tarutė & Gatautis, 2014). However, the strong focus on sales increase due to more selling options, data analytics and SEA campaigns is partly presented in the theory, but not specifically centred (Bouwman et al., 2018; Bouwman et al., 2019; McCann & Barlow, 2015; Saridakis, Lai, Mohammed, & Hansen, 2018). Especially the aspect of creating and using customer knowledge via data analytics and BI tools, to individualize offerings, react in real time on sales data, activating local customers and forecasting in-depth consumer behaviour to make them buying products, is mentioned in the current literature but not in this extent as it appeared in this analysis. Today, SMEs are not only interested in "accessing the customer" but rather in understanding the concrete behaviour, buying cycles, search actions, customer requirements and displaying the products to improve the buying process and generate more revenue in the end. This is due to the topicality big data and data analytics as it is still an exceptionally recent topic for SMEs.

Plotting the cases leads to insights on how higher performance output can be reached through different pathways. As shown in the findings, data analytics can lead to a measurable ROI. To date, research has been limited in the context of accurate figures of ROIs as well as a transparent, easy to use framework to proof the investment of a data analytics solution for SMEs. There are few attempts to measure the use of social media and other technologies without a concrete defined value (Coreynen, Matthyssens, & van Bockhaven, 2017; Mangiuc, 2009; McCann & Barlow, 2015). The findings of this case study fill this gap by evaluating 13 positive ROI examples based on different solutions.

However, the findings need further discussion. First, as previously shown, most of the ROIs are generated through decreased costs, especially through lower working time and personnel costs. Compared to higher sales, SMEs usually benefit fourth times more often through a saving-cost-case instead of increasing revenue with data analytics, at least for the calculation of the return. This goes in line with the above-mentioned findings that SMEs are reasonably interested in cutting costs when implementing analytics.

Second, most of the computed ROIs are larger than ten implying that the analysed SMEs are benefiting significantly more than of a ten-fold return. In principle, the higher a result of the ROI, the more worthwhile the investment for the SME. However, it is recommended to target a value above ten, but as the findings clearly demonstrate it is strongly dependent on the smart solution, the costs for it as well as the process that is optimized. The findings reveal a clear difference between the calculated ROIs as some analytics solutions are generating a lower ROI, compared to a few SMEs that have created a high return. As previously mentioned on the one hand this is because different data approaches are used, and on the other, costs are reasonably higher in cases of own developments. These relatively high investments grounded in the development time, external agencies and IT-support that is needed lower the ROI tremendously, as it can be seen in the case of N4 and N5. Consequently, the ROI becomes higher when no initial implementation investment is needed, and costs only occur due to license fees or monthly software subscriptions for instance in a pay-as-you-go-model instead of high development costs. This "simple form" can finally lead to a higher ROI, as found in N3 and N5.

Third, it appears that the ROI does not depend on the industry or company size as both, a high as well as a low return, are achieved in all companies. Thus, no dependency on industry or size can be evaluated in this analysis.

Fourth, the findings reveal that it is still of high importance for SMEs to compute a ROI and calculate the business case of an analytics solution as it always correlates with costs. This has also been found by Coreynen et al. (2017), Gono, Harindranath, and Berna Özcan (2016) as well as Saridakis et al. (2018). This is also reinforced by the research conducted in this study as the computed specific ROIs are still rare (compared to the multitude of digital benefits and added values), vary tremendously and even are very low in some cases and thus at the border to be worthy. Consequently, not all solutions are clearly worthwhile. Moreover, the analysis shows that the SME entrepreneurs still implement data analytics without knowing if the solution adds a concrete financial value and therefore finally increases company performance. Costs and ROIs are often ignored respectively entrepreneurs are not aware of. Thus, the computation of a ROI is still inevitable.

Conclusion

Previous research has shown that SMEs are lagging in digital technology adoption. Most of the SME managers are not fully aware of the positive digital values they can receive. This research elucidated how SMEs can benefit of a positive return by implementing analytics in their business processes. It was conducted as a qualitative case study with six SMEs from the retail and production industry from May 2020 to November 2020. The paper provided a rich overview of benefits and a variety of ROI possibilities when using analytics in SMEs. It contributes a well-founded set of digitally added values to the business performance and has facilitated an improved understanding of digital value creation. The findings reveal five driving values: increased revenue, improved customer satisfaction and employee’s satisfaction, efficiency, and productivity. In addition, the six case studies proved a significant positive ROI in numerous use cases where digital solutions are implemented to improve revenue or cut costs. The weighted ROI average of these companies is 15,3, the median is 15,17 and consequently far above 10. Thus, most of the investments are highly worthwhile.

Theoretical and Managerial Implications

The study enriches the literature on digital transformation. The findings are relevant for those in academia who aim to understand not only the core values and returns of digitizing the business model, but also how value can be created by adopting big data and analytics. One theoretical implication is that the paper develops insight into several potential pathways for SME managers to increase their business performance through data analytics. In doing so, the study shed light on this complex issue by showing recent use cases and adoption possibilities. Therefore, it presents a current state of latest sophisticated analytics solutions used in SME value chains.

Although a lot of previous literature on digital value creation focused on implementation, usage and benefits, this paper took a different angle and demonstrated the need to focus on costs of the solution by measuring a ROI when using data analytics technology. Hitherto, the focus of the literature has largely been on the added values of analytics adoption, as highlighted in the previous literature review. The contribution of this study is to stress the need for a ROI computation and show concrete examples of how SMEs generated a positive ROI by increasing revenue or saving costs with analytics technologies.

In addition to the theoretical contribution, interesting and challenging managerial implications emerge from the findings. The research has substantial practical relevance for SME managers and offers concrete guidelines for entrepreneurs who seek to increase their business performance through data analytics. This study untangles and integrates analytics technologies that can be used by SMEs to improve business operations. It shows several opportunities for SMEs to innovate their business models. Therefore, this multiple-case study offers strong appropriate suggestions and experiences for managers to systematically encourage innovation by demonstrating concrete examples of data analytics solutions, use cases, inspirations, and benchmarks of other companies. It also demonstrates a level or status of using data in other companies to compare with and learn from. It further motivates SME managers to drive data analytics internally as the findings prove the worthwhileness.

Additionally, since the implementation of data analytics tools is often costly and SME managers are afraid of investing in them, this paper offers strong examples and practical insights into the necessary investments, costs of development and implementation, but finally the positive return. This study's case illustrations offer concrete examples of such ROIs along with the context and way they were applied.

However, the findings indicate that the SME managers need to be aware of the variation of ROIs depending on each use case. Especially high invests into development and implementation of tailormade analytics use cases are costly and consequently lower the ROI. Thus, the recommendations this study offer is to start with standardized solutions, monthly subscription ("pay-as-you-go") models and simple data use cases with an immediate return when SMEs begin to digitize.

Limitations and Further Research

This study is not impervious to *limitations.* First, limitations are present in this study due to the context-laden nature of qualitative research. The qualitative nature of the research does not allow generalizability. Therefore, it will be essential to conduct research in other companies. However, the findings from six very different SMEs highly converge on their created digital values and returns by data analytics adoption. As noted by Yin (2018), a convergence of findings across different cases is a strong indicator of robust findings. Thus, the applicability of the findings may be anticipated to be relatively high. In this context, another drawback is that the study mostly relies on interviews with a relatively small number of informants, although data triangulation and systematic analysis increase the reliability of findings. Further quantitative research is needed to develop and test hypotheses regarding, for instance, the impact of analytics technologies on SME business performance and growth, and the success of investments as far as their concrete ROI.

Second, the research was conducted in the unique economic context of Germany as all SMEs are based there. Thus, the findings might be unique to the particular social and economic market situation of Germany. Similar research in different regions and countries is needed to further test the validity and generalizability of these findings.

A third limitation is considered as companies were selected from Germanys retail and production industry as case illustrations, the use and benefit of analytics approaches can certainly be found in other industries as well, including service, transport, food, etc. Investigating cases from other business sectors could well lead to different values and ROIs being discovered, providing further valid contributions to the literature. Further research should be done in other and additional industries to verify this assumption.

Another fourth limitation is considered as fewer return examples are proven as presumed. However, this study reveals various values and benefits, but not all of them are clearly measurable. Thus, this study lacks in providing a ROI for all analytics tools used in the presented SMEs. More research of concrete measurable ROIs should be conducted to develop further return examples.

Fifth, this research solely focuses on benefits and values in terms of data analytics rather than inducing barriers, disadvantages and challenges that may arise as well. In the interviews with the SME managers, various challenges and risks of data analytics have also been demonstrated. However, this study focused on the added values and ROI. All in all, the present paper encourages future studies to evaluate the added values and gained ROIs of data analytics in SMEs quantitatively and qualitatively.

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1 2
Topic »What's next? Innovative Service Research«

12.1
List of Papers

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A bridge between Social Innovation and Sustainability research: Cases of active mobility public services

Silvia Stuchi Cruz, Mariana Sayuri Kachiwazaki, Sonia Regina Paulino (University of Sao Paulo, Brazil)

Introduction

This paper aims to deepen the dialogue between social innovation and innovation in services, with a focus on sustainability and the 2030 Agenda. The social innovation approach allows us to emphasize the leading role of third sector organizations that seek to ensure that society is the beneficiary to appropriate the results of innovation in services. As case studies, we address experiences of civil society organizations and collectives that work to improve services and infrastructure for pedestrians in the city of São Paulo, Brazil, together with government bodies.

Social innovation has been used as a denominator for the different types of collective actions and social transformations that would lead us from a "top down" economy and society to a more participatory and "bottom up" society (Moulaert et al, 2013; Ardill e Oliveira, 2018). A brief definition of social innovation points to innovations defined by their (social) goals to improve the well-being of individuals or communities (Moulaert et al. 2007; Moulaert and MacMallum 2019, Djellal and Gallouj 2012). The occurrence of social innovation requires the participation of third sector organizations, groups or social movements ensuring that society is the beneficiary by appropriating the results of innovation (Desmarchelier et al., 2020a, 2020b). These include regional and local urban transformations (Windrum et al., 2016).

Co-creation in social innovation focused on urban services is a recent study in the literature (Moulaert et al., 2005), and still needs to be investigated in more depth, as the literatures addressing service and social innovation, despite their intrinsic relationship, continue to be treated as separate subfields of study (Windrum et al., 2016). However, their relevance is evident in innovation processes affecting services, since these may depend on an organized relationship between actors to occur. It should also be noted that social innovation and innovation in services are referenced in European literature, with a predominance of studies of innovation focused on technology and on the business sector.

Regarding urban mobility, it is sustainable when it aims to minimize and mitigate environmental impacts and when there is universal access of the entire population to the city and opportunities, contributing to economic and social development (Gomide and Galindo, 2013). Active mobility (non-motorized transport) is related to walking, cycling, wheelchair and all means of transportation that are made by means of human propulsion. In the city of São Paulo, despite taking only 30% of passengers, automobiles are responsible for 73% of greenhouse gas emissions. It is also noteworthy that 80% of road space is occupied by individual cars (IEMA, 2017), but, on the other hand, 66% of displacements in the São Paulo capital are made exclusively or partially by foot and collective public transportation (Companhia do Metropolitano de São Paulo, 2019).

After this contextualization, the selected cases demonstrate to be a fruitful field for analysis from the social innovation perspective, since it differs from traditional innovation not only in its nature, but also in its modes of production and in its stakeholders, because to achieve the objectives, social technologies are used, which involve, necessarily, the interaction of people. Another fundamental characteristic is the local or popular nature, focused on the role of social innovation for the development of communities, neighborhoods, cities, regions, urban or rural areas, emphasizing the role of governance and institutions, participation, inclusion or empowerment of citizens and its relationship with sustainability (Ardill and Oliveira, 2018; Djellal and Gallouj, 2012; Kon, 2018; Cruz and Paulino, 2020; Desmarchelier et al., 2020a; 2020b).

After the introduction, section 2 presents social innovation in public management, with a focus on multi-agent configuration and co-creation in public services, section 3 presents the methodology, with the variables used to characterize the social innovation, section 4 presents the results of the application of the analysis variables, and finally, the conclusions are presented.

Social innovation in public management

Considering that different types of actors are involved in the innovation process, the provision of services in a multiagent configuration allows the development of complementarities and synergies among the different agents, each one with its own objectives and specific competences (Windrum and García-Goñi, 2008; Windrum et al., 2016; Desmarchelier et al., 2020a).

Since social innovation aims to solve a problem in society, new or improved services compared to pre-existing ones are used to meet these social demands, and these services are developed and selected in a complex environment of interaction between the interests/preferences of various agents, including local service providers, policy makers, and citizens. These agents can also act in various directions: users can act as providers of a technical solution, they can lead the innovation process, while providers can also act as users. Thus, service innovation has a strong relationship with social innovation, because service innovation can result from social innovation, and both have similar characteristics such as multi-actor collaboration and the development and implementation of new innovative solutions. Social innovations can bring a variety of contributions to society, such as improving living conditions in large cities through innovation in services focused on mobility and habitation, for example.

The development and diffusion of social innovations requires the direct implementation of the knowledge and competences of citizens and organizations (public, private, or third sector); and the mobilization of material and/or immaterial factors. The interactions among the agents will determine the facility or inhibition of social innovations, as well as their outcomes and possible diffusion. As expressed in Windrum et al. (2016), in this paper the concept of co-creation is linked to innovation - not to value generation between supplier and customer. In other words, it differs from the application of the concept in service dominant logic and in some other service marketing theories.

Co-creation, in its different forms, allows for better service delivery by identifying user needs and behavior and adapting to them in a dynamic manner. It is worth noting that different definitions of co-creation are given by different authors who discuss the role of citizens in public service delivery. Traditionally, citizens are referred to as "recipients", "subjects" and "service users", but in the last three decades, citizens have come to be referred to as "consumers", "customers", "entrepreneurs" and "co-makers" (Gofen, 2015). In these positions, when citizens are dissatisfied with some public service, they can create an alternative rather than choosing from existing possibilities, enabling citizens to introduce innovations, it fosters social innovation and influences the citizen-government relationship. In this paper we chose to consider Mureddu and Osimo's (2019) definition of co-creation that considers degrees of citizen engagement that applies to public services, be it analog or digital. In summary, two types of co-creation are pointed out: intrinsic and extrinsic (table 01):

Table 01: Types of co-creation

Intrinsic Co-creation	Extrinsic Co-creation	
Co-construction	**Codesign**	**Co-production**
Citizens participate passively	Citizens actively participate through feedback and ideas	Citizens actively participate and are part of the implementation

Source: Mureddu and Osimo (2019, p.07)

In intrinsic co-creation, the passive and unconscious participation of citizens is considered, aimed at bringing about improvements in the design of the service. Extrinsic co-creation, on the other hand, denotes active participation of individuals in improving existing services, innovating new ways of delivering public services, and collaborating effectively in the management and delivery of those services (Mureddu and Osimo, 2019, p.07). Co-design and co-production can benefit from open data and participatory tools. Thus, co-creation becomes more complex when the number of participants in the activity increases, requiring resources to integrate the people, technologies, organizations, and information shared (Gallouj; Rajala, and Toivonen, 2016). Co-creation can also bring positive results for the public sector: increased transparency and efficiency, reduced costs, reduced risk of failure, better adaptation to social needs, and consequently increased user satisfaction.

In this view, public administration research, particularly in the context of the New Public Governance Paradigm (Osborne, 2010), is considering the multi perspective/agent (or network) approach to analyze outcomes and processes in public organizations, since according to the co-creation literature it involves different actors and levels in the interaction. According to the role that citizens assume in service change, some types of service change can be considered (Table 2) (Gofen, 2015):

Table 2: Types of service change

Order of change	Type of change	Description
First-order	Incremental change of the existing service	Replaces public provision with self-provision of services and rejects government involvement, assuming all the risks
Second-order	Participatory change of the existing service	Introduction of a new form of service, complementary to the existing public service, is considered to involve citizens to improve existing provision. In contrast to the previous approach, it does not reject public sector involvement and risks are shared
Third-order	Reforming the existing service	Introduction of a new form of service by citizens that acts as a means of pressure to change the existing arrangement, which may become a legitimate option in the future

Source: the authors, based on Gofen, 2015 p 413.

For the purposes of this research, the second and third order changes will be used, as none of the case studies reject government involvement as explained in the first order change. There are also other factors that influence the achievement of innovation in public-private partnerships, such as: structural factors, collaborative process factors, and participant-oriented factors, as detailed in Table 3 (Brogaard, 2019).

Table 3: Factors that influence the achievement of innovation in public-private partnerships

Factors	Description	Examples
Structural	Predetermine the structure and environment of the collaborative process, including institutional settings in the political and regulatory ambits that influence partners' actions and outcomes	- contract management, supporting performance and risk sharing - support and inclusion of the actors affected by the innovation process
Collaborative process	They are related to the interaction between those involved in the initiatives, with fundamental importance, as public-private partnerships involve organizations with different interests	- trust between the actors - convergence of goals - motivations and conflicting cultures
Participant-driven	Variables related to the relevant skills of public and private actors and the governance of the partnership	- competences: technical know-how, professional knowledge, skills or experience with inter-organizational collaboration and training in innovation - governance: public or private leadership can influence innovative outcomes

Source: the authors, based on Brogaard, 2019.

In this analytical framework model, innovation is a dependent variable defined as the development and implementation of new solutions. The presence of the variables are potential factors and their absence is considered a barrier, furthermore, they are considered interdependent in various degrees. The analytical framework proposed by Brogaard (2019) to analyze whether and how innovation is achieved in public-private partnerships has been adapted for our context through the incorporation of social innovation and service innovation. We can state that service innovation is part of social innovation, because, as pointed out earlier, service innovation relies on the addition, replacement, and (re)organization of technical features and process characteristics, seeking to create a better quality service for the customer/user and a more effective process for the provider. In addition, social innovation seeks to solve a problem in society and improve people's quality of life through new services resulting from social innovations (Windrum et al., 2016) and to this end new or improved services are used in relation to pre-existing ones to meet these social demands. Process innovation, on the other hand, is part of social innovation, because innovation relies on changes in social relationships, systems, and structures, and for this purpose, social technologies are used, which involve the interaction of people.

In this study, we focus on social innovations where co-creation is guided by the prominent position taken by third sector organizations in the innovation process, with a multidisciplinary, multi-agent approach and social innovation at the local level, and we observe in the cases analyzed a high interaction of the public sector with civil society for the development of the initiatives, promoting walkability improvements.

Methodology

Documentary research and semi-structured interviews were carried out. We applied categories and variables for analyzing social innovation. Social innovation, spearheaded by third sector organizations, involves the co-creation of new services/products, and is shaped by interactions between key stakeholders. The research methodology is based on the steps:

A. Selection and characterization of case studies - tactical urbanism
B. Primary and secondary data collection
C. Application of the factors and analysis variables based on the social innovation approach

A) Case studies

The criteria for the selection of cases in the city of São Paulo are:

- Interaction with public sector
- Lead by the 3rd sector
- Focused on walking
- Period of ascension/strengthening of the initiatives, concomitant with the rise of active mobility public policies
- Data available for analysis

From these criteria, the selected cases are:

Category →	Initiative
Reduced Speed Zone →	São Miguel Paulista
Reduced Speed Zone →	Santana
Safe route to school →	José Bonifácio
Complete Street →	Joel Carlos Borges
Open street →	Paulista Aberta

B) Primary and secondary data collection

For the primary data collection, representatives of civil society, start ups, universities participating in impact evaluation diagnostics, and the public sector (Secretariat of Urban Mobility) were interviewed. The secondary data sources used are: CET database of Reduced Speed Zones and the Life Protection program; diagnoses and reports of Impact Evaluation Studies and reports (Cidade Ativa, 2018a;2018b; CET, 2016; FGV, 2017a; 2017b; Guido et al., 2017; ITDP 2016; 2018; LabMob and WRI, 2018; Nacto, 2018; Urb-i, 2019; LabMob, 2019, Como anda, 2020) Essentially, the reports on interventions provide information about workshops, engagement with stakeholders, post-intervention impact evaluations, intervention design, and materials used (in-event, temporary and permanent actions).

C) Application of the factors and variables of analysis based on the social innovation approach

Subsequently, based on the theoretical framework that characterizes social innovation (Moulaert et al. 2017; Martinelli, 2012; Djellal and Gallouj, 2012; Kon, 2018; Windrum et al, 2016, Broogard, 2019), adapting them for the studied context, the following factors and analysis variables were used (Table 4):

Table 4: Factors and analysis variables

Structural Factors		**Description**
V.1	*Associations / collectives / activist groups*	The protagonism of civil society, related to the cases studied
V.2	*Financial Resources*	Sources of financial resources identified for the initiatives implementation
Collaborative Process Factors		**Description**
V.3	*Third sector interaction with the public sector*	The means of interaction with the public sector
V.4	*Support from public policies for the diffusion of innovation*	Public policies that are related to the contexts of the cases studied and that, in part, have originated because of the context
V.5	*Government bodies that support the provision of services*	Public bodies related to the projects, highlighting their interdisciplinarity and intersectionality
V.6	*Types of service changes*	First, second or third order
V.7	*Role of Citizens*	Co-construction, co-design, co-production
Factors that preceded the service implementation		**Description**
V.8	*Actions to highlight social needs*	Methods, tactics and tools used to gather information from the communities involved
V.9	*Expertise in identifying the intervention area*	Forms of participation in the elaboration of processes and procedures
V.10	*Establishment of an evidence base on the effectiveness of the techniques used in the service*	Participatory methodologies for disclosing and validating techniques
Final Service Factors		**Description**
V.11	*Solution to respond to social needs*	Local solutions, aimed at the population's wellbeing, resulting from the joint process of public sector interaction and civil society participation
V.12	*Improvement of environmental quality*	Aspects related to air and noise pollution
V.13	*Social Impact*	Developments achieved, measured by research methods and the impact evaluation

The author's, based on Moulaert et al. (2013), Martinelli (2012), Djellal and Gallouj (2012), Ardill and Oliveira (2018), Kon (2018), and Broogard (2019).

Results

From the criteria adopted, we selected the following cases: a Reduced Speed Zone (Sao Miguel Paulista and Santana), a Complete Street (Joel Carlos Borges), Safe route to school (José bonifácio), and Open street Program (Paulista aberta), that use tactical urbanism techniques and are characterized as follows (table 5).

These cases are characterized by the adoption of tactical urbanism. Tactical urbanism interventions encompass small-scale and short-term urban projects, meant to inspire long-term transformation with the purpose of recovering urban spaces, mainly through the engagement with, and participation of, civil society (Lydon and Garcia, 2015; Ahmed; Elrahmanm, 2015; Cloutier et al., 2018). Tactical urbanism has been addressed in studies that focus on local urban development, in contemporary social innovation research perspectives (Moulaert et al., 2017).

Table 5: Characterization of cases with tactical urbanism techniques

Case	Historical	Tactical Urbanism Interventions
Santana	Implementation: 2014 Temporary intervention: 2017 Permanent intervention: 2018	Micro-roundabout; reduction of corner radii; sidewalk extension; narrowing of traffic/moving lane
Sao Miguel Paulista	Implementation: 2015 Temporary intervention: 2016 Permanent intervention: has not occurred	Sidewalk extensions; mini plazas; narrowing of traffic/moving lane; crosswalk
Joel Carlos Borges	Implementation, temporary and permanent interventions: 2017	Sidewalk extensions; narrow traffic/moving lane; maximum speed reduced to 20 km/h
Jose Bonifacio	Implementation and temporary intervention: May 2018 Permanent intervention: Sep. 2018	Micro-roundabout; offset curb extensions/chicane; sidewalk extensions; narrow traffic/moving lane; new crosswalk; maximum speed was reduced from 40 km/h to 30 km/h during the temporary intervention (and remained after, as a permanent measure)
Paulista Aberta	Implementation and temporary intervention: 2014 and 2015 Permanent program: 2016	Open/ play street on Sundays, providing safe space for physical activity, play and leisure. Install temporary traffic barriers, signs at intersections, Establishment of a grid of entry points into local streets where barricades are installed

Source: the authors.

In Table 6, we present the initiatives analyzed based on the factors and variables that characterize social innovation, in the context studied.

Table 6: Factors and Variables of social innovation applied to the case studies

<table>
<tr><th>Factors</th><th>Variables</th><th>São Miguel Paulista</th><th>Santana</th><th>Joel Carlos Borges</th><th>José Bonifácio</th><th>Paulista Aberta</th></tr>
<tr><td rowspan="2">Structural</td><td>Associations / collectives / activist groups</td><td>Bloomberg Initiative; ITDP, NACTO and WRI, Vital Strategies and iRap / GRSF</td><td>Bloomberg Initiative, NACTO, WRI and Vital Strategies (and in the impact evaluation study: FGV/CEPESP and ITDP)</td><td>WRI (and in the impact evaluation studies: Cidade Ativa, Urb-i, WRI, Labmob UFRJ, Metrópole 1: 1)</td><td>Bloomberg Initiative, NACTO, Vital Strategies, ITDP</td><td>Sampapé!; Minha sampa; Bike Anjo; Cidade Ativa</td></tr>
<tr><td>Financial resources</td><td>Citi Foundation</td><td>Citi Foundation</td><td>Indutil and Dow companies (paint donation); Public resources</td><td>Public resources</td><td>Public resources</td></tr>
<tr><td rowspan="5">Collaborative process</td><td>Third sector interaction with the public sector</td><td colspan="4">Elaboration and approval of the temporary intervention project; cooperation agreements with City Hall</td><td>Program elaboration; decree elaboration; public hearings</td></tr>
<tr><td>Support from public policies for the diffusion of innovation</td><td colspan="4">Life Protection Program, Safe Pedestrian Program, implementation of areas with reduced maximum speed, Municipal Plan for Urban Mobility, Pedestrian Statute, Sidewalk Emergency Plan (PEC), Cycle Plan, Master Municipal Plan Law, Zoning Municipal Law</td><td>Life Protection Program, Safe Pedestrian Program, Municipal Plan for Urban Mobility; Master Municipal Plan Law; Open streets Program.</td></tr>
<tr><td>Government bodies that support the provision of services</td><td colspan="4">Mobility and Transport Secretariat, Traffic Engineering Company (CET), sub-prefectures</td><td>Traffic Engineering Company (CET), Mobility and Transport Secretariat, Sports Secretariat</td></tr>
<tr><td>Type of change in service</td><td colspan="4">Second and third order (approximately)</td><td>Terceira ordem (aproximadamente)</td></tr>
<tr><td>Role of Citizens</td><td colspan="5">Co-construction and codesign (approximately)</td></tr>
<tr><td rowspan="3">Before Service Implementation</td><td>Actions to highlight social needs</td><td colspan="4">Actions to obtain community involvement; interviews to assess the acceptance of the proposal and to detect potential points of improvement not foreseen in the project; participatory workshops; development of informative and interactive panels</td><td>Test of the initiative; survey of site frequenters; information panels; program acceptance survey</td></tr>
<tr><td>Expertise in identifying intervention areas</td><td colspan="3">Discussion and analysis with municipal bodies on sites that could receive temporary intervention; workshops with the community</td><td>There was joint discussion and analysis, however, in this initiative, a protagonism of the public sector is identified, based on the experiences acquired with previous interventions.</td><td>Elaboration of a project for the occupation of three blocks by the social organizations, with suggested detour routes for vehicle traffic</td></tr>
<tr><td>Establishment of an evidence base on the effectiveness of the techniques used in the service</td><td colspan="4">Testing at lower costs, with painting materials, vases, and temporary interventions; data collection for preparatory diagnosis and the road safety audit</td><td>Online campaign; media attention; meetings with government; holding testing events</td></tr>
<tr><td rowspan="3">Final Service</td><td>Solution to respond to social needs</td><td colspan="4">New urban design with requalification and redistribution of road space; consolidation of the speed reductions; prioritization of active mobility</td><td>Prioritization of active mobility; recognition of public space with cultural activities; reduction of car use.</td></tr>
<tr><td>Improvement of environmental quality</td><td colspan="5">Although the initiative reports indicate a tendency to improve environmental quality, especially in aspects related to air quality and reduction of noise pollution, until now, there are no evaluation methods to prove such improvements</td></tr>
<tr><td>Social Impact</td><td colspan="3">Definition of temporary steps to measure impacts and results; impact evaluation was carried out by the organizations Cidade Ativa and Lab-Mob UFRJ (surveys of the flow of people and vehicles, opinion polls and user profiles)</td><td>Definition of temporary steps to measure impacts and results; impact analysis was carried out by CET</td><td>Physical activity in public spaces; increased walking; lively, active, democratic public space with cultural activities</td></tr>
</table>

Source: the authors

The introduction of new services in the local context stands out, focusing on the treatment of infrastructure pedestrian road: sidewalks; crossings, accessibility, horizontal and vertical signage in public space, traffic light system suitable for non-motorized transport; and traffic moderation. Aiming to improve the conditions for integration with public transport, the initiatives studied sought to increase safety and comfort for pedestrians by reducing speed, renovating and expanding sidewalks. The interventions are based on tactical urbanism techniques and corroborate that 'scarcity' is not necessarily resolved by adding 'more' space, but can be resolved by transforming and managing the need for mobility, with the redistribution of spaces, emphasizing the active mobility. In other words, we highlight the need for a better redistribution of the common space (Cruz and Paulino, 2020) linked to compliance with legislation, in order to divide or limit access to a limited resource, since two thirds of the population use active and collective modes of transport; but a third using individual motorized transport occupies about 80% of the road space (IEMA, 2017). The cases studied show the introduction of new public services in the common infrastructure to improve road safety conditions, active mobility and access to public transport, and can potentially help to reduce noise levels, improve air quality and reduce greenhouse gases emissions (negative externalities and social costs).

The introduction of public road space treatment services for walking mobility was combined with the development of competences in the public sector related to evaluation methodologies for urban interventions and the broadening view of the urban reading methodology, beyond pedestrian and vehicular volumetric counts, resulting in a systemic view on the uses, local dynamics and behavioral aspects of the users themselves. In this aspect, the multi-agent configuration is evidenced, opening possibilities for the development of complementarities and synergies among the different agents- Each possesses their own specific objectives and competences. Regarding co-creation (Mureddu and Osimo, 2019), in the cases studied, there was participation in co-construction and codesign through feedbacks and ideas, according to Table 7:

Table 7: Co-creation in the initiatives studied

Initiative	**Co-creation *(similarities)***	**Comments**
José Bonifácio	Codesign / co-construction	Opinion surveys and also participatory idea workshops with the surrounding communities to identify suggestions for changes at the intervention site; local residents contributed with feedbacks and ideas about the proposed redesign
São Miguel Paulista	Co-construction	Citizens participate passively and are unaware of their role; interviews were held with local residents to collect information about the site of intervention, but no events were held to explain the project to the population
Santana	Codesign / co-construction	Training intended for technicians of the City Hall; Ideas workshop with the population and a presentation at the Commercial Association; on the intervention day there were educational and cultural activities; panels and banners displayed for feedbacks and ideas
Joel Carlos Borges	Co-construction	Interviews with the population that frequents the intervention site, but no events were held to explain the project to the population
Paulista aberta	Codesign / co-construction	Citizens' protagonism in the program implementation ideas; surveys conducted with the intervention site's frequenters

Source: the authors

Even with the limitations for a deeper analysis, it is emphasized that the importance of co-creation resides in the ability to involve citizens, contemplating their experiences and capabilities, since, as a user of public services, citizens have a unique perspective on the quality of public services. In this sense, in the scope of the initiatives studied, opinion surveys and also participatory idea workshops were conducted with the surrounding communities to identify suggestions for changes on the intervention site.

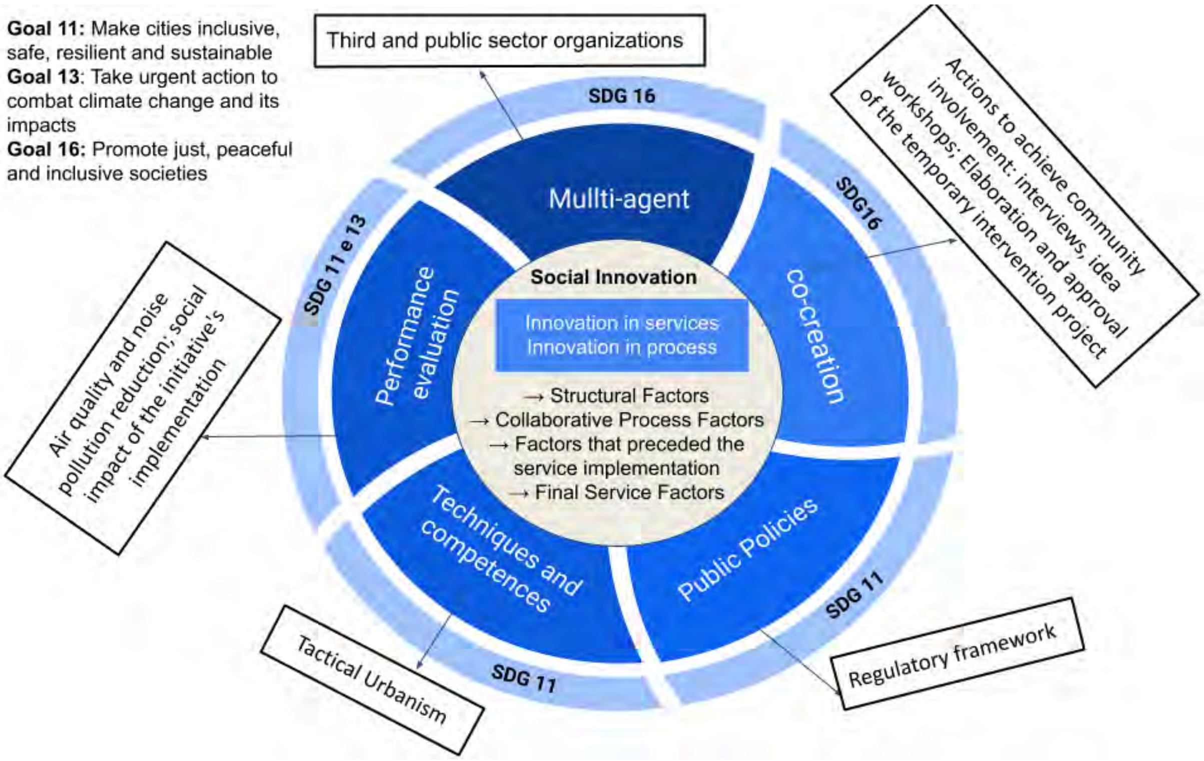
The ideas workshops sought to contemplate different audiences, however, it is observed that the meetings that proposed to engage the surrounding community, in relation to the totality of the local population, did not obtain a satisfactory audience. If, on one hand, there is the likelihood of little interest and/or low engagement of the population, on the other hand, there is the very process of communication and information about the events that could have been better carried out and providing more opportunities of different schedules. Despite this, the participants' comments were favorable to the proposed interventions.

Finally, even with the mentioned gaps in the expansion of participation and consolidation of more perennial actions of this nature, aiming to consolidate the process of co-creation in the long term, it is noteworthy that actions to encourage co-creation by the local community contribute to broaden the positive impacts of actions, as pointed out in the evaluation reports of the interventions. Regarding the new services to treat the public road space, they occurred in several ways, such as: sidewalk extensions and requalification, road narrowings, raised crossings and intersections, speed bumps, creation of a square, accessibility improvements, paving, drainage, signaling, and landscaping. In the Paulista Open street initiative, a great protagonism of the citizens is observed, thus approaching a third order change, because society pressures the public power in the implementation of the program, and this later becomes legitimate.

In the configuration of the provision of services in urban mobility, aiming to also include socio-environmental aspects (Cruz and Paulino, 2019; Cruz and Paulino, 2020).

Figure 01 summarizes the main aspects of social innovation, based on the analysis variables and the relationship with the SDGs targets.

Figure 1: Social innovation, categories of analysis, and relationship with SDGs goals.



Source: the authors

The initiatives studied are mainly aligned with the Sustainable Development Goals - SDG 11 Make cities and human settlements inclusive, safe, secure, resilient and sustainable; SDG 13 Take urgent action to combat climate change and its impacts; and SDG 16 Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels. However, the pursuit of the SDGs and related targets requires radical transformations to achieve the ambitious scope established, requiring cooperation among actors, disciplines, and perspectives, as well as the generation and application of new knowledge.

The municipal government goals identified in the recent regulatory framework prioritize active mobility in the city of São Paulo. Regarding SDG 11, we highlight the promotion of new perspectives for the transformation of urban public road spaces, through social innovation, which also stimulates decision-making in favor of a sustainable urban mobility system. Nevertheless, there is a deep gap between public policies and practices: in theory, the priority to active mobility is often presented, however, the practical results of environment qualification, infrastructure and services for active mobility, and connectivity with public transport are tiny.

Regarding SDG 16, the multi-agent configuration is identified, with the design of new forms of collaboration and partnerships between public, social, economic, knowledge and civic actors. Still, it is important to highlight that in the contexts of developing and emerging economies, in a situation substantially marked by information asymmetry, lack of accountability, transparency and responsiveness to their users' needs, the challenges are even greater, e.g., negotiating conditions, responsibilities, empowerment, linkages between agents from different sectors vary widely. Thus, in the cases studied, the conditions of negotiation, responsibilities, empowerment, and links between agents from different sectors vary widely. Through the actions of third sector organizations, we also highlight the role of volunteers and collectives in the creation and introduction of innovative solutions for active mobility in the local context that meet social needs by including pedestrians as a priority in the use of urban road space. The organizations draw attention to the interests of individual citizens and use their experience (techniques and competences) to interact with the public service provider (City Hall) in identifying areas of intervention and establishing evidence bases on the effectiveness of the techniques used for the requalification of road space. Regarding SDG 13, although the initiative reports indicate a tendency to improve air quality and reduction of noise pollution, until now, there are no evaluation methods to prove such improvements.

In conclusion, although timidly, some of these practical results of the SDGs and related targets can be verified in the outcomes of the initiatives studied. But there is still a great potential for the continuous introduction of innovations for the improvement and gain of scale of public pedestrian mobility services, and for the promotion of participatory restructuring as a form of (re) appropriation of urban space by the users themselves, aiming at the SGDs as well.

Conclusion

The co-creation is highlighted in the actions to obtain community involvement, interviews to evaluate the acceptance of the new proposal and detect potential points of improvement not foreseen in the project, preparation of the temporary intervention, and joint discussion and analysis with municipal agencies .Also, in the new urban design with a requalification and redistribution of the road space, consolidating the reduction of speeds, prioritizing pedestrian displacement, with the local society benefiting and appropriating the results of innovation.

Social innovation, led by third sector organizations, involves the co-creation of new services/products, and is shaped by the interactions between the main stakeholders. In the cases studied, because they are punctual, we can momentarily categorize that in the processes that occurred, basically, co-construction and co-design through feedback and ideas. The co-creation is highlighted in the actions to obtain community involvement, interviews to evaluate the acceptance of the proposal and detect potential points of improvement not foreseen in the initial project, participatory workshops, installation of informative and interactive panels, preparation and approval of the temporary intervention project and joint discussion and analysis with municipal agencies about the points that could receive the temporary intervention. Also, in the new urban design with requalification and redistribution of the road space, consolidating the reduction of speeds, prioritizing walking mobility, with the local society beneficiary by appropriating the results of innovation

It is considered that the cases analyzed are embryonic initiatives due to the low number of studies that analyze the innovation of public services of walking mobility based on social innovation. It is important to emphasize the relevance of further studies of social innovation focused on public services, considering the great challenges faced in urban environments and in the relations of citizens with public authorities, with great potential to solve social, environmental and economic problems and promote sustainability. It is also noteworthy that despite the impossibility of measuring the improvement of environmental quality through the initiatives, there is a relationship between sustainability and the cases analyzed and social innovation, because improvements are promoted directly or indirectly in the environmental field.

The research results are aligned, above all, with Sustainable Development Goal SDG 16, regarding transparency and social participation, SDG 11, by the search for the improvement of spaces for active and sustainable mobility, and SDG 13 by the tendency to improve environmental quality. The concepts of social innovation and innovation in services have strong references in the technological and industrial/ business field, therefore most of the variables used here were adapted to the Brazilian context of public services, specifically to services of walking mobility. It should be emphasized that due to the discrepancies between the contexts of origin of the theoretical reference framework, substantially European, and the context studied, Latin American, the cases analyzed here are considered to be embryonic initiatives in social innovation and innovation in services. In the cases studied, by applying the analysis variables to the cases selected, it can be observed that society has different forms of participation in the implementation of services and that the relationship between public authorities and citizens can occur in different ways, leading to various paths to be followed in the implementation of social innovation in public services. In the initiatives the citizens built, together with the public authorities, safer and more attractive spaces for pedestrians, and in the Paulista aberta, open street initiative, there was initially a demand from society and later a joint work of the two parties.

Finally, co-creation in social innovation is a recent study and still needs to be investigated in greater depth. However, its relevance to innovation processes in services is evident, as these depend on an organized relationship between the actors to occur, as in the case of public services. Several questions remain and should be addressed in future research, seeking dialogue between social innovation and innovation in services, in other approaches and contexts, since the initiatives are recent and cover specific geographic-temporal boundaries. The impacts of initiatives of this nature, which approach the analysis of social innovation through case studies focused on urban services, will only be better understood with the continuous monitoring and evaluation of impacts and the establishment of comparative bases. Further analysis of the results of the projects studied is required, as well as the analysis of projects of the same nature in other urban contexts.

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Service innovation capabilities: toward a comprehensive framework

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Problem/Goal

Innovation capability refers to the ability of a firm to perform an innovation. There are several studies that seek to understand the innovation capabilities of firms, mainly in manufacturing industries (Yam et al., 2011; Zawislak et al., 2012). As a consequence, these studies do not necessarily fit into service specificities, such as the simultaneity of production and consumption as well as the key aspects played by relationships in service provision.

To overcome this missing link, some authors are concerned with innovation capabilities in services (e.g. Den Hertog, Van der Aa, & De Jong, 2010; Janssen, Castaldi & Alexiev, 2016). However, most of these attempts are still fragmented in a variety of theoretical approaches (Thanasopon, Papadopoulos, & Vidgen, 2016; Salunke, Weerawardena, & McColl-Kennedy, 2019). Therefore, this paper aims to systematize this literature and propose a comprehensive framework on innovation capabilities in services.

Methodology

A systematic review of the literature was carried out by using pre-validated keywords in Scopus and Web of Science databases. To define the documents to be reviewed, it was considered only scientific articles published in business, management and economics journals classified as Q1 in the SJR as well as deal with innovation capabilities in services. After purifying the analysis corpus, 108 articles were included.

Then, NVIVO software was used aiming to reach the main dimensions of analysis. The 500 most frequent words with exact correspondence were considered to create codes related to the capabilities. After that, cluster analysis based on Pearson's correlation parameters was performed, which enabled the creation of a dendrogram with the codes. The five clusters resulting from these analyzes represent the categories used to conduct the literature review.

Results

Through cluster formation, it was possible to take a first step towards a comprehensive framework of innovation capabilities in services. Following Zawislak et al. (2012), to better understand the behaviour of the firm, one should look for its different dimensions. In fact, taking in account the specificities of services, when considering the ordinary and dynamic capabilities approach (Alves et al. 2017; Teece, 2018), results show, in the five-fold dendrogram, that service innovation capabilities can be classified into ordinary - organizational capability and relational capability - and dynamic - data analytics capability, service development capability and ambidexterity capability.

Organizational Capability

Organizational capability refers to a company's ability to coordinate and use its resources to become unique. This capability must enable the company to employ and combine these resources, aligning them with the external environment. The more coherent, the greater the ability to focus on specific aspects of the decision-making process, improving service and customer satisfaction (Lin & Wu, 2008). It must involve decision makers with high levels of education and training (Ferreira, Raposo & Fernandes, 2013), in addition to an organizational climate conducive to innovation and adequate to human capital investments (Rothkopf & Wald, 2011; Wirtz & Jerger, 2017; Tuzovic, Wirtz & Heracleous, 2018). The result of this arrangement defines the strategic orientation in terms of customers, competition and entrepreneurial behavior (Grawe, Schen & Daugherty, 2009).

Relational Capability

The relational capability encompasses the firm's routines to create, maintain or extract value from its relationships with partners in a network and from customers. It involves the agile collaboration in a service delivery system and how firms engage in their relationships (Chen, Tsou & Huang, 2009).

In this sense, it is possible to strengthen the network by attracting external actors to engage in the project (Behnam; Cagliano & Grijalvo, 2018), which allows the company to better create or extract value. The restless firm – in conjunction with its restless network counterparts – is engaged in network reconfiguration rather than simply "moving downstream" (Spring & Araujo, 2013). In short, how network reconfiguration is done by service firms can allow the revelation of service opportunities.

Focusing on the customer, this capability represents the entrepreneurial readiness needed to identify opportunities to create and capture customer value. Hence, firms can improve their relational capability based on customer satisfaction, customer loyalty and company reputation (Dotzel, Shankar & Berry, 2013). Moreover, customer participation increases the personalization of service experiences and can also be strengthened with the customer's affective commitment being active participants in the co-creation process (Salunke, Weerawardena & McColl-Kennedy, 2013).

Data Analytics Capability

Data analytics capability refers to routines that focus on monitoring, analyzing and processing internal and external data to make assertive decisions regarding alternatives for change/improvement in product, process and organizational aspects. The ability to improve the digitalization of the firm encompasses the strategy to understand the granularity of existing data (e.g. open datasets) (Barile, et al., 2016; Chester & Faullant, 2018), changes in the organizational structure to launch digital projects (Achi, Salinesi & Viscusi, 2016), improvement in the IT infrastructure (Iden, Eikebrokk & Marrone, 2020), integration with the service ecosystem and generation of insights for the provision of new services (e.g. servitization) (Hunt, 2013; Chou, Chen & Liu, 2017; Kroh et al., 2018).

Moreover, some studies have found that information and communication technologies (ICT's) may ease innovation in services through the establishment of networks of actors (i.e., companies and customers) for co-creation of products and more efficient service delivery (Achi, Salinesi & Viscusi, 2016; Castro-Lucas, Diallo & Leo, 2013; Pohlmann & Kaartemo, 2017).

Service Development Capability

Service development capability stands for the challenges of incorporating knowledge and technologies to offer new services or modify existing ones. These changes may be contained in a new concept of service, a new service delivery system, or even a new interface for interaction with the consumer (Ryu & Lee, 2018).

In this regard, the flow and ability to integrate knowledge are crucial for the innovation process, mainly in the sense of incorporating behaviors and perceptions of stakeholders. The more flexible and versatile the knowledge management processes, the faster and more robust the innovation efforts. Service sectors must use versatile human resource policies to facilitate knowledge sharing among the most diverse actors participating in the service operation (Aranda & Molina-Fernandez, 2002). It is necessary to scale and conceptualize the essential resources to select an idea and develop it into a detailed proposition, possibly composed of recombined or isolated service concepts (Janssen et al., 2016).

Ambidexterity Capability

Finally, the ambidexterity deals with the agent's behavior in order to maintain and/or increase performance in response to changes in the environment. In this sense, it is fundamental for service innovation as it leads to sustained service innovation performance (Tuzovic, Wirtz & Heracleous, 2018). The firm would then need to be able to carry out an environmental scanning, which would allow it to understand the current context, enabling managers to make decisions for the company's future (Chang, 2018). Once this environment is understood, the key term for the firm would be flexibility. In an increasingly dynamic environment, the company must be able to adapt through the creation of flexible organizational structures and systems (Ferreira et al., 2013; Anning-Dorson & Nyamekye, 2020).

IDEA - Towards an interactive intelligent supportive tool that facilitates collaborative creativity sessions

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Introduction

To come up with new ideas and innovations, product developers are faced with the challenge of finding a suitable way through a jungle of tools and methods, e.g., creativity tools, CAD software and project management applications. Every tool is developed to support them during the creativity process, but only covers a part of the process. Therefore, product developers are faced with dealing with multiple applications simultaneously. The usable space for software applications on common work environments is usually limited by displays on personal desks or wall displays in conference rooms. This leads to application switching and/or splitting up the already limited screen space. Furthermore, due to the vertical arrangement of these screen spaces and limited interaction usually being performed by one presenter, collaboration takes place in a hierarchical manner and impacts the interaction of a team (Al-Megren et al., 2015).

Moreover, during the early stages of product development product developers have a variety of different methods at their disposal and new methods are continuously being developed and established (Becerril, Guertler, & Longa, 2019). This leads to a "method and application jungle" in which it is difficult for product developers to find the most suitable way to solve a problem. Therefore, it is essential to not only provide a suitable interface and surface solution to enable mutual interactive space to collaborate on, but also to incorporate guidance to support product developers in this jungle of methods and applications to find a suitable path.

To dissolve these restrictions, an interactive surface that enables horizontal collaboration and interaction during creativity sessions in product development, integrating a variety of applications (e.g., whiteboard, CAD) to collaborate with simultaneously, is proposed. In this paper previously elicited requirements are presented in a first coherent digital assistant tool that guides product developers through the creativity process (Kaschub, Wechner, Lossack, & Bues, 2021). In the first part of the paper the process from requirements to a holistic concept is illustrated. In the second part the concept is presented with a description of its different features. The paper concludes with a discussion of the presented concept and proposes future research.

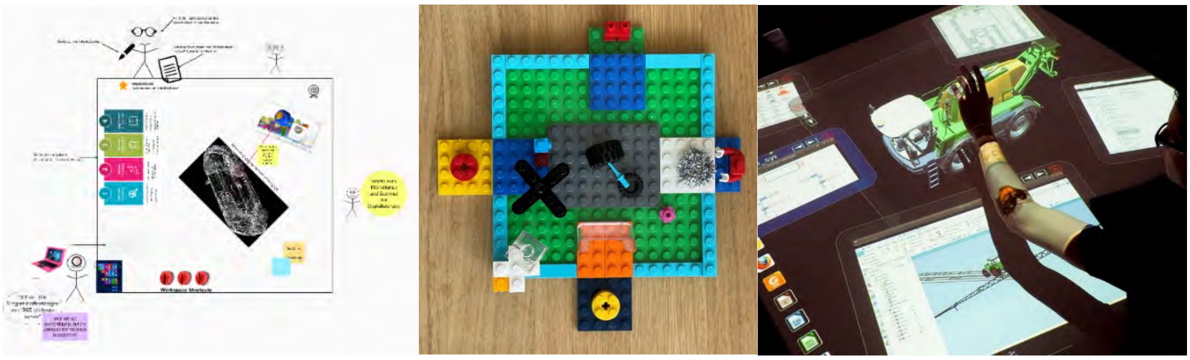
From Design Space and Requirements to a Creativity Support Tool Concept

In a previous multi-stage explorative study, requirements were elicited which form the foundation of a supportive tool for product developers that tackle these different shortcomings of conventional settings. In the first part of this study, digital expert workshops were used to set up a design. This space is defined by a variety of dimensions, for example size, color or tactile quality of a product. Dimensions can also be more complex, such as interaction and connectivity (Flemisch et al., 2013). In the second and third phase of this study, the design space and its dimensions were explored further to elicit specific requirements for the different dimensions. The aim was not only to derive relevant requirements but furthermore form a first vision for a supportive tool concept. These dimensions span the design space and its requirements to provide the framework for the exploration of this paper.

The results of the previous study suggested a vision of a supportive tool that provides a holistic understanding of the creativity process and its activities by integrating a variety of tools in a digital environment (preferable a tabletop) as well as providing guidance for product developers to structure their path through a jungle of tools and supporting methods. The supportive tool should pave the way to a new form of digital collaboration and furthermore enhance the acceptance of creativity methods. Moreover, the tool should be adaptive and provide the suitable assistance based on the users’ current needs and their environment (e.g., time limits). According to Kaschub et al. (2021) these functionalities should be unobtrusive and minimalistic in order not to disturb or distract from the process itself.

Therefore, as a next step these previously elicited requirements were then applied to the design principles of Shneiderman (2007) regarding creativity support tools. These principles functioned as orientation to further structure ideas and guide the concept into a synergized solution. To back up this fusion of different ideas and specifications into one holistic concept idea, LEGO® Serious Play (LSP) was applied to iteratively come up with a consolidated view. In total three sessions took place in which researchers that accompanied the workshops composed a first vision. An evolution of the concept from idea sketches to a LSP concept is shown in Figure.

Figure 1: Evolution IDEA (from digital paper prototype to LSP concept to ProTable prototype)



Technical Foundation

A variety of features was added during the different sessions to frame the concept. The final concept is based on an interactive tabletop, the ProTable (see section 0) to enable collocated collaboration with different digital tools. This setting provides functionalities to implement key requirements such as common and individual space (see section 0 and 0) and integration of two- and three-dimensional physical objects (see section 0) The following sections provide further details on the different specifications and functionalities of the supportive tool. These specifications are each followed by a proposition for the technical implementation. A final view of the concept is shown in figure 5 to get a better grasp of the concept.

ProTable

The tabletop ProTable forms the basis of the concept (see figure 2). It is a digital work environment for meetings and group collaboration. It enhances the familiar way of working at a conventional table with paper documents and physical items by extending it with the ability to work seamlessly with digital documents on the same table surface. According to Mateescu, Pimmer, Zahn, Klinkhammer, & Reiterer (2021) positive effects in collaborative settings of tabletops can be knowledge gains and enhanced social indicators as well as positive effects on task-related outcomes. To ensure that users can benefit from a tabletop environment, clear separation of personal and group spaces should be implemented (see following sections) (Mateescu et al., 2021) .

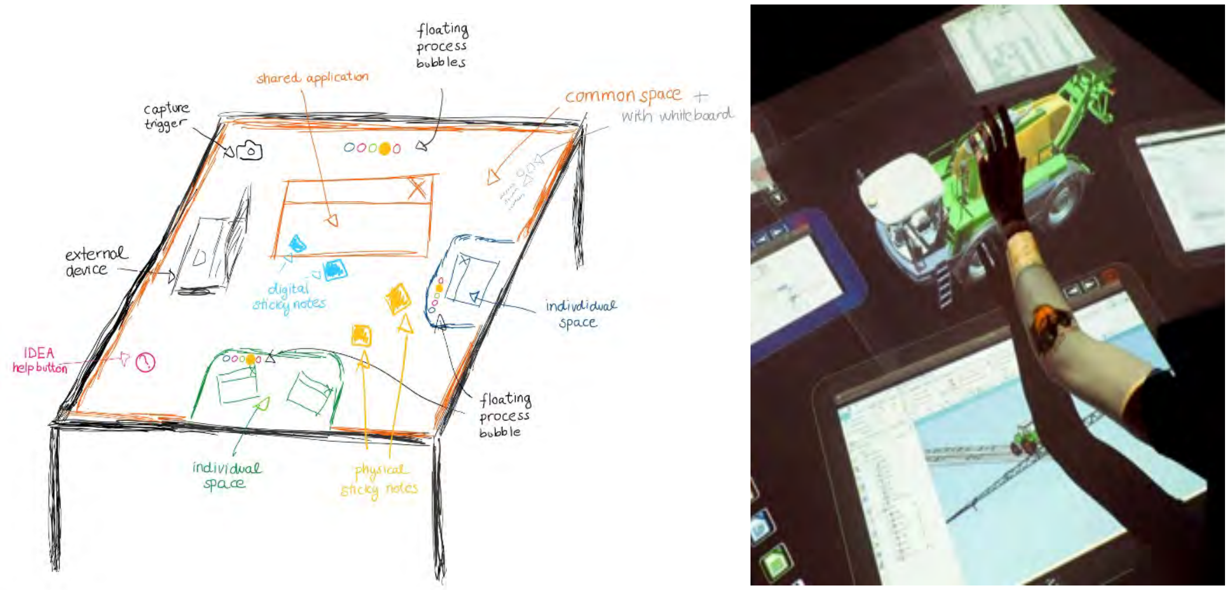
The hardware of the ProTable consist of high-resolution projectors and a camera system mounted over a table. Typical ProTable configurations provide a resolution of at least 55 dpi, providing good text readability. The projectors create an image on top of the table and the camera system tracks finger touches and head movements to make the surface interactive. In addition to the camera input, conventional mice and keyboards can be used. On the tabletop surface, users can work with the same familiar software applications they normally use on their desktop computers. The windows of these applications can be arranged in a way that mimics the familiar handling with paper, e.g., windows can be freely rotated, moved and stacked. Additionally, the applications can also be scaled, in addition to the usual resize function.

According to Kaschub, Wechner, Lossack, & Bues (2021), the integration of three-dimensional content is a required feature. Besides two-dimensional applications, the ProTable therefore supports three-dimensional content which can be arranged on the tabletop in a similar manner as the applications. Furthermore, by tracking the users' head position, the three-dimensional content can be displayed in a perspective correct way to enhance the spatial perception e.g., the virtual three-dimensional content appears to the users as if it stood physically on the tabletop.

The software that enables the illustrated visual representation and interaction of two- and three-dimensional content is Virtual Desktop One (VD1). It is deeply integrated into a Linux system and is developed by Fraunhofer Institute for Industrial Engineering (Bues, Wingert, & Riedel, 2018).

In spite of being a rectangular table, the users can interact from all four sides. In this concept however it was decided to only use three sides, to enable the users to work on content together without mentally rotating it. This might otherwise distract from the discussion and process itself due to mental capacity occupied for rotation (Xu & Franconeri, 2015).

Figure 2: IDEA – creativity support tool concept sketch and prototype



Individual Space

According to Klinkhammer, Mateescu, Zahn, & Reiterer (2018) territories help people to coordinate their task and social interaction at large interactive tabletops. To provide product developers with their accustomed digital environment an individual space was therefore integrated to the concept (Sinmai, 2016). The individual space is located **directly in front** of each product developer on the ProTable. Inside this space, product developers can open their familiar application and access their personal data. Depending on their preferences, this space can be directly projected and **integrated** on the ProTable itself or **external hardware** (e.g., Laptop, Tablet) can be connected to the tabletop environment. The latter solution provides more privacy to the user and provides the users with the possibility to shift and relocate themselves in-between creativity sessions (for example incoming phone calls without changing hardware). The users themselves decide which applications run inside their individual space (e.g., when talking about a previous prototype, the user can open the mail that suggested shortcomings on this specific prototype).

The technical implementation differs whether the individual space is within the ProTable environment e.g., VD1 or on an external hardware. In VD1, a user management is implemented, which connects input devices, touch inputs, application launchers and application windows to certain users. Therefore, interactions with applications inside foreign individual spaces can be prevented by VD1 itself. On external hardware the concept of the individual space exists implicitly, as no other user can interact with the device.

Common Space

The common space occupies the whole tabletop (Sinmai, 2016). The main functionality of the common space is to provide a **whiteboard tool**. This can be a specifically developed tool within VD1 or existing software such as MURAL (2021). Here, product developers can take notes and sketches. The interaction functions via a digital pen or via mouse and keyboard. This whiteboard tool is always on bottom and like a vertical whiteboard, extras can be added on top. These extras can be **digital** (CAD, project management tools, calculation…) as well as **analog** (post-its, clay, prototypes etc.).

To open additional applications on top of the whiteboard, the current running tool from the **individual space can be shared** to the common space by dragging the window into the common space or using a custom share tool on external hardware. When shared to the common space, every user can interact with the application. The common space itself provides no app launcher. Instead, users will open applications inside their individual space and share them. This reinforces exchange and discussion of ideas between users. Applications in the common space can only be dragged into its owner's individual space, so nobody else can get the 'exclusive control' over the open window. 'Closing' an application has the same effect e.g., the window switches back to the respective individual space and is no longer shared.

When an app is shared, the window can be changed in size (scale as well as resize) to accommodate the current needs of users. The shared windows cannot be duplicated to prevent confusion and mental rotation during discussion (one user points at a detail in the specification sheet and other users would need to mentally rotate their position on the document to match their own view) (Müller, Hesse, & Meyerhoff, 2021). These functionalities of the common space provide an integration of almost any app to accompany the individual preferences of users' tools as well as corporate guidelines (e.g., using company specific software).

From a technical point of view, the common space lives within VD1. If a window originates from an individual space within the ProTable, the window's user´s privileges must be adjusted in VD1 to enable interactions to all users. If an application is shared from an external device, a screen sharing protocol (e.g., WebRTC, 2021) will be used to transfer the application's visual content to the ProTable. The inputs which are executed inside the common space are then sent back to the device and applied locally (e.g., via WebRTC's data channel). Like so, applications seem to run in the ProTable's common space, while remaining on the external device.

Analog and Screen Capture

According to Kaschub et al. (2021) a tool that captures physical three-dimensional content for further digital processing is required by product developers. Therefore, different approaches could be used like structured light (Bell, Li, & Zhang, 2016) or photogrammetry (Ma, Kosecka, Soatto, Sastry, & Koˇ, 2006). The camera system can also be used to digitize 'two dimensional' physical elements like sticky-notes using state of the art computer vision. Software libraries for these use cases already exist (e.g., "Structured-light 3D scanner," and PhotomodelerTechnologies) and can be adapted to the ProTable's hardware. Since the ProTable already uses projectors, these could be re-used for structured light and camera calibration.

To enable the feature of analog capture, a 3D-scanning technology and tool must be picked and linked to VD1 to transfer physical objects into the ProTable environment as three-dimensional content. The system design and actual implementation of such an analog element capturer is an ongoing process and beyond the scope of this paper.

As the ProTable uses VD1 as window manager, the user privileges, position, orientation and scale of every open window as well as its content (including three-dimensional content) is always accessible in software. Therefore, a capturing of all windows in the common space into an image stream can be performed to document the work process.

IDEA - Interactive Intelligent Supportive Tool

IDEA (Integrated Development Environment Assistant) extends the described technical foundation and forms a personal assistant that analyses and manages the creativity process, applications and other features. IDEA's purpose is to analyze the process and its users in the background and only intervene and be noticeable when needed (e.g., make method suggestions) to keep the focus on the content and process itself. As an assistant, the role of IDEA is to stand in the background and unobtrusively provide tools (e.g., track changes in workspaces) that fit with users' current needs. The following sections provide an overview of the different functionalities of IDEA.

Floating Process Bubbles

To provide an overview of the creativity process and its phases (and the phases and sessions already executed beforehand), IDEA tracks different workspaces of the phases of the creativity process (e.g., 'idea generation') in so-called **floating process bubbles** (see Figure). A workspace in this context consists of all elements used during a phase (e.g., shared applications, whiteboard, 3D content…) that are visible on the common space. The floating process bubble of the current phase that is worked on/in is highlighted to provide orientation for users within the process. Furthermore, the edges of the table are colored in the same color (see figure 3). By clicking or touching a process bubble, the common space switches to the corresponding workspace. When a process bubble of a past phase is accessed, the last working state is presented (data from capture functions). Within this specific bubble the possibility exists to view the chronological progress of the phase itself (e.g., to research how an idea might have evolved or results that might not have made it to the final workspace). This can be done via a **timeline function** that merges the different screen captures of the workspaces.

The process bubbles are draggable as a whole and float over the other applications on the ProTable and are therefore always accessible. Furthermore, the process bubbles of IDEA also function as an external application on the personal hardware or the individual space directly integrated to the ProTable to be able to track or view sessions when not working directly at the ProTable. Here, the workspaces of different phases can only be viewed, but not changed or edited, to assure that results and changes are agreed on with the whole team.

Figure 3: Floating Process Bubbles during first phase (current phase is highlighted)

Creativity Method Integration

To assure guidance within the phases of a creativity process, IDEA can make **method suggestions** that fit the current context. This method suggestions can be, for example, based on situational context factors such as 'available time', 'number of people', 'available infrastructure'. These situational factors can be chosen according to factors presented by (Albers, Reiss, Bursac, Urbanec, & Lüdcke (2014). Here, situational aspects were chosen to determine the most suitable method in this context. The tool suggests an applicable method and asks if users want to proceed. If users decline, the tool only suggest a new method at the beginning of the next phase in order not to be intrusive. If users revise their decision within the phase, they can ask for guidance via the IDEA help button.

When the product development team decides on a suggested method (e.g., 635, gallery method), IDEA provides them with **instructions and a template** to guide them through the different steps of the method and support the documentation of the developed results. An example for suitable templates and methods for IDEA could be the 'Toolkit' by Lewrick, Link, & Leifer (2020). Here, templates are available that guide users through the different steps of a method while also connecting these steps with spaces for result documentation. These templates are opened on the common space, while the functionality to use the other applications above remains.

Based on users' preferences and data tracked during usage (method completed, method suggestion rejection, time spend…) IDEA's future method selection can be adapted. IDEA could learn from users' preferences to suggest and accommodate users' future needs.

Digital Workspace and Physical Workspace Capturing

When digital apps are not sufficient to support the creativity process, IDEA is able to capture physical elements. During the product development process these can, for example, vary from sticky notes to LEGO, applied during different creativity methods that aid the process, up to MVPs (minimal viable product) and prototypes of the actual product itself. IDEA already captures the workspaces of the different phases (see section 0). To document the elements used on the ProTable's surface, the analog capturer is integrated. The analog capturer tracks all utilized physical elements during the creativity process automatically with a frequency depending on the current phase. Therefore, the analog capturer creates a digital copy of the analog elements (either two or three-dimensional) and stores it inside IDEA's database. IDEA uses this data to track work environments which consist of the digital workspace and the (digitalized) physical workspace.

In the early phases the workspace is captured every minute and when proceeding to the next phase. During later phases (e.g., idea generation or prototyping) the intervals increase to 30 seconds. Additionally, IDEA integrates a floating camera icon on the common space that enables capturing triggered by users themselves. The tracked work environments (digital workspace and physical workspace) can also be viewed within the phase bubbles to enable 'rich history' keeping of the process (Resnick, Myers, Nakakoji, Shneiderman, & Pausch, 2005). The analog capturer does not track the whole development process via a video function, firstly in order not to intervene in the process by disturbing the privacy of individuals/team and secondly not to overwhelm users later when tracing back the process.

Retrospective

Another feature that supports 'rich history' keeping and the functionality of tracing back ideas is the '**Retrospective'** function of IDEA. Here, users are asked to evaluate their working progress after a phase is finished or when the session has ended. IDEA provides the users with guided questions to structure the results and tag important information. Therefore, users are presented with the current state of their work environment that is tracked by IDEA. Depending on available time, developed content and users' current preferences, different levels of detailing of the retrospective are possible. The least detailed level can accommodate situations with limited time for reflection. Here, IDEA only asks for three 'tags' that represent and describe the current work environment the best. These 'tags' are layered over the blurred work environment as 'blops' (Brade, Heseler, & Groh, 2011). These 'blops' provide an immersive kind of data grasping (Brade, Keck, Kammer, & Groh, 2011). If more time is available, the retrospective can be executed on a more detailed level. Here, users are asked to connect elements of the work environment with 'blops' that contain the summarized tags. Like in mind maps, this creates a hierarchal structure with connected spatial data/information. Furthermore, tags can later be directly traced back to the data they evolved from. This enables a 'richer' kind of history keeping, although mental capacity and therefore time needed is higher. Retrospectives are performed in the same space as the results themselves. This enables users to spatially link their aggregated results directly to the data it has evolved from.

In conclusion, the retrospective constructs a memory log of group knowledge from data acquired during the session. It ensures that data can be aggregated and therefore structured by users themselves in a unique way. This might lead to a higher degree of consensus due to actively needing to reflect and discuss the results within the group. Furthermore, new ideas might arise when discussing current data.

When a retrospective of a session/phase/current working state exists, users have the option to trace back results. These can be not only results from current projects, but also results of previous projects with similar topics. Former results might aid the current creativity process itself by studying solutions derived from previous problems.

Figure 4: Retrospective level of first phase (blue floating process bubble) in ZUI – tagged main results on blurred whiteboard

ZUI – Zoomable User Interface

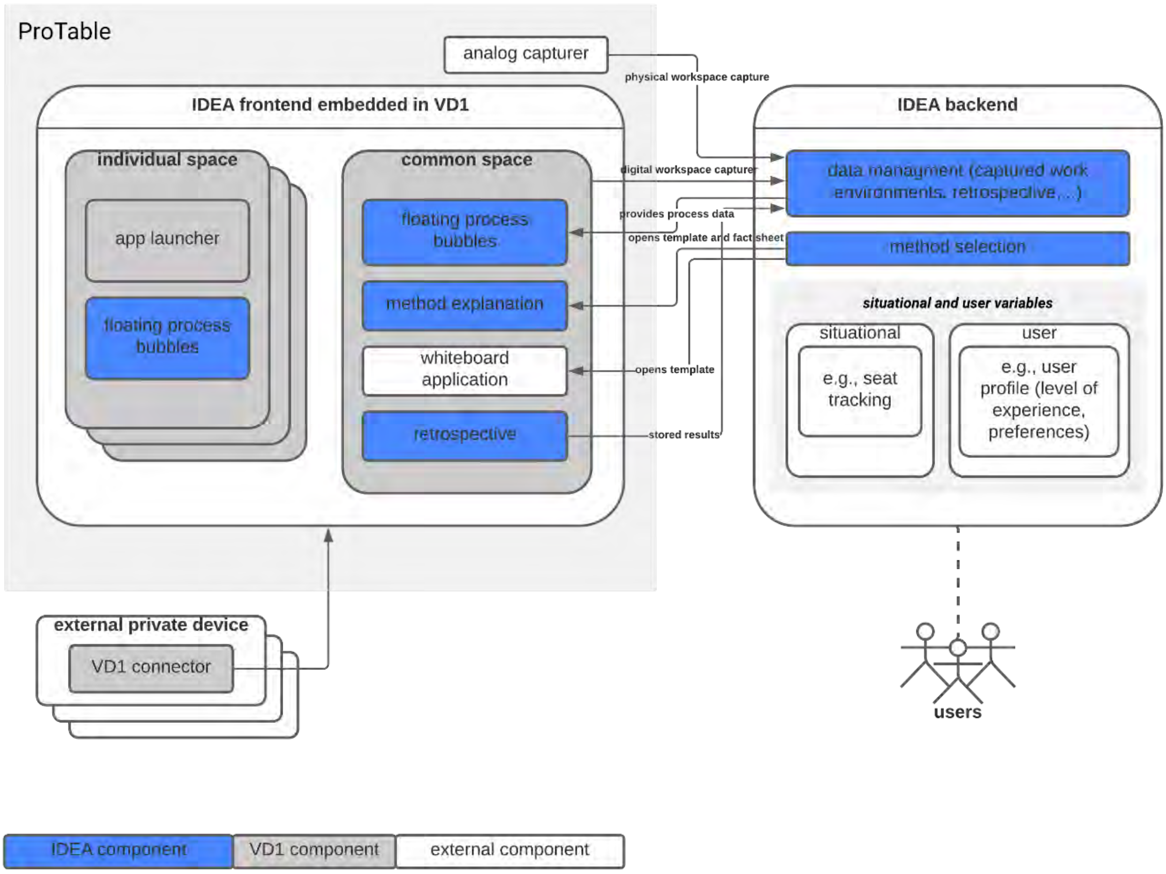
To provide a comprehensible view of the individual creativity process with different degrees of abstraction for product developers, IDEA connects and links different process levels in a zoomable user interface (ZUI). This ZUI connects three different layers to an integrated spatially connected view, the highest level being the process bubbles (see section 0). When orthogonally zooming into a process bubble (e.g., ideation) the middle level is visible. This level shows the retrospective and aggregated results (e.g., ‘blops’ with tags and important connected results). When zooming in further, the lowest level is reached, the workspace/work environment. Here, all data can be viewed based on the screen and analog capture feature. The last state of the work environment can be viewed as well as the history that this work environment evolved from (via the timeline function).

In general, the 'zoom in' function enables the users to view the available data on a detailed level. ‘Zooming out' of the objects conversely, provides more of the overall view with less detail (Brade, n.d.; Brade, Heseler, et al., 2011). By adopting this type of UI, information and data can be organized and connected spatially. This can lead to a lower cognitive load and aids conceptual learning (Akgün, Babur, & Albayrak, 2016).

Adaptability

The adaptability of the levels of support was stated as a main requirement for user acceptance of a supportive tool. Therefore, every functionality of IDEA can be disabled/enabled or changed according to users’ preferences, situations and needs. This allows IDEA to serve as a highly structured assistant (method suggestions, structuring of methods, capturing ideas, process reviewing…) - to an interactive table that only shares applications and enables note taking. Users can decide for themselves how engaging the interaction between them and IDEA should be.

Figure 5: Concept Overview



Conclusion and Discussion

According to the consolidated requirements stated in Kaschub et al. (2021), Dieterich, Kaschub, & Ohlhausen (2021) and the design principles suggested by Resnick et al. (2005), a first coherent concept of an intelligent and interactive creativity support tool was developed. The concept considers the main requirements: being intuitive and easy to use, providing freedom in levels of assistance to users and only integrating minimal add-ons while not being too intrusive to disturb the creative process itself. The concept integrates different features, such as the common and individual space on an interactive ProTable or the 'Retrospective' functions to retrace results. Its main feature IDEA provides the possibility of an intelligent digital assistant during the creativity process. A first step is taken towards answering the research question on how to integrate applications in one work environment while also supporting users and guide them through the creativity process.

The concept is based on theoretical design principles and elicited requirements. Further evaluation e.g., user testing with first prototypes could lead to new insights and further specify and revise the concept. Features might not be accepted by users and therefore need to be adapted or eliminated completely. Therefore, it is essential to let users experience the concept directly to fully comprehend these features. Although IDEA provides the option to disable all features, there might still be features that need to be changed in the base version of IDEA. This could be especially important for the ZUI and the corresponding process bubbles and retrospective. These features are highly correlated to the content level. Depending on the developed kind of data (e.g., sketches, notes …) the retrospective and its levels of details or the aggregation itself need to be adjusted. To evaluate the tool with users, a creativity support tool index could be applied, such as the support index from Cherry & Latulipe (2014).

Although a big part of the technical foundation is already available, missing functionalities like the analog capturer imply defining its technical concept and implementation. Such integrations and developments always entail the risks of not performing as expected.

The integration of third-party tools like MURAL involves the risk of not providing all functionalities needed to seamlessly use the creativity support tool. One example is that MURAL does not support collocated multiuser inputs. A workaround could be looping the local user inputs via different accounts into the web application. An alternative approach is implementing custom whiteboard functionalities in VD1. This would eliminate the disadvantages of integrating existing tools but brings all the disadvantages and risks of new development.

Future research should therefore focus on an existing use case where the features can be tested and evaluated within a realistic setting and provide users with the possibility of comparing the functions to their current setting. Moreover, a closer look should be taken at the option if data derived from the different levels of the process can be used for automating future creativity sessions of the tool. For example, on a content level – suggestions of IDEA can be made about similar ideas developed with the tool before; on a process level – suggestions on methods that worked well during a specific phase of the process; and on a user level – adapting features to user preferences. This can uplift IDEA to an assistive artificial intelligence that can adapt to its environment.

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Towards a Shared Understanding in Transdisciplinary, Experiential Entrepreneurial Education

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Introduction

Background

Entrepreneurial education, since its beginnings at the start of the twentieth century, has grown into a key aspect of higher education offerings around the world. Entrepreneurial approach has entered to the missions of universities (Etzkowitz, Chou, 2007). Universities have become the institutions for the training and educating of entrepreneurs, and "putting the knowledge to use" through entrepreneurship (Etzkowitz, Chou, 2007).

Further, the *"legitimation of economic development as a function of higher education"* (Philpott, Dooley, O'Reilly, Lupton, 2010) has highlighted the importance of understanding of the methods and applications of entrepreneurial education within universities. The core functions of an entrepreneurial university can be classified into three key areas: research, entrepreneurial activity, and teaching (Guerrero, Urbano, 2010).

The entrepreneurial education itself can be classified into 1) learning to understand entrepreneurship, 2) learning to become entrepreneurial, and 3) learning to become an entrepreneur (Hytti, O'Gorman, 2004). After identifying the purpose of entrepreneurial education (teaching about, for, or through entrepreneurship), the teaching methods are identified – experiential teaching methods, often referred to as "learning by doing," are seen as a valued and appropriate method (Gibb, 2002). The extant literature agrees that the applied nature of business education makes "*entrepreneurial education an appropriate discipline for the use of experiential learning pedagogies*" (Gentry, p.12, 1990). The experiential methods for teaching entrepreneurship may include, e.g., consulting projects, placements in entrepreneurial businesses, simulations, and initializing startup businesses (Mason, Arshed, 2013).

The field of experiential entrepreneurial education has seen an increase in the use of transdisciplinary teamworking environments as a teaching method. Moreover, as outlined by Gibb (2002), entrepreneurship programs should be taken out of the "out of the locker room of economics," and placed in a "wider, interdisciplinary context." Regarding the term transdisciplinarity itself, Nicolescu (2005) makes clear distinction between transdisciplinarity and more familiar concepts of multidisciplinarity and interdisciplinarity. Multidisciplinarity concerns itself with studying a research topic in not just one discipline only, but in several at the same time. Interdisciplinarity, in turn, has a different goal: it concerns the interaction between disciplines with focus on the transfer of knowledge and methods from one discipline to another. Transdisciplinary perspectives, on the other hand, consider both relevant disciplinary and domain knowledge, and additional, relevant external factors such as culture, shared understanding and definitions, as well as experiences (Nicolescu, 2005; Hyun, 2011; Jahn et al., 2012).

However, entrepreneurial universities today still have certain limitations in their understanding of the roles and actions of the different stakeholders (the role of the educators, students, and the student teams) that are involved within transdisciplinary, experiential entrepreneurial education. Therefore, in this study, we draw on existing literature within entrepreneurial education and empirical research on experiential learning methods to outline the foundations for successful implementation of transdisciplinary, experiential entrepreneurial education. Thus, the research question of this study is:

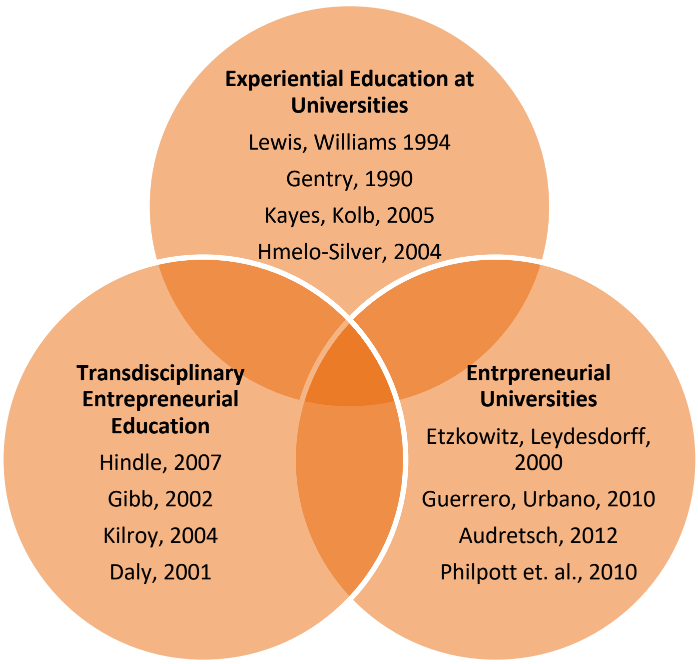
RQ: What are the foundations for the successful implementation of transdisciplinary, experiential entrepreneurial education?

Purpose of Research

As outlined previously, the limitations in the understanding of the role of the stakeholders, primarily the educators, followed by the students and student teams, requires us to take a closer look at the foundations for the successful implementation of transdisciplinary, entrepreneurial education. Research on entrepreneurial education and entrepreneurial universities has discussed the emergence of an experiential approach for teaching entrepreneurship. Experiential entrepreneurial education, however, comes with own set of challenges: 1) shifting from a push to a pull model of learning, 2) adjusting the level of involvement of students and level of control exerted by the faculty, and 3) the sufficient facilitation of knowledge creation processes.

To understand and mitigate the mentioned challenges, we identified three themes that were then explored through an empirical study. We looked at a pilot on entrepreneurial education aimed at master's students, gathering perspectives from the students, faculty, and the organizing committee. First, we aimed to understand the evolution of archetypes on entrepreneurship. This pertains to the skills, aptitudes, and traits we associate and attribute to entrepreneurs. Second, we looked at transdisciplinarity, and its possible effects on student motivations and team dynamics. Here, we focused upon possible factors that may enhance teamworking capabilities, and how student teams can communicate and integrate transdisciplinary practices within their study modules. Thirdly, we explored narratives on entrepreneurial universities, looking at the definitions and perspectives on entrepreneurial universities, looking at the possible implications on educational institutions. This involved looking at the roles, functions, and limitations of entrepreneurial universities, and juxtaposing them to other, 'traditional' universities. Consequently, the research makes use of existing literature within the paradigms of experiential education, entrepreneurial universities, and transdisciplinary, entrepreneurial education (see fig.1).

Figure 1: Research Focus Areas



Methodology

A grounded theory approach was used to explore the phenomena under interest. The study takes an approach to grounded theory that is closest to Charmaz's (2006) perspective – which recreates grounded theory from a constructivist perspective, and particularly outlines that meaning is derived by the "mutual interpretations" of researchers and participants (Sato, 2019). Moreover, when comparing between Glaser (1967) and Strauss & Corbin's (1997) perspective to grounded theory, this study aligns closer with the latter – where the focuses lie not only on the creation of theory through induction, but also deduction and verification (Clooney, 2010 cited in Sato, 2019).

A case study approach was utilized to provide a context that allowed for multiple perspectives and the exploration of a phenomenon and discovering meaning through interactions with the stakeholders (Licqurish S, Seibold C, 2011). The case for this study was the *Young Innovator and Entrepreneurs Pilot* which was run under the overall ATTRACT Phase 1 initiative. ATTRACT, as an initiative, aims at "bringing together Europe's fundamental research and industrial communities to lead the next generation of detection and imaging technologies" with the "larger vision of creating a thriving co-innovation ecosystem between research, and industrial communities" (ATTRACT, n, d.). Within this large initiative lies the Young Innovator and Entrepreneurs Pilot where "students from Aalto University, ESADE Business School, the Polytechnic University of Catalonia (UPC) and IED Barcelona Design School worked with 10 ATTRACT projects to develop applications needed for their innovations." The goal of the pilot was to test and bridge the gap between fundamental research and product/service development methodologies by connecting the two stakeholders together – providing a new pilot in entrepreneurial education at a European level.

The empirical evidence was derived with a total of 22 interviews conducted in a semi-structured format. The informants were selected using theoretical sampling, garnering a rounded representation of the participants within the pilots, prominently featuring the organizing committee, the students involved within the pilot, and the teachers/faculty responsible for the implementation of the pilot. 22 semi-structured interviews were conducted over two rounds, with 12 in the first round and 10 in the second round. The participants were assigned to three possible groups: the organizing committee (n=7), the academic faculty (n=5), and the active participants of the Young Innovators and Entrepreneurs Pilot (n=10).

On average, the interviews lasted approximately 40 minutes; with interviews with the organizing committee being the longest, while the interviews with the active participants being the shortest. The interviews were all conducted in the same manner – virtually and recorded. These interviews were then transcribed using third party services and then by the author, after which they were coded using a line-by-line coding process. The codes were then consolidated and converted into first and second order codes using the Gioia Methodology (Gioia, Corley, Hamilton 2013). The data was analyzed using a constant comparative method (Charmaz, 2006).

Background for Research

Entrepreneurial Education at Universities

Entrepreneurial education at universities, from its beginnings in the 1940s, has now developed into various courses, degrees, and programs all over the world. As outlined by Hytti and O'Gorman, entrepreneurial education can be classified into three key areas: understanding entrepreneurship, becoming entrepreneurial, becoming an entrepreneur (2004). However, models for teaching and defining entrepreneurship are varied and different.

Moroz and Hindle (2011) view factors such as modality, generality, and the level of analysis as aspects to consider when defining and teaching entrepreneurship. Hindle views the field of entrepreneurship as the "scholarly examination of how, by whom and with what effects opportunities to create future goods and services are discovered, evaluated and exploited" (p.107, 2007). Perhaps a key differentiator for entrepreneurial education from other similar subjects and topics is that it should address "the equivocal nature of business entry" – providing education in topics like negotiation, leadership, new product development, creative thinking, and exposure to technological innovations (Garner, Bird, Starr, 1992, cited in Kuratko, 2005).

Figure 2: Key Areas within Entrepreneurial Education

Since its inception, entrepreneurial education today encompasses several domains and fields of knowledge. For the purpose of this study, entrepreneurial education within universities can today be classified into the three key areas outlined by Hytti and O'Gorman; however, with several overlaps in terms of the topics, aspects, and subjects considered within those (see fig.2). Looking more in detail, these three areas focus upon the skills associated with an entrepreneur and entrepreneurship, provide a succinct understanding of the entrepreneurial ecosystem and business environments, and education into topics such as negotiation, venture financing, and evaluation of opportunities (see fig.2).

Moving from the "what" to the "how," several scholars have advocated for the utilization of a learn by doing, experiential method of learning (Gibb, 2002; Clark, 2000; Balan, Metcalfe, 2011; Hindle, 2007). As advocated by Neck and Greene, they view entrepreneurial education as a method; one that should consist of a body of skills or techniques, a toolkit as opposed to a process, be creative, iterative, encourage experimentation, and one that adopts a practice-based approach (2011). Experiential entrepreneurial education also shifts from a "push model" of learning to a "pull model," one where the students access a range of learning sources when required (Rae, 2012, cited in Mason, Arshed, 2013). This demand led approach to education also means that the support for the students in provided in "ways that are unplanned, emergent, short-term and non-sequential" (Mason, Arshed, 2013). Consequently, perhaps, educators have to tolerate the "serendipitous experiential nature of learning outcomes" (Daly, 2001).

Thus, in experiential entrepreneurial education, the key aspects that affect the education and the subsequent roles of the educators and students are: the level of involvement (from both the educators and the students), the proximity to 'real life' and entrepreneurial environments, the depth of learning (from low to high), the facilitation of knowledge creation processes (by educators), a shift from a push to a pull learning model, and changes in the control exerted by the educator (typically from high to low).

Educators within Experiential Entrepreneurial Education

Educators within experiential education as a whole, and experiential entrepreneurial education in particular, shift from their traditional roles as teachers into facilitators. In this role, the educators are expected to use their expertise to provide "encourage and guidance" to the students (Kilroy, 2004). In a larger sense, Luczkiw advocates for educators within experiential entrepreneurial education to view themselves as "agents of change – committed to engaging, enabling, and empowering students to become enterprising" (2007). In a similar vein, Hmelo-Silver views the role of the facilitators as the ones to provide the "metacognitive scaffolding" for the students, enabling them to understand, reflect upon, and synthesize their learnings from the education (2004).

For experiential entrepreneurial education, it is argued that a team of diverse educators, as opposed to a single or similar individuals, may be more beneficial (Gibb, Hannon, 2006; Hindle, 2007). This, of course, can be justified due to the complex and multidisciplinary environments in which experiential entrepreneurial education usually thrives. As Gibb states, taking entrepreneurship "out of the locker room of economics" and into a context "that is built upon a diffused view of society and of the cultural nature of markets" (2002). Then, as stated by Allen et al., experiential entrepreneurial education as a whole benefit from an "integrated, multidisciplinary knowledge base" (Allen, Donham, Bernhardt, 2011).

Moreover, educators within this paradigm can also be from a non-academic background, such as entrepreneurs, lawyers, accountants, and consultants. However, demarcating clear roles and tasks for external educators such as entrepreneurs is an essential aspect to, as Hindle highlighted, avoid misconceived beliefs such as "only those forged in the fire of practical experience have a 'right' to teach entrepreneurship (p.114, 2007)" and an over-emphasis on "war stories" as mentioned by Hayward (2000, cited in Gibb, 2002). In a positive light, external educators such as entrepreneurs can provide appropriate role-models for the students (Azizi, Mahmoudi, 2019). And as pointed out by Luczkiw, additional (external) stakeholders can provide the faculty with "access to external core capabilities" such as additional mentoring, legal or financial advice, for example (2007).

To summarize, educators within experiential entrepreneurial education have to find the right balance between coaching and teaching (Hytti, O'Gorman, 2004). Moreover, the educators need to be able to identify when a student or a team may require assistance, when certain lectures may be beneficial, and how certain information and knowledge may be best delivered to the students and the teams.

Students within Experiential Entrepreneurial Education

Students within experiential entrepreneurial education also need to have certain skills and characteristics that can assist in learning through a "pull based" learning model and system (Rae, 2012; cited in Mason, Arshed, 2013). Motivations, characteristics, and attitudes were seen as key factors in understanding why students may opt for entrepreneurial education (Duval-Couetil et al., 2014).

Critical reflection is seen as an important factor in benefiting from experiential education (Lewis, Williams, 1994). As experiential entrepreneurial education is largely based upon experiences and situation-based learning, students have to be given opportunities to "articulate their thoughts and feelings as to what the experience is involving" (Gentry, p.14, 1990). More specifically, Cooper et. al., advocate that reflection upon the experience is essential for the students to reap the benefits (2004). This, of course, strongly links back to Hmelo-Silver's comments on educators having to provide the necessary "metacognitive scaffolding" for the students (2004).

Furthermore, the use of teams, and more specifically multidisciplinary and diverse teams, is advocated for within experiential entrepreneurial education. Team based learning has been seen as more engaging (Balan, Metcalfe, 2011), and multicultural teams were also deemed efficient in strengthening global competencies within teams in one study (Oda et al., 2017). Bailey et al. have also indicated the advantages of cognitive diversity within team-based learning activities (2021).

However, it is also stated that while the diversity is desirable, the student perceived benefits of interdisciplinary knowledge are not always guaranteed (Garcia-Rodriguez et al., 2012; Lüthje, Prügl, 2006 as cited in Bailey et al., 2021). To facilitate positive results, developing a shared sense of purpose within the team is deemed essential (Kayes and Kolb, 2005). The team members should feel included within the process, and a sense of trust and psychological safety should also be present within the teams (Kayes and Kolb, 2005). This is of course something that both, the educators, and the students themselves must provide within experiential learning environments. This is perhaps where the jigsaw model where team members view themselves as different pieces of the puzzle fitting in together to create effective teams is beneficial (Aronson, Patnoe, 2010 as cited in Bailey et al., 2021).

Thus, student teams within experiential entrepreneurial education should ideally be a multidisciplinary, motivated, reflective group of students who then are supported by facilitators and educators in a pull-based learning model. As outlined by Kayes and Kolb (2005), students within these teams can then specify roles for teamwork between action, analytical, information, and interpersonal roles. By outlining these roles; in terms of managing, using, and creating new knowledge and information, student interactions can be a key factor in the success of experiential entrepreneurial education methods (García-Rodríguez et al., 2012).

Findings

Transdisciplinary Teamwork

The case exhibited several motivations for transdisciplinarity and key factors that facilitate transdisciplinarity teamwork in experiential entrepreneurial education. First, transdisciplinarity enables students to look at the problem space more holistically, and to empathize with views different from their own in terms of their disciplines.

“I would say that getting to understand the perspective from an individual and also someone from like a, like designer's point of view, compared to an engineer's point of view compared to a businessperson’s point of view, like within the same discussion is really, really something that that anyone can benefit from.” (Participant O, round 2).

Then, as another participant pointed out, one key advantage of the transdisciplinary experiential educational experience lies in its proximity to the “real world” in terms of how products, services, and innovations take place outside of the educational context.

“I think that this project kind of gave me a more realistic insight how in the real world, new projects and new products are like made, what the interaction between the designer and engineers, and that part of the team, how the interaction with the person that actually has the money, in our case, the technology.” (Participant I, round 1).

From the educator’s perspective, it was seen that team’s collective (transdisciplinarity) intelligence and chemistry were seen as key components towards the success of the projects, even more so than the skills of the individuals. As such, for transdisciplinary experiential entrepreneurial education to succeed, enough thought and care needs to be placed on the team formation, dynamics, and team building activities.

“One of the biggest learnings in the history of PDP[1] was when we understood that the intelligence or understanding as a team it's much better than an individual level. So many years back, the students they could

[1] Product Development Project, Aalto University, https://pdp.fi/

apply for their favorite projects, as individuals and teams were built that way. Now, we build the team first, and then the teams apply it for their kind of favorite projects." (Participant E, round 2).

As a whole, it could be seen that the transdisciplinary environment provided in experiential entrepreneurial education afforded students a closer look at the "real world," but like with any key aspect, understanding and fostering those team dynamics, chemistry and providing the students with the tools to empathize with one another is just as crucial. More specifically, for the benefits of transdisciplinary teamwork to be understood by the students, educators need to provide enough tools and methods for self and team-based reflections.

Individual-level Entrepreneurial Skills and Aptitudes

The case showed there are certain skills and aptitudes that constitute an "entrepreneurial mindset", and those need to be transferred through experiential education methods. The findings outline that such skills include the ability to be creative, the ability to take risks, being visionaries; have the ability to do what's necessary – even if it may be boring or mundane.

"There's a whole mindset to entrepreneur, there's an entrepreneurial mindset, actually, one of the skills also that you need to have as an entrepreneur is willingness to take risks." (Participant F, round 2.)

Also, risk-taking was seen as a key skill for entrepreneurs, and for instilling the entrepreneurial mindset, by most of the participants from all the three groups. Perhaps, more interestingly, the risk-taking aspect was also closely linked with the ideals of being a visionary and showcasing leadership like traits. As two participants pointed out, the idea of being a leader, within this context, was not necessarily in a business sense, but more as a trailblazing individual.

"So, when you're an entrepreneur is often a leader, not necessarily a businessman." (Participant B, round 2).

"(I) Think the characteristics that is that, like, I feel like they're, they're visionaries." (Participant M, round 2).

Similarly, creativity was seen as the other universal trait that is essential for the development of entrepreneurial mindset. Closely linked to creativity was curiosity; the ability for the individuals to make connections between different ideas, understanding how various things connect with each other, and being able to make sense out of them.

The findings also highlight the importance of making a distinction between an entrepreneur and an innovator. The key differences, according to the participants, between an innovator and an entrepreneur pertained to business acumen, and the "ability to do the necessary." As one of the participants suggested that they could never be an entrepreneur as they would never be able to undertake all of the necessary, mundane tasks required from entrepreneurs.

On a general level, it was also evident in the findings that the participants viewed innovators and innovations as the ability to create and identify new values and opportunities, and entrepreneurs and entrepreneurship was seen as the ability to capture that identified value and bringing that value to the market. In essence, entrepreneurship was seen as more closely linked towards business activities and acumen than innovation.

"(Name of Participant), you'll never do it, you know. Because you're not willing to spend hours and hours filling in tax forms and all the rest of it." (Participant B, round 2)

As a whole, the individual level skills and aptitudes closely associated with an "entrepreneurial mindset" pertain towards creativity, leadership, and risk-taking. Delving deeper, entrepreneurs were also seen as those willing to do the mundane tasks, and "get things done." As such, it is also evident that these are skills that can be taught through transdisciplinary, experiential entrepreneurial education methods.

Educators as Gatekeepers

Looking closer at the role of educators within transdisciplinary experiential entrepreneurial education, the findings indicate that the role could be best described as a gatekeeper; ensuring that the minimum requirements and learning objectives were met, while being available for the students when necessary, and stepping in (in terms of client management) if needed. Interestingly and importantly, these roles were understood by all of the stakeholder groups, including the students.

As one of the participants from the academic faculty stakeholder group pointed out, they saw their role as one of being approachable for the students, while ensuring that all of the course requirements were being met.

"It's in a way a design factory[1] thing, where you have this low hierarchy, sort of, sort of a model, because then the point is that, sure, okay, we are responsible for like handling some of the bureaucratic stuff like seeing if they are following and making the submissions or not in time that needs to be checked. But then at the same time, it's like an open-door policy. So, if you need something from us, just contact Don't hesitate, we'll facilitate that for you" (Participant F, round 2)

In this role, some educators took a different approach towards the teaching and education of the student participants as a whole. As one of the participants mentioned, for the successful implementation of transdisciplinary experiential entrepreneurial education, they have adopted a 'learning on demand' principle.

"We are more applying this learning on demand principle, so that we trust that the students they should come to us when they when they need advice or help." (Participant E, round 2)

Then, to keep tabs on the progress of the students and their teams, educators took on the role of coaches, organizing several mentoring sessions over the course of the projects. In the pilot at Aalto Design Factory, the students met with the educators around five times over the duration of the project in a series of "checkpoint meetings" where the students presented their updates to the educators. At the pilot in ESADE, students were assigned a team coach/mentor who was responsible for meeting with the teams on a fortnightly basis.

As a whole, educators within these pilots were tasked with creating a reasonable timeline for the duration of the projects, outlining the key deliverables and milestones for the students, assist the students on an "on demand" principle, act as gatekeepers in terms of managing the expectations, as well as ensuring that the learning objectives of the pilot were obtained.

Discussion

Towards a Shared Understanding in Transdisciplinary Teamwork

It was evident that while all students understood the need for an inclusive environment, the benefits of a transdisciplinary knowledge base and its perceived gains were underutilized, like previous literature has indicated (Garcia-Rodriguez et al., 2012; and Lüthje, Prügl 2006). More specifically, moving between the "knowledge generation, sharing, and integration phases" is something that should be stronger facilitated by the educators (Bailey et al., 2021). For example, providing tools and templates for the effective sharing and discussing of knowledge can assist teams in better understanding the value of transdisciplinary experiential learning.

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[1] Aalto Design Factory, https://designfactory.aalto.fi/

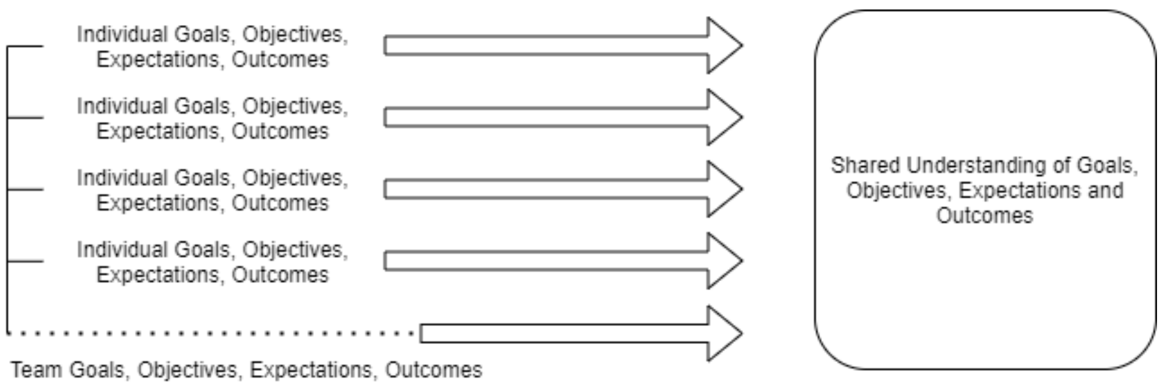
Also, the provision of a psychologically safe and inclusive environment are key factors that must be met to ensure that the cognitive diversity within a transdisciplinary team is utilized. Furthermore, as highlighted by Garcia-Rodriguez et al. (2012) and Lüthje, Prügl (2006), assisting students in understanding the perceived benefits of these gains is also essential.

Connecting to the transdisciplinarity teamworking is the concept of individual and team learning objectives, expectations, and outcomes. It is essential for experiential entrepreneurial education methods to ensure that the students are provided with the skills and tools to move and effectively align individual and team motivations and goals.

As such, the role of the educator may also require assisting the students in coming to a shared understanding in terms of their goals and objectives. This can be done through, for example, the provision of team-based learning tools (Bailey, 2021). It should be stated; however, that the goal is not for the creation of a single answer, but rather a shared understanding of the goal and expectations (see fig.3).

It was also evident that while the project results were satisfactory, self and team-based reflections by the students were rather minimal. As outlined by Hmelo-Silver (2004), this is where the educators need to provide the necessary "metacognitive scaffolding" for the students. This could be done through the provision of individual, and team-based mentoring, as well as various reflective tasks such as journals, readings, or even peer-to-peer discussions.

Figure 3: Framing towards a Shared Understanding

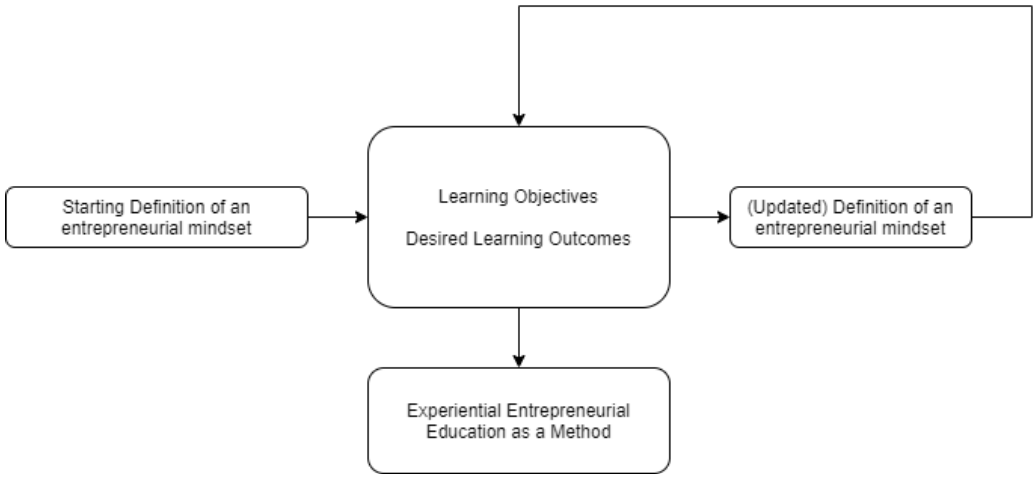


Clarifying the learning expectations

The entrepreneurial mindset, as a concept itself encapsulates several skills, attributes and behaviors which may be taught to and learned by the students. Due to the nature of experiential learning methods, as well as the large number of possible skills, attributes, and behaviors that may be assigned to the concept of the entrepreneurial mindset, there is no one, all-encompassing definition.

However, as highlighted by Secundo et al. (2020), the mindset includes "the willingness and ability to recognize and pursue opportunities for new value creation," attributes that are closely linked with creativity, risk taking and ideating. The findings support the notion that the teaching of the entrepreneurial mindset involves empathizing and understanding the entrepreneurial spirit (Kuratko, 2005; Wilson, 2008) and the entrepreneurial ways of "seeing, feeling, doing, thinking, and learning" (Gibb, 2002).

Figure 4: Relationship between definitions and learning objectives and outcomes



The figure above (see fig.4) indicates that the learning objectives and outcomes set by the educators on experiential entrepreneurial education may be largely based upon their own views on what constitutes this mindset. Similarly, a student may not view certain skills, attributes, and behaviors they may have been taught, as being part of the "entrepreneurial mindset," simply due to their own definitions of this mindset.

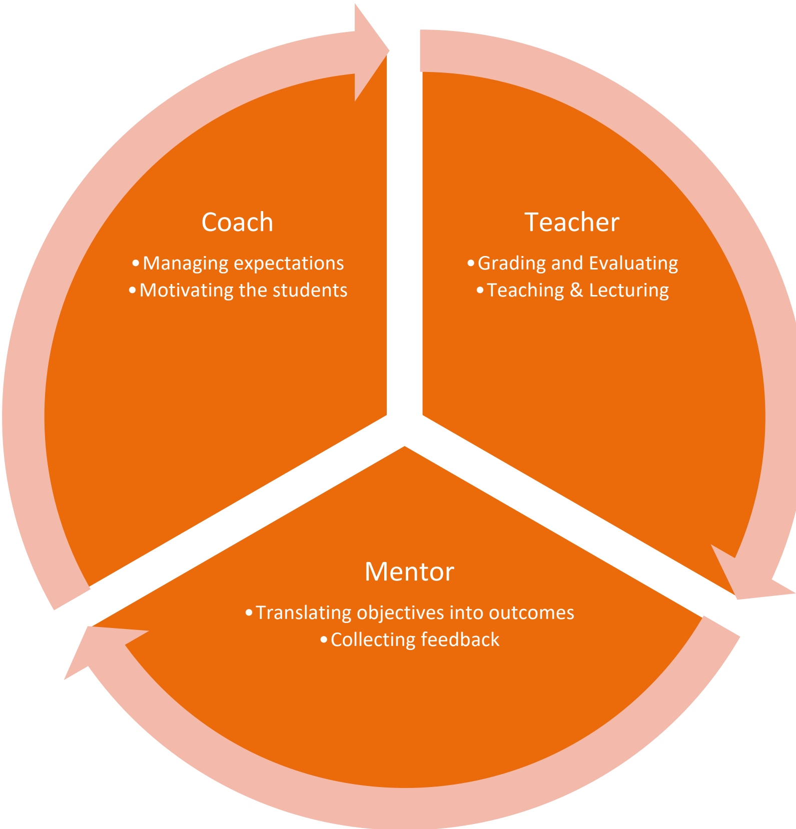
As such, coming to a shared understanding towards the constituents of this mindset may be desirable. Consequently, it is also possible for the experiential entrepreneurial education program or course to assist in the development or redefining of the entrepreneurial mindset within a student or an educator. As outlined by Neck and Greene, a good starting point may be simply with the following question: "how do people think entrepreneurially" (2011)?

Implications

Role of educators within Experiential Entrepreneurial Education

We see the role of educators within transdisciplinary, experiential entrepreneurial education as one that shifts between that of a mentor, coach, and teacher (see fig.5). As highlighted by scholars before, finding the right balance is key in ensuring that the student teams are best supported by the educators (Hytti, O'Gorman, 2004). This means that educators need to identify what aspects of the experience should/can be controlled, provide the students with tools and methods to co-create with, and also understand the limitations in delivering on "real-life" experiences.

Figure 5: Role of educators within transdisciplinary, experiential education



While randomness and serendipity can mean that no two student experiences may be alike, educators should still practice and obtain relevant, regular feedback pertaining to the course/program. These, while providing additional mentoring to the students, will also give the educators added insights into the development of experiential entrepreneurial education. In essence, while educators may not be able to guarantee replicable experiences, consistent and systematized feedback may provide them with key insights into avoiding past mistakes.

Entrepreneurship vs. Entrepreneurial Mindset

Another implication of my findings is that educators should make clearer distinctions between teaching entrepreneurship and teaching the entrepreneurial mindset. As outlined by several scholars, entrepreneurial education can be classified into many categories (Hytti, O'Gorman, 2004; Davey, Galan-Muros, 2013; Moroz, Hindle, 2011; Hindle, 2007; Maritz, Donovan, 2013; Gibb, 2002).

From the findings of this study, we identify that the key differences between teaching entrepreneurship and the entrepreneurial mindset lie in terms of encapsulating the full experience of becoming an entrepreneur. Teaching the entrepreneurial mindset through experiential learning methods allows students to explore in somewhat real, life-like situations some of the entrepreneurial processes such as new product development (Kuratko, 2005), stakeholder management (Gibb, 2002), and to pursue, to some extent, opportunities for new value creation (Secundo et al., 2020). In terms of the key skills, the findings indicate that creativity, leadership, and risk-taking were seen as the prominent skills to be learned and experienced by the students within transdisciplinary experiential education programs.

It is evident in both, the findings and existing literature, that there is firstly, a distinction between the teaching of the entrepreneurial mindset, and the teaching of entrepreneurship or how to become an entrepreneur. It is, however, certainly possible that certain entrepreneurial education programs and courses may aim to teach and educate on both. Demarcating a clear distinction assists in both, identifying clearer learning objectives from the educators, and achieving the desired learning outcomes within the students.

Limitations and Further Research

This study focused upon the Young Innovator and Entrepreneurs Pilot that was run as part of the EU ATTRACT Initiative. The research conducted within this study focused primarily upon the learning objectives, methods, and outcomes of the student pilots, without taking a closer look at other aspects of the EU ATTRACT Initiative. We also did not conduct any interviews with stakeholders who were not connected with the Young Innovator and Entrepreneurs Pilot in any way.

The results of this study encourage research in experiential entrepreneurial education to look further into the concepts of the entrepreneurial mindset, outlining the key learning objectives and outcomes from such educational programs and methods. Moreover, additional research into the context within which these transdisciplinary experiential education methods are placed can also be looked into further.

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Visualization of uncertainty and probabilities – A generic design approach for user-centered information visualization using the example of warehouse logistics

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Problem/Goal

Digital services such as the provision of AI-based data and forecasts have become increasingly important in recent years. Various tracking apps have already become an integral part of our everyday lives - be it in COVID-19-warning app, postal tracking, public transport, weather, and many more - and provide a basis for planning, orientation and decision-making. Computational modeling methods form the basis of this prognostic information, such as Bayesian networks. They use large amounts of data to provide statistical forecasts about the probability of occurrence of events. Over the past years, those methods have become increasingly sophisticated and the data basis more reliable. Yet, decision making based on the outcomes of these methods challenges users cognitively as it requires statistical knowledge for a correct interpretation of probability and inherent uncertainty. Instead, users tend to rely on mean values which lead to false expectations by presenting point estimations that leave out statistical uncertainties. To address this issue, we situate ourselves in the translator role, between developer view, i.e., what is technically possible, and user view, i.e., what is understandable and useful with practical but not expert knowledge.

In our study, we draw upon prior research on the visualization of uncertainty (Hullman et al., 2019; Wilke, 2019), decision making under uncertainty (Kale et al., 2019) and approaches towards designing forecasting interfaces (Hemment et al., 2016). Since the question of how to interpret and apply prognostic information has received little attention (e.g. Kay et al., 2016), we pursued two aims in our research: a) to explore how uncertainty can be visualized so that it can be interpreted by users without statistical knowledge and b) to develop a generic design approach on how to visualize uncertainty.

Methodology

The study was prepared between June 2020 and February 2021 as part of the research project ”PRODAB” for process data analysis and forecasting of lead times in logistics and production of Fraunhofer Center for Applied Research on Supply Chain Services (SCS) of the Fraunhofer IIS.

Starting from a specific case in a warehouse logistics context, namely a multi-stage loading process, we followed the design science research methodology (DSRM) (Peffers et al., 2007) and developed an artefact for visualizing uncertainties and probabilities in the form of an easily interpretable graphical user interface (GUI). Following a process analysis of our case and an information analysis of already existing forecast data services in the form of apps, as an approximation to a communication logic of uncertainty representations, we drafted 10 colorless GUIs by following a design grid on two information levels (overview of all shipments in the process and detailed information on a specific shipment) with 5 differentiated representations each from complex to low complex. The aim was to ensure equivalent information within the various presentations, to offer a comparable level of design in terms of content and to figure out if and where color can provide supporting impulses: Which shipment is time-critical and can be identified and prioritized as such or is so far behind schedule that the customer must be informed of a delay? A transdisciplinary research team from data science, social and cognitive sciences, graphic and UX design ensured that multiple perspectives were taken into account.

Subsequently, we performed an artificial, formative evaluation (Venable et al., 2016). The 10 GUI representations functioned as a basis for communication. The evaluation included n=10 (6 women, 4 men; age 24-41; varying statistical expertise from low to high) qualitative interviews of 60 min each (online/offline) and was structured as follows: scenario, descriptive observation (thinking aloud) of randomized individual screens (general understanding, identification of critical shipment, interpretation), ranking of all representations in comparison (visual location, critical location, representation of uncertainty), final favorite screen combination (How many levels of information are useful and desired?).

Next, based on the qualitative data analysis, the strengths of each representation were combined, information needs, and readings were derived, and a final concept of the GUI was elaborated.

Results

The results are twofold: (1) the resulting artefact (GUI) as well as the associated formative evaluation show which visual elements should be considered for easily interpretable visualizations of statistical forecasts. The identified elements allow application and adoption to other cases. (2) Following this, we derived an eight-stage generic approach, embedded in the DSRM, for the development of user-centered artefacts visualizing uncertainties and probabilities.

(1) Visual elements

As with any interface design, the following visual qualities must first be taken into account in order to convey information in a target-oriented manner: Clear, focus, good readability of relevant data, appropriate information density (regarding medium, context, target, usage), clear interpretability (intuitive or required additional information), clear process location (reference times, reference sub- and overall process), appropriate time required to capture.

The following points aggregate what to consider when designing a GUI in the forecasting context:

- To determine the case-specific degree between provision of information and instruction for action, locate the visualizations gradually between two extremes: (1) expert knowledge/ complex/ high data density/ data pool/ plain text/ progress forecast (2) no previous statistical knowledge/ simplified/ information selection/ decision support/ storytelling/ point estimation
- The simpler and denser the visual representation, the more the system takes over decision making.
- Use colorless representations for the formative evaluation drafts. In this way, the role of color becomes visible: What information should be emphasized and where can color provide supporting impulses?
- Visually condensed representations with little verbal information offer great potential for intuitive and quick comprehension, but also harbor a great risk of misinterpretation if not explicitly instructed or daily used.

(2) Eight-stage generic approach

With a view to replicating the approach to other cases, we propose our concrete approach to exploring, analyzing, implementing, and testing uncertainty visualizations in the form of GUIs: (1) Start with understanding preconditions by a collecting and identifying case-specific requirements. (2) In addition to a subsequent literature research, observe of the communication and use of forecasts in everyday life for insights and inspiration. (3) Analyze different types of uncertainty visualization, identify commonalities, and derive additional design elements. (4) Create a multi-level representation logic for the above-mentioned poles (complex with much data - low-complexity with little information) as an abstract GUI design grid. (5) Draft a selection of GUIs by following a design grid on two information levels (overview and detailed information) with differentiated representations by ensuring the validity of the representations, with diverging shapes in sufficient diversity and yet shared information base/usage horizon. (6) Conduct a formative evaluation of GUIs using qualitative interviews (criteria: visual quality, readability/understandability, perception of communication of information with uncertainty). (7) Identify relevant information particles and translate the gained insights into visuals. (8) End up with an iterated and reflected GUI conception as a basis for a further and more specific field test.

Our approach is promising. Transferability to other contexts is expected but needs to be tested. Limitations are the artificial evaluation and the restricted context. Tests and further development are strongly encouraged.

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