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INTERNATIONAL PERSPECTIVES AND RESEARCH ON THE "FUTURE OF WORK"

INTERNATIONAL SCIENTIFIC SYMPOSIUM HELD IN STUTTGART IN JULY 2019



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FOREWORD

How is work going to change and what impact will new technologies have on our working life in the future? How can we understand these changes from a research perspective and how can we shape and design the work of the future accordingly? These were the central questions tackled by the Conference "Future of Work" held in Stuttgart last October. At this event funded by the German Federal Ministry of Education and Research (BMBF), almost 500 participants attended keynote speeches and interactive workshops, took part in roundtable discussions and visited an extensive exhibition of research projects.

During the course of the Conference "Future of Work", a new and innovative format of exchange and dialogue was tested: the Virtual World Tour. In 24 hours around the world, experts from twelve renowned research institutes were connected via live stream to initiate an international discussion on how digitalization is transforming the world of work. Now, the International Scientific Symposium aims to continue und consolidate this exchange.

As we know, society needs to find answers to a series of challenges regarding the future of work, such as the role and significance of agile working, the development of organisational resilience, new concepts for enabling employees to participate in the digital transformation, the impact of Artificial Intelligence on tasks and jobs, as well as new strategies for competence development and occupational health in socio-technical systems. Appropriate platforms for interdisciplinary cooperation and scientific communication are absolutely essential in order to address these topics.

The German Federal Ministry of Education and Research (BMBF) acknowledges the commitment and contributions of all participants to the Virtual World Tour and the International Scientific Symposium and will continue to support further scenarios for international collaboration in the field of labour research. In this context, we warmly invite the research community to European Conference on Labour Research "beyondwork2020", which will be held from October 21–22, 2020 in Bonn, Germany within the context of the German Presidency of the Council of the European Union.

We hope this publication is just the beginning of a long-term international cooperation and we invite you to keep on shaping the work of the future.

Dr. Otto Fritz Bode and Dr. Henning Krassen,
German Federal Ministry of Education and Research (BMBF)

INTRODUCTION

The Conference "Future of Work" held in Stuttgart on December 4–5, 2018 as part of the Science Year 2018 looked ahead to examine the Working Life of the Future. It featured interactive workshops, keynote speeches, roundtable discussions and an exhibition of current projects funded by the German Federal Ministry of Education and Research (BMBF). All these activities focused on the question of the scope and depth of changes that lie ahead in tomorrow's working world.

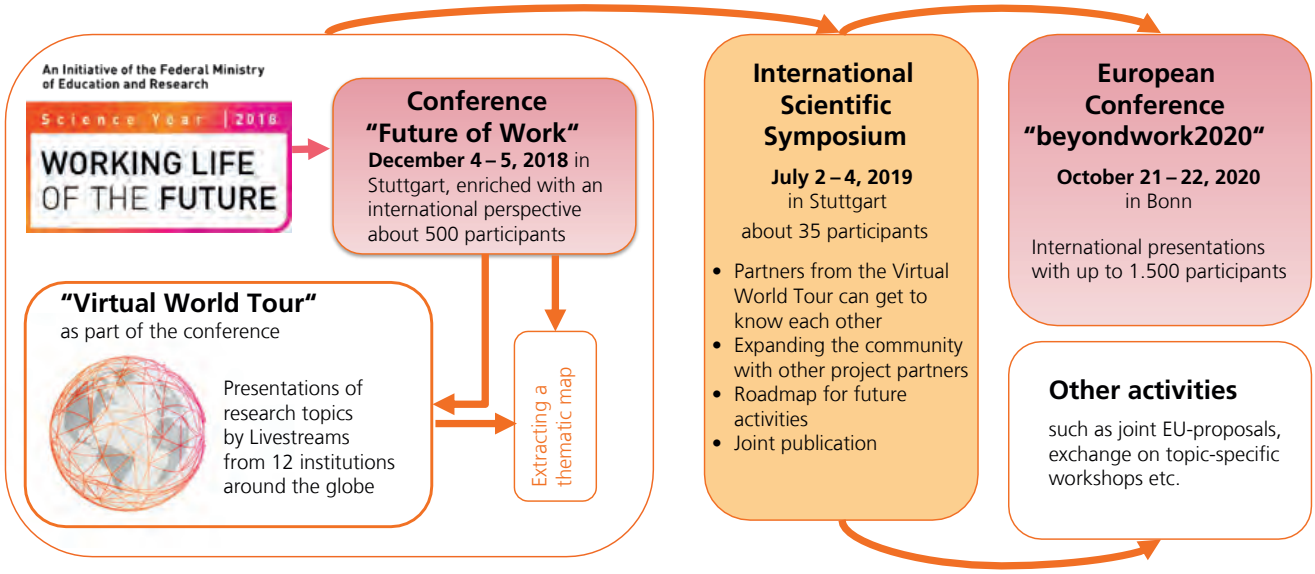
But these matters were not just discussed in Stuttgart; they were also explored on a Virtual World Tour. This digital format was a first for the Conference "Future of Work". A virtual 24-hour trip around the world connected experts from twelve renowned research institutes on four continents and across eight time zones to the conference via live streams.

This Virtual World Tour aimed to invigorate the international dialog about the shape of things to come in the way people work. With the motto "Future Worlds of Work around the World" setting the tone, it enabled the audience to experience the global discourse on this topic. It also pinpointed the areas where the scientists that research labor need to step up their efforts. These insights served to chart an international knowledge map. Research institutes addressed a wide spectrum of topics related to how digitalization is transforming working life.

The International Scientific Symposium held from July 3–4, 2019, will afforded the international representatives of the Virtual World Tour and an extended community of the BMBF, as well as the partners of the Virtual World Tour and Fraunhofer IAO, the opportunity to get to know each other in person and explore shared research interests. The event also goes to acknowledge the contributions of all participants in the Virtual World Tour and will serve as a stepping-stone toward further joint activities such as the European Conference "Future of Work", scheduled for October 20, 2020 in Bonn.

The articles in this anthology afford more penetrating insights into symposium and Virtual World Tour participants' select research topics for the extended international research community to explore and discuss. The anthology comes in two versions. One is a purely digital preview to be published prior to the symposium to furnish preliminary information to its participants. The final version supplemented by further articles will to appear after the symposium in digital and printed formats.

The Conference "Future of Work" with its Virtual World Tour and the International Scientific Symposium are activities undertaken as part of a priority research program known as "Work in the Digitalized World", funded by a grant from the German Federal Ministry of Education and Research (BMBF) and the European Social Fund (ESF). It is part of the "Future of Work" research and development program. The "Work in the Digitalized World" priority research program is closely connected to the joint project entitled "Transformation of Work through Digitalization" (TransWork), which is also funded within the framework of "Future of Work". The TransWork project supports 29 collaborative projects funded by the "Work in the Digitalized World" priority research program and pursues research objectives of its own. Another key task of this research project is to expedite the transfer of research results to industry and science.



A look at the "Future of Work" International Scientific Symposium in context



1

FUTURE OF WORK (GENERAL)

WORK, COMPETENCIES AND THEIR DEVELOPMENT IN A DIGITALIZED WORLD

RECENT RESEARCH FROM THE TRANSWORK PROJECT

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Abstract

Digitalization offers tremendous opportunities for companies. At the same time, digitalization presents more than purely technical challenges. It also distributes work and decision-making between humans and technology in new ways, requiring completely new competencies from the employee. The present article explores the status of research on the topic of digitalization and its impact on work and competence requirements in Germany. In addition to general scientific findings, the article also presents specific highlights from the TransWork research project (Transformation of work through digitalization) regarding the current status of digitalization in various corporate sectors. How work activities will change and which (digital) competencies will become increasingly necessary in the work of tomorrow are elucidated through examples.

Key words
Skill Development, Competence Development, Work Design, Transformation Process, Future of Work

Digital technologies are changing the working world. Today, ideas of how the working world of tomorrow might look are already taking shape. Bauer (2015) sees three drivers changing work: First, changes in humans and in the society in which work is performed. Topics here include increased individualization due to new values and lifestyles, the aging of society in the course of demographic change, the development of a new awareness of physical and psychological health as well as increasing social and cultural diversity among employees with the associated opportunities and potentials for conflict. The second driver of change encompasses the evolving business models that establish new value creation networks by means of digital infrastructures. This includes trends towards customer-centricity and in the diversity of providers, as well as the development of individualized service packages in the respective contexts, across the entire product lifecycle, everywhere and at all times. According to a study on Industrie 4.0, digitalization is changing work assignments e. g. with regard to greater individualization of products and services and a growing range of variants. Individual customer-specific solutions have to be formulated jointly with the customer, resulting in higher demands being placed on employees in terms of time flexibility, for example. The third driver consists of new technologies that lead to sharp disruptions in an increasingly digital and networked world (Spath et al. 2013). Today, almost every form of gainful employment in Germany already involves some kind of digital work resources. Developments in the areas of robotics and Artificial Intelligence promise even more far-reaching consequences for our working world.

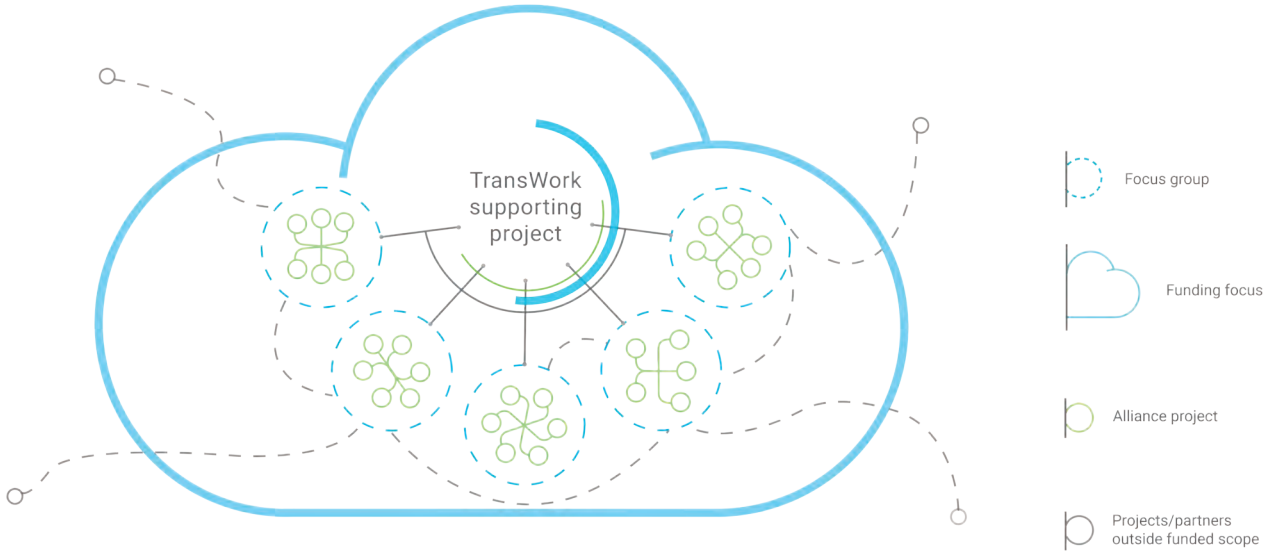


Diagram 1: Structural representation of the prioritized funding program (authors' representation)

The major challenges in the transformation process include the impacts of digitalization and automation on the labor market and on employment, professional qualifications and health protection, division of labor between humans and machines, as well as the organization of work inside and outside of companies. Occupational scientists are being called upon to analyze these changes in work activities and to organize them to create a productive and healthy work environment. Application-oriented research is concerned with investigating how innovative technologies and assistance systems, digitalized forms of work, management and business processes etc. impact companies, and more particularly, their employees. In this context, questions of acceptance and qualification play a role, alongside aspects of safety and health as well as criteria governing effectiveness and efficiency. At the same time, it is equally important to fully utilize the existing possibilities and potentials available to companies and employees through the targeted development and trial of new holistic concepts and systems. Digitalization as a social innovation requires the comprehensive involvement of all stakeholders.

The focus of "Work in the Digitalized World," funded by a federal grant from the German Federal Ministry of Education and Research (BMBF) and the European Social Fund (ESF), offers an outstanding overall context in support of corresponding research and development activities. It is part of the research and development program "Future of Work", itself pursued under the umbrella of the "Innovations for the Manufacturing, Services and Work of Tomorrow" program, which focuses on the retention and creation of jobs in Germany. A total of 29 alliance projects sponsored by the prioritized funding program will be conducted in various sectors, including mechanical engineering, services and geriatric care. These projects aim to develop and disseminate approaches to solutions based on the possibilities presented by digital technologies in the working world. The program promotes research into innovative forms of work design, development of employee competencies, the trial of socially beneficial health-oriented employment models, and much more (see Bauer et al. 2019).

WORK, COMPETENCIES AND THEIR DEVELOPMENT IN A DIGITALIZED WORLD

The alliance projects supported by funding measures cover a wide spectrum of challenges and solution strategies for working in the digitalized world. Five focus groups, to which five or six of the 29 alliance projects have been allocated, form the structure and support provided by the funding. Each focus group concentrates on one of the following relevant topics in the digitalized working world:

1. Assistance systems and development of competencies
2. Project work and team work in the digitalized working world
3. Productivity management – defining and strategically developing productivity parameters
4. The organization of networked and flexible work
5. Work design in the digital transformation process

In order to optimize the use of digital technologies – as an opportunity for social innovation, as a means to improve the value of work processes and to further health-oriented work design – it is necessary to maintain an overall view of the individual research projects and accompanying scientific research. TransWork[1] accompanies the project and undertakes these tasks by networking participants in the prioritized funding program, supervising the focus groups and supporting the transfer of results to business and science. An advisory research council of prominent representatives from business, science and society addresses further potential for networking and transfer.

In addition to networking the prioritized funding participants and transfer activities, the tasks of the TransWork project include independent research as well as identification of Good Practices from the research projects.

In its independent research,TransWork addresses current research fields in work organization (competence, complexity, productivity, regulation) and develops new solutions. Changes resulting from the digitalization of work are analyzed, evaluated and examples for designing "good work" are prepared and transferred in a manner targeted at norm setting agents. This promotes the sustainable development of these agents' competencies and makes it possible for them to constructively accompany the transformation of work. In addition, TransWork identifies and closes gaps in research and development on behalf of the projects included in this prioritized funding program, and in the joint ongoing development of the topics being addressed. The following diagram illustrates the structure of the secondary project.

The organizational solutions developed, such as qualification modules and action tools, are primarily oriented toward various transfer activities to operational norm setting agents. This is maintained permanently by the development of continuing education concepts and by anchoring these in educational structures (e. g. ver.di b + b education and consulting, DAA (vocational education), the professional education network Bildungswerke der deutschen Wirtschaft, etc.). The organizational solutions are transferred to companies in media partnerships with e. g. ifaa (institute for applied occupational science) magazine "Betriebspraxis & Arbeitsforschung" (corporate practice and occupational research). In addition, the project promotes the transfer of results to government, the scientific community and practical application by networking with the Gesellschaft für Arbeitswissenschaft (Society for Occupational Science) and with the German federal government's Hightech Forum. Findings are also integrated in research and teaching as well as in the corporate portfolio of support measures drawn up by the interdisciplinary consortium. The secondary research thus provides a comprehensive range of instruments for addressing the transformation of work through digitalization (see Bauer et al. 2019; Schnalzer/Dworschak 2019).

1 The TransWork project is funded by the Federal Ministry of Education and Research under the "Arbeit in der digitisierten Welt" Förderkennzeichen 02L15A160) and supervised by the Karlsruhe Project Management Agency.



Diagram 2: Structure of the TransWork alliance project (authors' representation)

The following presents current Fraunhofer IAO research results in the context of the TransWork project (Hamann et al. 2019).

1 Impact of digitalization on work and development of competencies

Among the major challenges posed by the transformation of work through digitalization is the question of how work and the required qualifications will change and which corresponding strategies to develop competencies will be useful to companies. The TransWork subproject on analysis and design of future competencies focuses on these topics. The present article summarizes current expert assessments from a variety of industry sectors and types of companies, providing a representative overview of current developments, opportunities, challenges and fields of action emerging in the course of digitalization. Strategic management of competencies is identified as an essential success factor and as a central field of action requiring additional research across different development paths.

How should we take advantage of new technological possibilities to make work even more effective, more socially compatible and healthier? How will digitalization effect the structure of companies and the requirements placed on employees? What changes in workflows and qualification requirements are currently visible and how are they being encountered?

In the current discussion on the present and predicted risks and opportunities of digitalization, the TransWork project aims to assemble various assessments of this topic. Interviews were conducted with selected experts from manufacturing companies and service providers in the period between July and October 2017, focusing on the current status of digitalization in a variety of corporate sectors and the associated current developments, challenges and fields of action. The data collected was then subjected to a software-based analysis centered on a structuring qualitative analysis of content.

The experts interviewed are qualified due to their (primary or secondary) roles as digitalization officers within their respective companies.

Company	Sector	Size
1	Automobile component supplier	> 5,000 employees
2	Mechanical engineering/special-purpose vehicle manufacturer	50-249 employees
3	Automobile and mechanical engineering component supplier/metalworking	> 5,000 employees
4	Mechanical engineer/materials handling technologies	> 5,000 employees
5	Conglomerate/Mobility Services	> 5,000 employees
6	Insurance industry	> 5,000 employees
7	Insurance industry/public service sector	> 5,000 employees
8	Consultancy for Industry 4.0 in reference to a company from the control and automation technologies sector	> 5,000 employees
9	Mechanical engineering	> 5,000 employees

Table 1: Sectors and company sizes of the experts interviewed (authors' representation)

The present article focuses on the assessments of the experts regarding the impacts of digitalization on work and development of appropriate competencies.

2 Impact of digitalization on work

The effects of digitalization and automation are evident not only in terms of quantitative employment figures, but also in qualitative changes to the way we work.

When asked about what topics play a central role in the transformation of workflows, the manufacturing companies surveyed point to machine connectivity, smart services, KPI reporting, cross divisional networking as well as improved planning and optimization of processes.

Company 4 (materials handling technology) illustrates specific changes in production. The company manufactures autonomous transport vehicles that recognize their immediate surroundings and other employees as they automatically follow the operator's movements. The autonomy of these vehicles

eliminates previously necessary intermediate activities on the part of the logistics personnel, for example mounting and driving a vehicle (e. g. a forklift). This makes it possible to optimize the entire process and increase productivity, but at the same time it subjects the employees to increased one-sided strain. This kind of semi-automated workflow places special challenges on the design of human-friendly work, according to current occupational research findings.

Company 7 (insurance industry) is an example of tangible change in the area of administrative activities. Here office tasks (case processing) are increasingly distributed according to digital logic from a shared pool. One advantage of which is that tasks can be allocated to employees according to various skills and performance capabilities. This kind of digital planning and communication tool makes a new type of flexible and agile teamwork possible.

New forms of agile work are also found in the composition of complementary teams for topically oriented issues requiring short-term solutions. "This is where our networks and communications bring together agile new constellations, putting the right people together." (Company 5)

Across all sectors, and independent of new work forms, data capture directly linked with the use of technology to organize work efficiently serves to increase transparency, while making it possible to comprehensively monitor individual performance and behavior. This calls for stronger protective regulations applying to the handling of personalized data: "With digitalization you create an incredibly transparent production process in which you can track every movement any technician makes." (Company 1)

The experts agree that there has been a manifold increase in the speed and density of information and that this trend will continue to grow stronger. Permanent availability and the rapid flow of information also carry the risk of overloading individual employees.

However, referring to the organization of internal processes, several companies say that speed has more likely decelerated. "High information density means that it takes a long time before a process can be established […] However, as soon as something is established, things move quickly." (Company 8)

3 Impact of digitalization on qualification and development of competencies

The ongoing transformation of the working world through digitalization requires that high priority be given to the early recognition of new competence requirements. Personnel management within a company now calls for strategic competence management. The digitalized working world is set to fundamentally change the form of work and the demands placed on many employees in their activities (Rainie/Anderson 2016). In order to master new assignments, these employees increasingly need basic digital as well as non-digital skills. Acquiring these basic skills will affect employees with and without management assignments in different ways.

The experts interviewed placed a particularly high value on the significance of the exemplary function of managers when it comes to acquiring and applying digital know-how.

The high relevance of the implementation of digital strategies at the executive level within the company is evident in the new area of responsibility assigned to a Chief Digital Officer (CDO). The CDO is usually on the second management tier. The CDO's assignments focus on the objective of developing an overall corporate digitalization strategy for the company, anchoring it and implementing it in institutional terms.

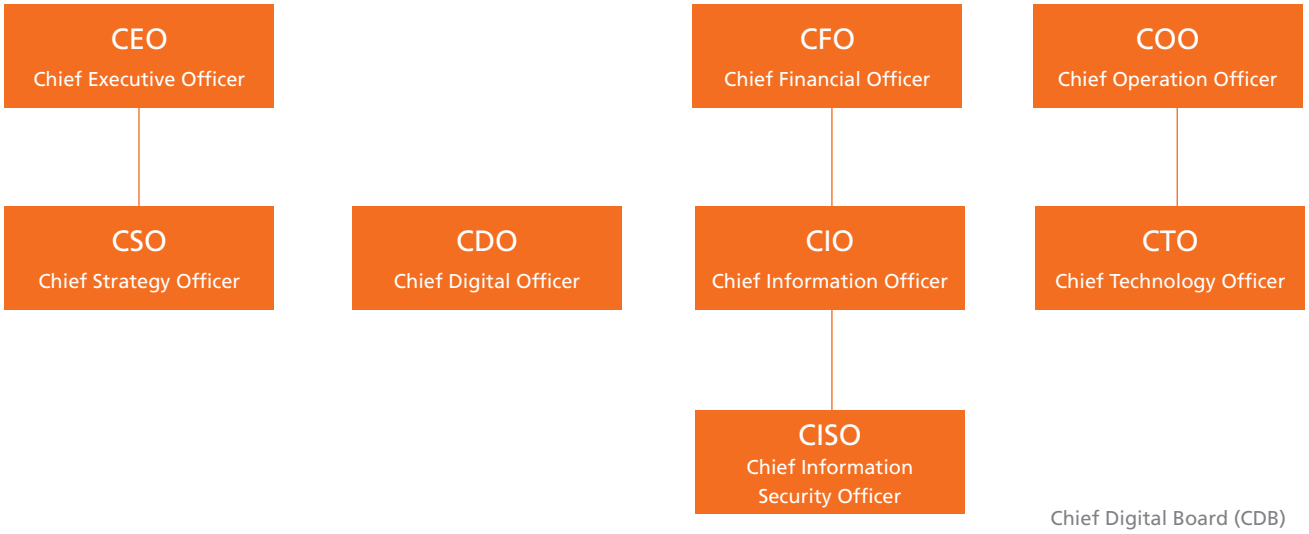


Diagram 3: New management structure (authors' graphic, based on Plass 2016, p. 24)

In their interviews, the experts from company 3 indicated that all the members of the managing board came from financial or mechanical engineering fields and had not had much contact with digitalization in their previous assignments. They also reported that engaging with this topic and developing the corresponding competencies is a major challenge for such managers. The expert from company 5 reports that training top managers in the programing of apps and similar content has already taken place for several years.

All sectors continue to assume that an increasing number of IT specialists will be needed to handle transformative technologies in companies and organizations. The technical skills these specialists will have to bring with them include: complex data analysis, development of hardware and robotics, Web development, user-centric design, structuring and administration of networked IT systems, data protection know-how, blockchain technology development and tech-translation, i. e. facilitating communications between technology experts and non-experts (bitkom 2016).

Various studies reveal increasing requirements in dealing with the complexity and lack of transparency in technical systems, reacting to and rectifying disruptive incidents, supervision and control activities, and the need for abstract thinking and problem solving. As a result, the pace of change for qualification requirements is expected rise (Abel 2018).

In this context, the expansion of digital continuing education and its integration in the area of human resources is essential to successful digitalization (Kerres 2016).

4 Conclusion

The changes resulting from digitalization as illustrated in the current research reports are reflected in the representative statements by the experts surveyed. It is clear that digitalization not only provides new potential benefits and reductions in workload, but also poses major challenges in creating a work organization that promotes health and learning. Experts point out that digitalization may create potential for overloading employees and that work will in future more often entail monitoring than the actual performance of tasks. In this context, pure optimization through technology is not the issue, but rather how to organize collaboration between humans and technology in a positive way.

At management level, the essential challenge is to generate a willingness and motivation amongst the entire staff to fully explore previously unknown digital terrain in each individual's respective working environment. New approaches to employee development are particularly beneficial here, providing company employees faced with new requirements with support through the transfer of knowledge and skills they need. A fundamental success factor for mastering current changes in this context is the strategic management of competencies, which is increasingly seen as a central field of action in digitalization. Making further training and education of employees a permanent and embedded part of daily work activities will become a key factor in determining a company's competitive position. This calls for new approaches and digital tools to facilitate the early recognition and correspondingly rapid development of required skills (Fraunhofer-Gesellschaft 2018). Personnel management needs new mechanisms and instruments to identify trends and develop competencies relevant to future needs. This could take the form of a "control cockpit" for employees, which supports personal development by allowing them to ask and investigate questions relating to what skills they will require in the future.

Research on how learning is organized and designed is necessary if developing competencies and thus learning experiences in the work process, and expanding the cognitive models of individuals using networked systems, are to be achieved: Design of work systems that are conducive to learning, the adaptive, individual modification of the systems to fit the respective learner, and the use of knowledge gained through experience, are initial approaches to development. Thus of central importance to the dimension of the design is the need to customize relevant tasks, didactic methods as well as the technological implementation and connection with existing systems (Stich et al. 2015). Here technical possibilities have to be integrated in didactically viable learning concepts in order to create activities which both promote learning and are productive (Abele 2015). In operative arena, training management must consider how corporate training is organized and designed and how individual training measures are carried out: from the analysis of competence and education requirements and how training is executed in practice, through to outcome and cost management (Dehnbostel 2012). The question posed by research, particularly in this context, relates to how resources can be made available from a business perspective for the newly designed learning concepts. Recent cognitive science and didactic research has formulated relevant results in connection with human-machine interfaces; however, these findings have not yet been implemented as comprehensive approaches. For example, adaptive learning and intelligent tutorial systems make it possible to use data collected on learning behavior to create personalized learning offers. Learning analytics, accompanied for example by tracking, measurement of processing times, or specifically targeted questions to the learner, provide feedback on the actual support provided by training courses. Furthermore, learning will become physical interaction, through embodiment and spatial representations or gesture control, and thus creating the necessary degree of conscious awareness (Gallagher 2005). The transformation of the learning organization as well as

the design of the digital tools and assistance systems, which will determine both the customization of assignments and the requirements placed on employees, are important fields of research that are being investigated in the course of these research activities.

References

Abel, J.: Kompetenzentwicklungsbedarf für die digitalisierte Arbeitswelt. In: FGW Study Digitalisierung von Arbeit 09 (2018) [Online]. [Accessed on: October 21, 2019]. Available at: https://www.fgw-nrw.de/fileadmin/user_upload/FGW-Studie-I40-09-Abel-komplett-web.pdf

Abele, E.: Kompetenzaufbau und Bildung - ein Zukunftsthema für den Maschinenbau. In: wt Werkstattstechnik online 105 (2015) No. 1/2, p. 1

Bauer, W.: Working smarter. Menschen. Räume. Technologien. Lecture at Zukunftsforum 2015. Stuttgart, Germany

Bauer, W.; Stowasser, S.; Mütze-Niewöhner, S.; Zanker, C.; Brandl, K.-H. (Ed.): Arbeit in der digitalisierten Welt. Stand der Forschung und Anwendung im BMBF-Förderschwerpunkt (2019) [Online]. [Zugriff am 21.10.2019]. Verfügbar unter: https://www.transwork.de/wp-content/uploads/2019/07/transwork-broschuere-2.pdf

Bundesverband Informationswirtschaft, Telekommunikation und Neue Medien e.V. (bitkom): Published report "Arbeit 4.0." Die deutsche Arbeitswelt zukunftsfähig gestalten (2016) [Online]. [Accessed on: October 21, 2019]. Available at: https://www.arbeitenviernull.de/fileadmin/user_upload/Bitkom.pdf

Dehnbostel, P.: Betriebliches Bildungsmanagement als Rahmung betrieblicher Bildungsarbeit. In: Weiterbildung. Zeitschrift für Grundlagen, Praxis und Trends (2012), No. 1/2012, p. 8–11

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.: Zehn Thesen zur #Zukunftsarbeit – Potenziale und Herausforderungen (2018) [Online]. [Accessed on: October 21, 2019]. Available at: https://www.fraunhofer.de/de/presse/presseinformationen/2018/oktober/fraunhofer-erlebniswelt-zukunftsarbeit.html

Gallagher, S.: How the Body Shapes the Mind. New York: Oxford University Press, 2005

Hamann, K.; Link, M.; Dworschak, B.; Schnalzer, K.: Auswirkungen der Digitalisierung auf Arbeit und Kompetenzentwicklung. In: Bauer, W.; Stowasser, S.; Mütze-Niewöhner, S.; Zanker, C.; Brandl, K.-H. (Ed.): Arbeit in der digitalisierten Welt. Stand der Forschung und Anwendung im BMBF-Förderschwerpunkt (2019) [Online]. [Accessed on: October 21, 2019]. Available at: https://www.transwork.de/wp-content/uploads/2019/07/transwork-broschuere-2.pdf

Kerres, M.: E-Learning vs. Digitalisierung der Bildung: Neues Label oder neues Paradigma? In: Hohenstein, A.; Wilbers, K. (Ed.): Handbuch E-Learning. Expertenwissen aus Wissenschaft und Praxis. (2016) [Online]. [Accessed on: October 21, 2019]. Available at: https://learninglab.uni-due.de/sites/default/files/elearning-vs-digitalisierung.pdf

Plass, C.: Digitale Geschäftsprozesse und -modelle verändern die Arbeitswelt (2016) [Online]. [Accessed on: October 21, 2019]. Available at: https://docplayer.org/41949500-Fakten-fuer-experten-und-entscheider-industrie-auflage-christoph-plass-digitale-geschaeftsprozesse-und-modelle-veraendern-die-arbeitswelt.html

Rainie, L.; Anderson, J.: The Future of Jobs and Jobs Training. Pew Research Center (2017) [Online]. [Accessed on: October 21, 2019]. Available at: http://www.pewinternet.org/2017/05/03/the-future-of-jobs-and-jobs-training/

Schnalzer, K.; Dworschak, B.: Digitalisierung und die Auswirkungen auf die Arbeitswelt. In: Verbundprojekt TransWork. Arbeit in der digitalisierten Welt. Übersicht über den BMBF-Förderschwerpunkt (2018) [Online]. [Zugriff am: 21.10.2019]. Verfügbar unter: https://www.transwork.de/wp-content/uploads/2019/07/wp-transwork-broschuere-1.pdf

Spath, D. (Ed.); Ganschar, O.; Gerlach, S.; Hämmerle, M.; Krause, T.; Schlund, S.: Produktionsarbeit der Zukunft – Industrie 4.0 (2013) [Online]. [Accessed on: October 21, 2019]. Available at: https://www.iao.fraunhofer.de/images/iao-news/produktionsarbeit-der-zukunft.pdf

Stich, V.; Gudergan, G.; Senderek, R.: Arbeiten und Lernen in der digitalisierten Welt. In: Hirsch-Kreinsen, H.; Ittermann, J.; Niehaus, J. (Ed.): Digitalisierung industrieller Arbeit. Berlin: Nomos Verlag, 2015, p. 109–30.

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THE DIVERSITY IN PLATFORM WORK: IMPACT ON WORKING CONDITIONS

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Abstract

Platform work refers to the matching of supply of and demand for paid work through an online platform. It emerged about a decade ago in Europe and is still small in scale. However, it is dynamically developing – particularly as regards its scope of application. The types of tasks offered through platforms are increasing, as is the diversity of business models and mechanisms of the platforms. This results in diverse working conditions for the affected workers. While some of them are advantageous, others are not. This challenges the existing standards, regulatory frameworks and traditional labour market institutions. To design and implement effective approaches to tackle the challenges related to platform work, a more nuanced discussion should take place – that identifies and takes into consideration the particularities of the individual types of platform work.

Key words
Platform Work, Working Conditions, Employment Status, Algorithms, Representation

1 Introduction

Platform work, the matching of supply of and demand for paid labour through an online platform (Eurofound, 2018b), emerged in Europe about a decade ago. Since then, it has been dynamically developing and has gained attention in public and policy debate due to its potential to contribute to innovation, competitiveness and the labour market, while at the same time raising concerns regarding employment and working conditions of workers and a level playing field compared to the traditional economy. Being start-ups in a not-yet-developed business environment, at least some existing platforms continuously expand the portfolio of tasks mediated through them or adapt their business models, and new platforms enter the market offering new types of services and mechanisms. Accordingly, there is an increasing diversity within platform work.

Against the assumption that this heterogeneity of platform work results in differences in the effects on employment and working conditions of the workers that should be identified for (better) consideration in informed policy-making, Eurofound (2018a, 2018b) developed a typology on platform work and investigated for selected types the employment and working conditions of affiliated workers. This was done through a combination of desk-research (literature review, national legal, policy and institutional framework analysis) and almost 60 half-standardised qualitative in-depth interviews with workers from late 2017 to early 2019 (Eurofound, 2018b, 2019). This article illustrates selected findings for some working conditions elements for three of the analysed types.

2 Prevalence and diversity of platform work in Europe

Neither at EU level nor within the Member States is there a shared terminology and understanding of "platform work". This results in a multitude of different terms used (for example, sharing economy, collaborative economy, gig economy, crowd employment, etc.). Even if the same term is used, the underlying concept might be different, while the same concept might be referred to by using different expressions.

For the purpose of this analysis, Eurofound applies the following understanding (Eurofound, 2018b):

Box 1: Eurofound's understanding of platform work

- Paid work is organised through an online platform.
- Three parties are involved: the online platform, the client and the worker.
- The aim is to carry out specific tasks or solve specific problems.
- The work is outsourced or contracted out.
- Jobs are broken down into tasks.
- Services are provided on demand.

Sales platforms (such as eBay) or platforms providing access to accommodation (such as Airbnb) or financial services (crowd funding) fall outside this definition. Similarly, non-commercial transactions like volunteering, networking, social media (such as LinkedIn) are not considered.

Available data collection efforts (see Eurofound, 2018a and Riso, 2019 for an overview) return different findings due to variations in applied concepts and methods. As of autumn 2019, the data with the widest EU coverage stem from Urzì Brancati et al (2019) who find that on average 1.4 percent of the European working-age population (aged 16–74) in 16 Member States are engaged in platform work as a main job. On average 4.1 percent provide services via digital labour platforms more than ten hours per week and earn between 25 percent and 50 percent of their income from platforms. Further 3.1 percent perform tasks through digital platforms less than 10 hours per week and earn less than 25 percent of their income through platforms.

Thus while still small in scale, platform work is characterised by an increasing scope of mediated tasks as well as business models and mechanisms of the platform. Eurofound (2018b) applied five criteria to establish an operational typology of platform work:

- The skills level required to perform the task (low, medium or high)
- How the service is provided (delivered on-location or online)
- The scale of the tasks (micro-tasks versus larger projects)
- The selection process (decision made by the platform, client or worker)
- The form of matching (an offer or a contest)

Cross-tabulating these five characteristics results in 120 types of platform work. The prevalence of each type was verified using data on platforms in Europe as of 2017 (Fabo et al, 2017) and available estimates on the number of platform workers (De Groen et al, 2017). This resulted in the finding that as of 2017, ten distinctive types of platform work were prevalent in Europe (see Table 1). The three most distinct types are analysed in this article (highlighted in the table).

Label	Service classification			Platform classification		Share of platforms in total number of platforms	Share of workers in total number of workers	Examples
	Skills level	Format of service provision	Scale of tasks	Selector	Form of matching			
On-location client-determined routine work	Low	On-location	Larger	Client	Offer	13.7 %	1.3 %	GoMore
On-location platform-determined routine work	Low	On-location	Larger	Platform	Offer	31.5 %	31.2 %	Uber
On-location client-determined moderately skilled work	Low to medium	On-location	Larger	Client	Offer	11.3 %	10.9 %	Oferia
On-location worker-initiated moderately skilled work	Low to medium	On-location	Larger	Worker	Offer	4.2 %	5.5 %	ListMinut
Online moderately skilled click-work	Low to medium	Online	Micro	Platform	Offer	0.6 %	5.3 %	CrowdFlower
On-location client-determined higher-skilled work	Medium	On-location	Larger	Client	Offer	2.4 %	3.3 %	appJobber
On-location platform-determined higher-skilled work	Medium	On-location	Larger	Platform	Offer	1.2 %	4.2 %	Be My Eyes
Online platform-determined higher-skilled work	Medium	Online	Larger	Platform	Offer	0.6 %	1.9 %	Clickworker
Online client-determined specialist work	Medium to high	Online	Larger	Client	Offer	5.4 %	30.3 %	Freelancer
Online contestant specialist work	High	Online	Larger	Client	Contest	5.4 %	4.6 %	99designs

Table 1: Most common types of platform work in Europe, 2017 (Source: Eurofound, 2018b)

On-location platform-determined routine work covers low-skilled work that is delivered in person and assigned to the worker by the platform. Accordingly, the platform (at least partially) tends to take the role of an employer without, in most cases, providing workers with an employment contract. These workers may find themselves in a precarious situation if they depend on the platform for work. This type of platform work is fairly widespread as regards both workers and platforms and refers mainly to transport services like taxi rides or food delivery. Workers tend to be students, people looking for relatively flexible work or those with limited access to the traditional labour market. Their main motivation to engage in platform work is to generate (additional) income, and they tend to consider platform work as a temporary solution in their professional career.

On-location worker-initiated moderately skilled work covers low- to medium-skilled tasks mainly looked for by private households (for example, cleaning, gardening, maintenance). Workers tend to be professionals at different stages of their career, seeking to make side earnings with flexible hours or strategically using platforms to try out self-employment. The workers receive offers from potential clients based on their profile and choose the assignments they want to accept, as well as the conditions such as prices or working time (in agreement with the client).

Online contestant specialist work is high-skilled online work where the client selects the worker by means of a contest. Workers, who tend to be freelancers or self-employed in the traditional economy, carry out part or all of a task before knowing whether they will be selected as winners and paid. Although the contestants are highly skilled, this uncertainty about their earnings and the international competition might put them in a precarious situation, especially for workers who depend on these earnings. This type of platform work is especially prevalent for creative tasks. Workers' main motivations are to use idle times for generating additional income, or the fun of applying their creative potential.

3 Selected working conditions by type of platform work

Employment status

Despite being one of the main topics in the debate on platform work, the employment status of platform workers remains uncertain from a regulatory perspective. Platform work, mainly due to its triangular organisation and fragmented character as regards tasks, is blurring the boundaries between traditional employment statuses, and in particular between employees and self-employed workers.

None of the EU Member States has clear regulations specifying the employment status of platform workers, so in practice it is the platforms' terms and conditions that determine the status of the workers. The vast majority of the platform workers interviewed for this study have a main activity outside of platform work, often as employees. As regards their platform work, most are considered self-employed or occasional workers (according to the respective national legal framework). The exception is platform-determined work where some platforms offered an employment contract to the interviewees.

Bogus self-employment is a concern in platform work, and for platform-determined workers in particular, as the relationship with the platform could in practice take the shape of an employment relationship, while the platforms' terms and conditions specify workers as self-employed. Correspondingly, court cases on the status of platform workers have focused on the platform-determined type. When deciding upon the employment status, courts apply a case-by-case approach, investigating the specific situation of the worker against set criteria. These differ somewhat across the Member States, but subordination/autonomy and control is one of the key elements widely considered (see below).

In general, employment rights and entitlements, including social protection, resulting from platform work (if conducted

as self-employed or occasional work) is limited compared to a standard employment contract. The interviewees are well informed about the technicalities of their employment status as regards taxation, but less so as regards social protection and employment rights.

Autonomy and control

In the context of platform work, autonomy – which is generally considered as one of the main drivers for workers to engage in this employment form (Berg, 2016; De Groen and Maselli, 2016) – involves the freedom of workers to choose which tasks they do, their working time, and how to organise and perform their work. In practice, however, the level of control exercised by the platforms varies considerably (Durward et al, 2016; Sundararajan, 2016).

On-location platform-determined workers have little choice over which tasks they perform, where, when and how. Task assignment is mostly done through algorithms, and they are supposed to follow instructions regarding work organisation which tend to be closely monitored in an automated way. The thereby generated performance data influences workers' access to future tasks, with limited opportunities for redress if they feel unfairly treated.

Online contestants, on the other hand, have essentially no limits on their autonomy. They choose in which contests to participate, as well as when, where and how to conduct the task. There is no supervision by the platform or the client. Between these two extremes, workers in the on-location worker-initiated group have complete freedom to choose what they work on, but must agree with clients on when, where and how the work is performed (as they would have to in the traditional economy). Interviewees do not experience a substantial level of control by the client and the platform.

Earnings

For the time being, few people rely exclusively on platform work for their income (Huws et al, 2017; Pesole et al, 2018).

Interviewees' pay varied substantially across the platform work types. In general, tasks carried out on location result in comparatively higher wages because of a more limited pool of workers (Aloisi, 2016; De Groen and Maselli, 2016). For on-location platform-determined work, rates tend to be low due to the small scale and low skills requirements, but rather stable and predictable, and comparable to market prices in the traditional economy.

For the on-location worker-initiated type, workers generally set the rates. All the interviewees indicated they could work and earn more if they wanted to, as there is always greater demand than ability to meet it.

Online contestants benefit from rather high rates for the tasks performed. However, they earn money only if they win a contest which results in high unpredictability and instability of income. Furthermore, time spent searching for or waiting on tasks is usually uncompensated (Berg, 2016).

Work intensity and working time quality

Work intensity refers to the physical and emotional effort and strain associated with carrying out the work. Organisation of working time refers to how the worker, platform and client manage the workers' time in terms of schedule and duration. Both influence workers' work-life balance.

The working time of on-location platform-determined workers is organised differently across platforms, but often refers to shifts to which the workers commit and during which they might be assigned tasks – in many cases algorithmically and sometimes on short notice. In general, they do not experience a lot of unpaid search time or waiting time between tasks. Interviewees mention that work intensity is adequate, unless some unforeseen event happens (such as receiving the wrong order or clients not answering the door). A few interviewees reported that if they cannot do an assigned task they have to look for a replacement themselves or need to have a very good reason to decline. Workers who miss a shift or are unexcused receive a "strike" (a negative mark of their perfor-

mance). When they have a few strikes, the platforms tend to suspend their account.

Workers engaged in on-location worker-initiated work have very few concerns about work intensity and scheduling, largely because they only perform tasks of their choosing and have high discretion as regards work organisation. Also these workers experience little unpaid working time as they receive offers rather than having to actively search for tasks. However, it happens that clients understate the scale or difficulty of the task at hand, resulting in the need for higher work intensity.

Online contestants valued the flexibility of their platform work and participated only when contests fitted their schedules. However, besides the above-mentioned potential for unpaid search time and unpaid effort if they are not successful in contests, they might suffer from increased work intensity due to tighter deadlines compared to the traditional economy.

Skills, training and career prospects

In many cases, workers are overqualified for their platform activities, particularly if they relate to low-skilled tasks. Platforms hardly set initiatives to develop workers' skills. Training, if provided, generally focuses on safety procedures or how to use the platform's app.

Also, occupational on-the-job training is limited. Low-skilled tasks allow for hardly any learning opportunities. For higher skilled tasks, workers tend to select those for which they already have the required skills to realise efficiency gains. The highest potential for occupational skills development is in online contests if workers select tasks in which they can try new ideas or approaches.

Accordingly, the contribution of platform work to career development is limited. Most interviewees indicated that their platform work is a temporary way to earn money without any long-term potential, rather than a desirable career path. Most also approached their platform work with that perspective in mind.

However, the worker-initiated type and online contests may boost workers' entrepreneurial spirit and self-employment competencies (such as self-organisation, dealing with clients etc.). Several interviewees used the platform strategically to try out self-employment (that is, as a tool to support career transition) or increase their already established business activity.

Representation

Both trade unions and new bodies, such as cooperatives and foundations, make an effort to represent platform workers in a considerable number of countries. However, both types are facing challenges in mobilising and organising workers, and in successfully negotiating working conditions. The uncertainty surrounding platform workers' employment status and the intermediary role of platforms imply that existing industrial relations and social dialogue structures are often not a good fit. Furthermore, platform workers typically do not share a common identity, may not consider themselves workers, are not physically present at a single workplace, may frequently enter and exit employment, and may fear retaliation if they join a union. The global nature of some platforms and the diversity in the types of platform work further complicate representation.

Both the literature and the interviews confirm that the characteristics of on-location platform-determined work facilitate efforts to organise workers, as workers can be more easily identified and approached (Kilhoffer et al, 2017). Furthermore, they appear to be the most likely to find themselves in precarious situations, which may also be a factor contributing to organisation efforts.

Most of the interviewees doing on-location worker-initiated work and online contests said that representation on the basis of their platform work is not important to them. Many of them were represented on the basis of their other activities and were therefore less interested in additional representation measures.

4 Concluding remarks

Platform work is a comparatively recent, still small-scale, but dynamically growing form of employment in Europe. It has been widely recognised in policy debate for its potential positive contributions to the economy and labour market. At the same time, some important challenges for employment and working conditions have been identified. Notably trade unions and governments across the EU Member States are seeking for and implementing first solutions to tackle these issues.

However, most of the discussions as well as the established initiatives consider platform work as a homogeneous phenomenon. This article shows that there exists a substantial heterogeneity among platform work, which results in different effects on the respective platform workers. These need to be considered for effective and efficient policy-making.

Among the three analysed distinct types of platform work, the platform-determined type raises most concerns, for example as regards a potential misclassification of the employment status (and the related rights and entitlements, including social protection). As this is the most widespread type for the time being, increased awareness as well as targeted solutions would be important to ensure decent working conditions and to avoid a race to the bottom.

While flexibility and additional income are generally the drivers for workers to engage in platform work, whether or not workers can realise such income depends to a large extent on the type of platform work. Autonomy is high in the worker-initiated and contest type, while rather limited in the platform-determined type. New technologies allow platforms to continuously monitor these workers while they work, and (automated) rating strongly influences workers' access to work and income.

Earnings are most promising in the worker-initiated type of platform work, although they are highly unpredictable and there is a high potential of unpaid working time for contests. For the platform-determined type of work, earnings are low, but generally decent and predictable.

While platform work is a beneficial tool for labour market integration, insufficient information is currently available on the long-term career prospects of platform workers. Overall, they seem to have little interest in establishing a career within the platform economy and have few opportunities to do so if they did. Skills development for use in the traditional economy is limited as regards occupational skills, but self-employment skills could be boosted in the worker-initiated and contest type of platform work.

Collective representation of platform workers remains small in scale and fragmented, and is challenged by the very nature of this employment form, which makes it difficult to identify, approach and mobilise workers.

	On-location platform-determined work	On-location worker-initiated work	Online contestant work
Employment status on platform	Self-employed or employee Potential misclassification due to tensions between the factual circumstances of work and contractual status	Self-employed or "occasional" worker	Self-employed or "occasional" worker
Autonomy and control	Limited flexibility to choose tasks, with medium-term negative effects if assigned tasks are declined Responsibility to find a replacement if not able to conduct assigned tasks Very limited as regards time, place and manner of work irrespective of employment status Automated performance monitoring Few recourse options if mistreated	Free to choose tasks Some gatekeeping functions by the platform Partly instructed by the platform on how to carry out tasks Control by clients through ratings Some checks by platforms, assessed positively as quality assurance tool	Full discretion No control by platforms or clients Feedback/ratings from clients assessed positively due to inherent learning/improvement potential
Earnings	Main income source (but not dependent on platform income) Moderately predictable Decent pay rates, but earnings low due to nature of tasks	Additional income source Often set own rates Could earn more but prefer to stay below certain thresholds to benefit from more favourable tax regime	Additional income source Highly unpredictable Potentially high pay rates (but depending on the contest)
	Differences in pay rates by employment status and work schedule		
Work intensity and working time quality	Algorithmically assigned shifts Potential to have negative effects on work-life balance Limited breaks	Unpredictable Potential that clients understate scale or complexity of tasks	Unpaid search and preparation time Tight deadlines
	Not stressful, unless complications arise No unpaid search time, some idle time in between tasks	Little unpaid search time	Flexibility appreciated
Skills, training and career prospects	Limited learning opportunities for developing occupational skills, limited training provision by the platform		
	Low-skilled tasks Overqualified workers	Depending on type of platform, some possibility to use a variety of skills Overqualified workers	Advanced skills Worker-selected skills match between worker and tasks Improve portfolio
	Not a career, but a suitable temporary income-generation tool in a certain life phase	Opportunity to try out self-employment, build up client base Gather entrepreneurial experience and transversal skills	
	Effects on transitions (stepping stone versus lock-in) unclear		
Representation	Efforts being made Mixed appreciation by workers	Specific initiatives limited Limited need due to representation in the other employment, but some need if autonomy is reduced	Limited interest among workers Challenged by the international character of the activities

Table 2: Comparative overview of selected characteristics of working conditions by type of platform work | Note: Under the traffic light system in the table, green indicates good working conditions, red indicates poor and yellow indicates conditions that have both good and poor aspects. (Source: Eurofound, 2018b)

5 Policy pointers

Platform work is rather intensively discussed at EU and Member State level. However, the blurred concept makes debate and the establishment of solutions challenging. Accordingly, the use of a common definition and understanding of "platform work" would be an important step to progress, also as regards data collection and analysis.

Policy initiatives should not aim for a "one-size-fits-all" approach, but take into consideration the heterogeneity among platform work and develop tailored and targeted solutions. This refers to one of the most-discussed issues: the employment status of platform workers. One approach could be setting a default status for platform workers, depending on the type of platform work they are conducting, and obliging platforms to provide evidence to justify a different status if they want to apply one.

An important particularity of platform work is algorithmic decision-making and control, even if there are considerable differences across types of platform work. As ratings at least in some types are decisive for workers' access to tasks and income, it needs to be ensured that they are fair, transparent, transferable across platforms and that workers have a possibility of redress if they feel unfairly treated.

Especially regarding platform-determined work, minimum working conditions should be set to ensure decent working conditions for what is most likely a dependent employment situation. Accordingly, greater protection of workers is justified, for example as regards minimum hourly wages, working time arrangements, access to training or health and safety measures. For such to be established, platform workers should also be supported in organising and establishing representation. This could either be done through traditional representative bodies or newly emerging bodies, or a cooperation among them.

References

Aloisi, A. (2016), 'Commoditized workers: Case study research on labor law issues arising from a set of "on-demand/gig economy" platforms'. Comparative Labor Law & Policy Journal, Vol. 37, No. 3, pp. 653–690.

Berg, J. (2016), Income security in the on-demand economy: Findings and policy lessons from a survey of crowdworkers. Conditions of Work and Employment Series No. 74, International Labour Office, Geneva.

De Groen, W. P. and Maselli, I. (2016), The impact of the collaborative economy on the labour market. Special Report No. 138, Centre for European Policy Studies, Brussels.

De Groen, W. P., Lenaerts, K., Bosc, R. and Paquier F. (2017), Impact of digitalisation and the on-demand economy on labour markets and the consequences for employment and industrial relations. European Economic and Social Committee, Brussels.

Durward, D., Blohm, I. and Leimeister, J. M. (2016), "Crowd work". Business & Information Systems Engineering, Vol. 58, No. 4, pp. 281–286.

Eurofound (2018a), Digital age. Platform work: Types and implications for work and employment. Literature review, Dublin.

Eurofound (2018b), Digital age. Employment and working conditions of selected types of platform work. Publications Office of the European Union, Luxembourg.

Eurofound (2019 forthcoming), Digital age: Platform work – Is it ALL that bad? Policy brief, Publications Office of the European Union, Luxembourg.

Fabo, B., Beblavý, M., Kilhoffer, Z. and K. Lenaerts (2017), An overview of European platforms: Scope and business models. Joint Research Centre, Publications Office of the European Union, Luxembourg.

Huws, U., Spencer, N. H., Syrdal, D. S. and Holts, K. (2017), Work in the European gig economy: Research results from the UK, Sweden, Germany, Austria, the Netherlands, Switzerland and Italy. Foundation of European Progressive Studies and UNI Europa, Brussels.

Kilhoffer, Z., Lenaerts, K. and Beblavý, M. (2017), The platform economy and industrial relations. CEPS Research Report No. 2017–12, Brussels.

Pesole, A., Urzì Brancati, C., Fernández-Macías, E., Biagi, F. and González Vázquez, I. (2018), Platform workers in Europe: Evidence from the COLLEEM survey. Joint Research Centre, Publications Office of the European Union, Luxembourg.

Urzì Brancati, M.C., Pesole, A. and Fernández-Macías, E. (2019), New evidence on platform workers in Europe. Results from the second COLLEEM survey. Joint Research Centre, Publications Office of the European Union, Luxembourg.

Riso, S. (2019), Digital age: Mapping the contours of the platform economy. Eurofound, Dublin.

Sundararajan, A. (2016), The sharing economy: The end of employment and the rise of crowd-based capitalism. MIT Press, Cambridge, USA.

Biography

Irene Mandl is head of the "Employment" research unit at Eurofound. She holds a master's degree in International Business Administration and one in Business and Law. Before joining Eurofound in 2009, she worked for about ten years in policy-oriented socioeconomic research in Austria in the fields of employment and labour market, as well as entrepreneurship and industry analysis.

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HUMAN AFTER ALL

THE EVOLUTION OF WORK IN THE DIGITAL AGE

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Abstract

The global economic and social landscape is changing the way we work. There is an ongoing debate on the actual meaning of the change, spanning from massive job destruction to massive job creation, as well as exploring the changing nature of work in general. In this chapter, we focus specifically on understanding the evolution of work from being characterized as the transfer of capital (from those who have it to those who need it), to a purpose-driven model where employees are in charge. This is not a discussion about "robots taking our jobs". This chapter is also not a discussion about the gig economy being the future model of work. Here, we focus on the vast opportunities emerging in the future of work and the growing possibilities for human contribution: the future of work being human after all.

In this chapter, we propose six trends in the future of work that speak to the changing nature of work and a blended workforce. These changes in the way we work also give rise to changes in the types of jobs that will emerge in the five-stage evolution of work. This chapter concludes by exploring what we as business, government, and society could do next to capitalize on the opportunities of this evolution.

Key words
Evolution of Employment, Algorithmic Employees, Algorithmic Managers, Self Automation, Human Checksum, Future of Work

1 Evolution of work as a concept

We tend to think about work as an immutable concept. However, just like any other construct in society, work is evolving. There was a time when there were no employers and employees; the concept of "employment" did not exist, we were just "making a living". Similarly, it is possible (and likely) that the idea of employment will disappear from our vocabulary at some point in the future, to be replaced by another approach. In our research, we think about the evolution of work in five stages.

Employment 1.0: emergence

The first phase of the evolution of work emerged as the concept of a paid job came into practice. The model worked such that those who owned capital hired those who needed capital (or other resources). Whether the model was one-to-one or one-to-many, employment was largely structured around a hierarchy of boss to worker(s). In this phase, the employee had limited power, with the employer holding most of the power.

Employment 2.0: industrialization

The second phase of work focuses on the optimization or industrialization of employment. Here, employers seek optimization gains and focus on the best utilization of the existing workforce. To achieve these optimizations, we witness the emergence of human resource (HR) systems. This phase of the evolution of work is characterized by hierarchies, top-down chain of commands, siloed and specialized teams, that are task-driven.

Employment 3.0: automation

The third phase of work involves the automation of employment, where employers are focused on the centralization of skills. During this phase we witness the introduction of shared services models, outsourcing skills that are not critical for the organization, and seeking productivity gains in technology employment. Here, we also observe the increased flexibility and mobility of where work is done (e. g. remote collaboration), enabled using collaborative technologies.

Employment 4.0: digitalization
The fourth phase of work involves the digitalization of employment tech industry realizes the potential of changing the dynamics of employment markets. We witness a decreasing power of employers, with a corresponding increasing power of employees. This phase embraces a shift towards flexible work hours. The emergence of platforms helps to remove market frictions and reduce entry barriers for employees, giving rise to first waves of gig-economy employees.

Employment 5.0: individualization
The fifth phase of work encapsulated individualization of employment. Here, there is a further shift in power distribution, whereby the employee is at the center of everything. We witness first examples of employees "hiring employers" to pursue their goals. Platforms such as Kaggle are a good illustration of what to expect in other areas of the economy.

Given that the fifth stage of work – individualization of work – is imaginable in the coming years, we are expecting to see new trends growing in dominance. They may be brought together in two larger trend-groups: the changing nature of work and blended workforce.

2 The changing nature of work: How technology will reshape what it means to be an employee

Technological innovation is already quite visibly changing employment dynamics. The "gig economy" has opened up a huge amount of flexibility, as gig workers pick up quick jobs and employers dip into a contingent workforce. But, perhaps more subtly and slowly, technology is also changing what it means to be a good employee.

At some point, algorithms and devices could completely replace human employees. This is already happening with smart programs that can answer the phone or chat online with humans, and as robotic arms doing repetitive and defined actions inside a factory.

But despite and until full automation, technology will augment human workers in many ways. In fact, it always has. The "best" employees are often those who can leverage these technological innovations.

For instance, ever deepening workplace tools have made office workers more connected and collaborative, able to work in virtual offices or wherever they are in the world. It's no coincidence that many of the biggest names in technology produce services aimed at white collar work - Microsoft, Google, Slack and Atlassian among them.

This is a process almost as old as time – as humans have invented wheels, writing, mathematics, engines and eventually computers, that have slowly augmented more and more of human life. Employees have also had to remain at the crest of the wave.

Once this was explicitly about labor saving – armed with levers and pulleys, men can do more, lift more, and accomplish more with less. But it has equally been of the mind – the civilizations that developed writing were able to organize and trade over large distances; the renaissance banks that survived were best able to price risk.

Not long ago a "computer" was actually a person. We saw rooms full of workers performing repetitive and complex math. Nowadays that room has been replaced with one person and a personal computer. The people that epitomized the old "computer" were excellent number crunchers, but they would be next to useless in the modern context.

As before, the key with new technologies like Artificial Intelligence will be how both employees and employers react. Those that flourish in the new world will be like those that came before – they will leverage the potential in new and profound ways, leaving behind those that fail to innovate.

Emerging trends

The rise of Employer Resource Management (or Employee Managed Relationships). Employees will control relations with employers, rather than the other way around (Human Resource Management). A new breed of applications – one can call them Personal Resource Planners – will make it very easy to maintain many-to-many relationships between employees and employers. Currently, most relationships are many-to-one (an employer typically has many employees, but many employees typically have only one employer). Early signals of this trend are visible in many-to-many gig-economy platforms (Kaggle, Fiverr, Airtasker).

Employees will become proactive faster than employers. Having access to more and more information about employers, employees will increasingly be able to offer their services even before employers realize they need them. Imagine a local government sharing some of their data using open data platforms. Individuals accessing the data may become aware of a potential future problem before the government does. This trend will lead to reimagining the "job offers" market, effectively flipping it. We can see early signals of this phenomenon: white-hat-hacker space is likely the most advanced in this area. Employers are typically not even aware that they truly need help when white-hat-hackers reach out to them after identifying critical cybersecurity flaws. Platforms such as Hacker One already allow employees to reach out to future employers proactively.

A shift from a focus on task to a focus on need. Digital start-ups have been continuously demonstrating that while improvement in processes might lead to gaining a competitive advantage, often truly transformational change results from applying a different perspective to the problem and using technology to create products and services driven by the new understanding. Similarly, jobs are commonly viewed as a description of tasks to be performed, and a true transformation can stem from applying a different lens. One such possible new lens is a focus on jobs to be done [1].

3 Blended workforce: Working with an algorithm

As technology increasingly augments human workers, picking up more and more capability on the way to replacing them entirely, we all need to get better at working with it. This is more than spreadsheets or e-mail. Algorithms can now sort through pools of job applicants, monitor competitors or employees. Algorithms that can do such routine tasks are increasingly powerful and accessible.

Soon, many companies will need to lean on such algorithms just to stay competitive, if not get ahead. But there can be unexpected pitfalls if algorithms are not managed correctly. Amazon, for instance, famously inadvertently created a hiring algorithm that selected for male traits.

With the Internet breaking down barriers to apply for jobs, and remote jobs multiplying, algorithms like this will soon prove essential for sorting through candidates. But successfully applying them will mean understanding when and how to slip automation into the workflow. For managers it also adds another wrinkle – how do you "manage" an algorithmic worker?

The first step is understanding the algorithm, how it works and itself makes "decisions". Algorithms aren't neutral tools but constructed using logic and code. For a human-written algorithm this means the conditions, use-cases and exemptions etc. baked into the code will govern how they act and react.

Making the best of an algorithm then takes a certain amount of understanding of what a particular algorithm is looking for and what it will then do.

For some machine-written algorithms, known as machine learning, how an algorithm will act or react may not even be understandable by the human programmer who set it all in motion. In this case it may help to understand the data that the algorithm was trained on, and the specific instructions that it was given at the start. Can you backtrack from there?

We are already starting to see the transition to algorithmic work at a lower level - with companies like Google introducing voice assistants that can book appointments or other low-level jobs independently. This means algorithms are moving away from the domain of the experts – IT teams who may have built them themselves, and so can pick apart and iterate if the needs require.

These new workplace algorithms are arriving prepackaged, plug and play, to workers who may be unable to tease them apart even if legally allowed to. While an algorithmically powered workforce could be incredibly powerful, it's also dangerous without the necessary understanding.

Emerging trends

Algorithmic employees. Many skills will be increasingly fragmented and disassociated from individuals (codified), offered as services by the very same individuals. Especially in highly specialized skills areas, we will see a growing codification of competencies, a trend currently emerging among software developers and knowledge workers. This trend is not science fiction. We can see early discussions concerning ethics of such approaches (Figure 1).

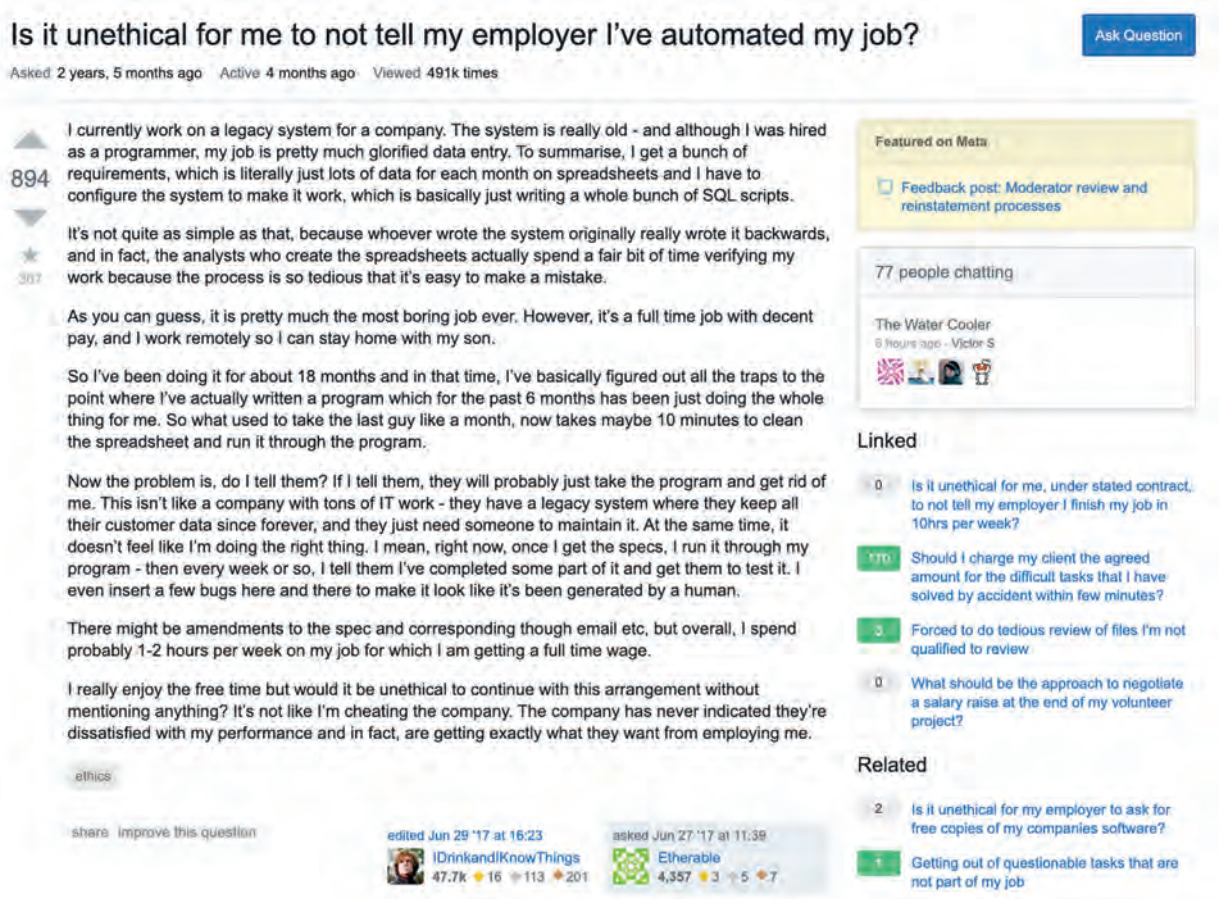


Figure 1: Screenshot from Workplace, 2017 [2]

Algorithmic managers. Decision support systems are now used in hiring, managing, and firing employees. In most cases the algorithms are used to facilitate the work of humans, but in more and more situations, for instance in screening of job candidates, algorithms make decisions autonomously, without any involvement of humans. This trend is being increasingly questioned [3], and humans are being brought back into the process, but the decision support part is most likely going to stay.

Humans managing algorithms. There is an ongoing debate about appropriateness of use of algorithms in certain scenarios. For instance, "black box" algorithms (based on neural networks etc.), are considered not suitable in situations where a full explanation of the decision process might be required (for instance court proceedings or welfare payment decisions). This gives rise to a new group of workers: managing algorithms, deploying them in the right scenarios, and deciding where and when they should not be used.

Case 1 of working with an algorithm:
The human checksum

Eric L. Loomis was arrested in February 2013. He was driving a stolen vehicle that had been used in a drive-by shooting. The police tried to stop the runaway car before it ran into a snow bank. The driver and passenger ran away but were later arrested. Loomis was one of the two. He pleaded guilty to eluding an officer and operating a vehicle without the owner's consent.

Loomis is not an angel. He is a registered sex offender, a result of a previous conviction. He had a sawed-off 12-gauge shotgun in the car, with two empty shotgun casings and some live rounds.

During the court proceedings, the judge in the case decided to turn to an algorithm, an application called COMPAS[1], to make a more informed decision. Before Loomis was sentenced, the judge generated a report that provided a risk-of-reoffending assessment. The score assessed Loomis as an individual with a high risk of reoffending. And the judge made it quite clear that the output of the algorithms helped in deciding on the 6-year jail term by saying: "you're identified, through the COMPAS assessment, as an individual who is a high risk to the community."

The case of Eric Loomis is not an exception. Quite the opposite: algorithmic assessment of the risk of reoffending is becoming a norm. Some are concerned[2].

When computer technology entered our workspaces in the last century, it acted as validation or enhancement of human activities. When Steve Jobs referred to computers as "bicycles for our minds"[3] he was suggesting that they help make us more efficient. Make better use of our energy: whether our creative energy, computing skills, or perhaps other forms. However, a bicycle does not decide where to go.

At some stage, however, it becomes less clear who is the rider and who is the bicycle. Are algorithms like COMPAS allowing us to be more efficient and hopefully less biased, or – in a perverse way – are we the bicycles, allowing algorithms like COMPAS to have more impact?

This is what Leanne Kemp, the CEO of Everledger and Queensland's Chief Entrepreneur has been introducing recently. While we were discussing the impact of technology on society, she casually mentioned how computers used to be "checksums" for humans, and now, increasingly, humans are checksums for computers.

A checksum, used in technical context, is a digital "summary" or "signature" of a piece of data. It has traditionally been used in data transmission, prone to errors caused by the medium

1 https://en.wikipedia.org/wiki/COMPAS_%28software%29

2 https://www.technologyreview.com/s/612775/algorithms-criminal-justice-ai/
3 https://www.youtube.com/watch?v=ob_GX50Za6c

(phone lines, radio waves, or even human transcription). If implemented well, the checksum is always the same if the data is identical on both ends of the medium, but will differ with even the smallest variations.

But we can also apply a slightly broader understanding:

A checksum provides an assurance that what we receive has been done without mistakes.

Can checksums only be provided to digital data? Can checksums only be done by algorithms? No. It is possible to have checksums that confirm no mistakes in human work. It is also possible to have humans confirm that what has been done by a computer algorithm is without mistakes.

There could be an algorithmic checksum and a human checksum. They can assure both human and computer outputs.

Remember the first "killer app" for personal computers? It was the spreadsheet[4]. It allowed humans not only to perform calculations more quickly but – more importantly – it allowed them to be confident about the results. As long as their spreadsheets were correctly designed, and the correct data was entered, any calculations would always be error free. Spreadsheet became a computer checksum for humans.

Today, the equivalents of spreadsheets are everywhere. Forms ensure the data we enter is error free. E-mail clients remind us to attach files mentioned in the email. Car navigation reminds us to slow down and change lanes to make sure we arrive at the destination according to our preferences (safely, quickly, without traffic fines).

Everywhere we look, we see the emergence of algorithms that operate independently, often without a human in the loop. Government algorithms make automatic decisions in simple cases, such as extending driver licenses or approving age-triggered services. Banks proactively block credit cards if they notice suspicious behavior. These automatic decisions have various levels of independence. To continue the bicycle metaphor, some algorithms are like basic bicycles, allowing humans to be more efficient; some are like trikes, preventing humans from harming themselves. Some algorithms are like bikes equipped with navigation, recommending to a human where to go. Finally, some are fully self-driving, seemingly not requiring humans at all.

And somehow the last group, the "self-driving" algorithms are all the rage. They are exciting, almost science-fiction. But they, just like science fiction characters, often go rogue, if not overseen by a human. "I am sorry Dave, I am afraid I can't do that."[5]

It might sound counterintuitive, that after so many years of trying to hand over all human activities to machines, we are now trying to get some back.

Case 2 of working with an algorithm: Self automation

In 2016, a Reddit user made a confession. FiletOfFish1066 had automated all of the work tasks and spent around six years "doing nothing". While the original post seems to have disappeared from Reddit, there are numerous reports about the admission. The original poster suggested that he (all the stories refer to FiletOfFish1066 as male) spent about 50 hours doing "real work". The rest "nothing". When his employer found out, FiletOfFish1066 was fired. This is possibly the worst mistake an employer can make.

Algorithms don't simply power applications, scripts, or automate tasks in other ways. Increasingly, they become our personal agents and make decisions on our behalf. For instance, Boston-based Quantopian, an investment firm focused on crowdsourcing, allows people to submit simple algorithms

4 https://en.wikipedia.org/wiki/Killer_application

5 https://www.youtube.com/watch?v=ARJ8cAGm6JE

that then make fund allocation decisions on behalf of investors. The algorithms are not yet as simple as Siri Shortcuts, but even beginner programmers should be able to write simple Quantopian algorithms. Imagine hundreds or thousands of such algorithms, each of them having access to information provided by Quantopian, deciding what to do with their creators' money. It is not science fiction; it is happening right now. An army of algorithms is continuously deciding how to allocate funds.

Artificial Intelligence algorithms are better than humans at detecting skin cancer. Software predicts the risk of reoffending by criminals (even though it cannot explain how it comes up with the risk assessments and it doesn't yet seem to be better than humans). But an algorithm cannot hold your hand when delivering news about melanoma. It doesn't see circumstances that may impact reoffending that are beyond the standard questions asked. Algorithms are making humans more efficient, and they are not making them less relevant. We have seen it in the age of industrialization (Employment 2.0), too. Tasks may change, but there's always an essential place for humans. There are plenty of opportunities.

More and more organizations are trying to identify tasks that are currently performed by humans but should not be. These automated tasks then need to be orchestrated, and that's where humans often play a crucial role. Introducing human-machine collaboration will not only provide better outcomes of existing processes but inevitably enable new value propositions, too.

In this ongoing race for efficiency, organizations need to look for opportunities to team up humans with machines (algorithms or robots). This search for opportunities could involve reviewing your current business processes and finding steps to remove, automate and enhance them. Where algorithms start to outperform humans – for instance in pattern recognition, data analytics or structured data management – they need to be hired there. Where humans are still better than machines – for example in creativity, inductive and deductive thinking or structured problem solving – more focus needs to be put on having humans do these tasks. If you do it well, you will grow your business, not just automate it.

4 Conclusion

There is no doubt we are witnessing profound changes in the global economic landscape, triggered by the new trends in business, technology, and society. The digital economy is here to stay, and many aspects of the world we live in, including the concept of work, are going to change, possibly dramatically. We expect that the major trends in the changing future of work are going to be in the space of the changing nature of work and the emerging blended workforce – humans working jointly with algorithms. We see this world as full of opportunities, while recognizing some pitfalls that need to be avoided. To put a new twist on a popular saying, the future of work is already here, we just need to find it.

References

[1] Christensen, C. M., Hall, T., Dillon, K., & Duncan, D. S. (2016). Know your customers' jobs to be done. Harvard Business Review, 94(9), 54–62.

[2] Workplace. (2017). Is it unethical for me to not tell my employer I've automated my job? Retrieved from https://workplace.stackexchange.com/questions/93696/is-it-unethical-for-me-to-not-tell-my-employer-i-ve-automated-my-job

[3] Walsh, M. (2019). When Algorithms Make Managers Worse. Retrieved from https://hbr.org/2019/05/when-algorithms-make-managers-worse

Biographies

Professor Marek Kowalkiewicz is an academic and industry leader with extensive experience in conducting academically sound research, co-innovating with industry and university partners and delivering innovative products to the market. Currently, as Professor and Chair in Digital Economy, as well as leader of the Embracing Digital Age research theme, he leads Queensland University of Technology's research agenda to inform and influence a robust digital economy in Australia and the region. He joined QUT from Silicon Valley, where he led innovation teams of one of the largest enterprise software vendors in the world. Before Silicon Valley, Marek worked in Singapore, Australia and China. Marek manages a contemporary research portfolio and converts industry driven opportunities into research outcomes of global relevance. He is an invited government expert, university lecturer and project lead, as well as an inventor and author.

Dr. Paula Dootson is a senior research fellow for the Chair in Digital Economy at the QUT Business School. In this role, she is researching how organizations transition through the digital economy and how consumers respond to changes in the market, which sometimes results in deviant or non-compliant behavior. Paula has received a number of national and international awards recognizing her extensive research engagement. To date, Paula has brought in over $2.5 million in funding and she is published in outlets such as the Journal of Marketing Management, Journal of Consumer Marketing, UNSW Law Journal and Advances in Consumer Research. Paula was awarded a PhD from QUT.

THE FUTURE OF WORK: DIGITAL WORKERS HELPING PEOPLE GET THINGS DONE

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Simon Fraser University | RWTH Aachen | ISSIP | IBM

Abstract

This chapter presents perspectives on the future of work and how value is co-created when more digital workers are helping people get things done. Where will digital workers come from? Digital workers will evolve from smarter apps on smartphones as well as service robots for individuals and industrial robots for businesses. This transformation of work will happen over the coming forty years. Not surprisingly everyone will be managing more and more digital workers over time, and so the skills of the best managers will be of great value. Furthermore, the global network that an individual can tap into for capabilities and opportunities will be of increasing value. Nevertheless, the growth in regional capabilities and opportunities will also be extremely important to individuals to ensure sustainability, resilience, and avoid mass migrations of people fleeing from turmoil and despair. Finally, we must also address the theoretical framework on which the continuing evolution of work is built.

Key words
Future of Work, Digital Workers, Service Systems, Service Science, Automation, Future of Regions

1 Introduction

Jobs and the nature of work as we know them are changing rapidly because of digitalization. Today, digitalization is a force fueled by advances in machine learning and data science. As digitalization disrupts markets and industries, two camps have emerged with very different views on AI's impact on the economy and jobs. The dystopian camp arguing that machines will be performing most of the jobs thus making humans irrelevant in the future, and the utopian camp postulating that machines will be doing all the grunt work, leaving the creative work to humans. If the reality is somewhere in-between, we still have a huge challenge navigating the tsunami of change in front of us. Institutions as corporations, educational establishments, and governments are grappling to take advantage of the tremendous opportunities and address significant challenges caused by these seismic shifts. These shifts have implications at the organization, team and individual levels. Innovative organizations are redesigning work and providing workforce retraining opportunities to ensure machines are enhancing, not replacing, human capabilities as they are transforming for exponential growth in the digital economy. Innovative teams are adapting agile practices to be more dynamic and respond to the fast-changing market forces by leveraging the best of people and technology. Innovative individuals are welcoming life-long learning to acquire the skills that enable them to up-skill and stay in demand. Disruptive changes to work behaviors and business models will have a profound impact on the nature of work and worker.

Table 1 summarizes advancing technologies and their impact on work and institutions across human history (Harari 2014). New technologies (column 1) enable new types of systems in which people live, work, travel, as well as govern themselves and make decisions about the possible futures in which to invest their resources (column 2). Over the years (column 3),

1 Order of authorship is alphabetical.

Technology	Service Systems	Years Ago	Comments
Stone Tools, Fire, Clothing, Animals, Carts	Families, Tribe Leader	~100,000 – 60,000	Hunter-Gathers; Crafts-people; Older Teaching Younger
Agriculture, Ships	Cities, Kings	~20,000 – 5000	Farmers; Shops; Apprenticeship
Steam Engine, Trains	Factories, Nations & Legislatures	~250 – 200	CraftWorkers; Schools; General Education
Electricity, Chemistry (Oil), Automobiles	Businesses, Financiers/Banks	~150 – 120	Business Employees; Suburbs; Higher Education
Computers, Internet, Airplanes/Spacecraft	Startups, Venture Capitalists	~70 – 50	Knowledge Workers; Globalization; Mega-cities; Graduate Education
Smart Phones, GPUs for Deep Learning, Artificial Intelligence, Drones/Avatars	Crowd & Platforms, Hedge Funds	~15 – 5	New Collar Worker/Learn On-Line and On-The-Job; Wikipedia, GitHub, Kaggle, LinkedIn, Uber, Airbnb

Table 1: Advancing technologies (based on Cellary et al. 2019)

advancing technologies, organizations and service system innovations have led to a growing population of people and a wide range of new roles in society and businesses, including new professions and disciplines interconnected with education systems (column 4). Service innovations that improve quality of life often depend on a complex co-evolving integration of systems related to efficient physical flows, fair human capital development and trustworthy governance across multiple scales of time and space (Spohrer/Maglio 2010a; 2010b). Determinants of trust between actors is fundamental to human collaboration and allows people to interact regularly and successfully with strangers (Seabright 2010). However, recent studies indicate that trust in IT businesses and government institutions is decreasing from earlier decades (Zuboff 2019; Ortiz-Ospina/Roser 2019). Addressing the challenge of the future of work with appropriate policies is necessary to regrow trust in business and societal institutions.

Each section of this chapter describes a source of value for individuals adapting to the future of work with more and more digital helpers that they will need to manage. Section 2 presents value from managing, with the specific example of the importance of the 4 Ts approach. Section 3 presents value from networks, and specifically the importance of ISSIP global professional network rooted in Silicon Valley. Section 4 presents the value of regions, as they become more sustainable and increase the quality of life and opportunities for citizens. Finally, Section 5 presents a summary and future research directions.

2 Managing: 4 Ts

"We need to start thinking in terms of human-system integration [and what work] will look like in the next century when technology is embedded in most organizational systems" (Salas et al. 2017, p. 595)

All of the chapters in this book take on the topic of the future of work. Automation and technology tools are critical aspects of all of our work and have been for millennia (Valavanis et al. 2007). That said, there is little agreement on how automation will affect jobs. Even within this volume there are both arguments that more jobs will be created by the introduction of Artificial Intelligence and that automation will be a devastating end of work for many. Besides new technologies, work is also affected by the increased use of independent workers, contractors, organizations built of remote workers, and even of crowd-sourced contributors (e. g. Majchrzak et al. 2018). Yet, little research or management effort focuses on how to proactively design and redesign work given these shifts in automation, human capabilities and interests, or new organizational practices.

Relevant research labeled as sociotechnical systems (Trist/Bamforth 1951; Winter et al. 2014) and sociomateriality (Orlikowski/Scott 2008) is available, but its broad application in work environments is not visible. In 2012, to address the gap one of the authors published a general audience book, The Plugged-In Manager: Get in Tune with Your People, Technology, and Organization to Thrive in an effort to bring some of these ideas into practice (the scholarly version is: Griffith et al. 2019). Seven years later and with much experience across audiences of all types, these ideas are resonating more, and we need to do more to help all of us adapt our work for the future.

Thinking in 4T

More recently, a marketing lens has begun to be applied to push the ideas further into practice narratives. Thinking in 4T is a concept built off a trope: We see in 3D, and we need to think in 4T. The four Ts are: Target, Talent, Technology and Technique.

Target: Goal
Talent: Human knowledge, skills and abilities
Technology: Automation and other tools
Technique: Organizational practices

Increasingly the job of managers is not simply overseeing the work that gets done, but constantly redesigning it to meet current and future needs. Thinking in 4T attempts to create a conceptually sticky approach to help people think about whether and how to design their own or their organization's work. This framing focus is similar to the 4 Ps used to describe the marketing mix of product, price, promotion, and place, or Porter's Five Forces as applied in the field of strategy.

Job and work crafting

In 2001, Wrzesniewski and Dutton added the idea of job crafting to the broad literature on top-down (managerially-derived) job design. They define this bottom-up approach as "the actions employees take to shape, mold, and redefine their jobs" (Wrzesniewski/Dutton 2001, p. 180). Job crafting is shown to increase job performance and work engagement (Bruning/Campion 2018), as well as organizational commitment (Leana et al. 2009). The dimensions of job crafting range across talent (e. g. shifting your own perspective, shifting who you work with), technology (e. g. tools adopted for completing work) and technique (e. g. changing task strategies).

A recent review of research in job crafting finds it is limited (for our focus on the future of work) in that only one (Bruning/Campion 2018) of six empirical pieces in the 2018-2019 window mention automation or technology of any kind. This

seems to be a perspective choice rather than technology not being important to job crafting: Bruning and Campion found that 13 percent of their examples included technology aspects. Bottom-up work design (or a better term is "work crafting" to acknowledge that future work may be more fluid than the term job would imply), as well as top-down, is critical to success as technology plays an increasingly greater role. The importance of these relationships is highlighted where individuals want greater control over how new forms of technology will affect their own work or employability (e. g. Hornung et al. 2010; Brenninkmeijer/Hekkert-Koning 2015). In summary, no matter what you call the myriad approaches related to how we come to design our work: sociotechnical, sociomaterial, job crafting -- none of these have reached a broad-based general management or worker audience.

We need to trigger a new way to think about the future of our work

The approach proposed here builds first on triggers for sense-making (Griffith 1999) and award-winning general audience presentations of behavioral decision theory by Nobel laureates Thaler and Kahneman (Thaler/Sunstein 2008; Kahneman 2011). Rather than letting future job creations or destructions evolve, technologies and work practices can be designed to trigger proactive work crafting by "nudging" (e. g., Thaler/Sunstein 2008) people toward thinking in 4T in their work and work design.

We derive two initial hypotheses from this approach:

- Artificial Intelligence tools that trigger/support individuals thinking in 4T will have an advantage over tools that are hidden in the background (e. g. blackbox approaches or embedded tools) -- individuals will extend the use of the tool beyond what designers may have considered
- Individuals who apply Thinking in 4T to crafting their work will have an advantage over those who let the organization do job design from the top-down -- individuals will improve their contributions to the organization both through their particular work and by showing others better ways to work with new tools and practices

This is, in fact, a 4T approach to work crafting. Figure 1 offers a summary.

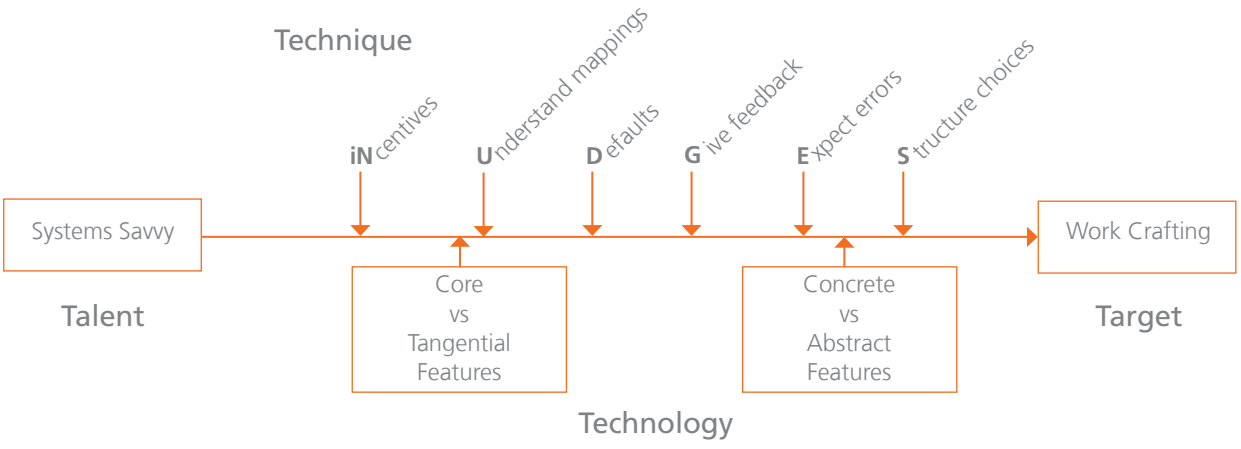


Figure 1: Target, Talent, Technology, and Technique in Work Crafting (from NUDGES)

Systems savvy (Griffith et al. 2019) is an individual's practical intelligence (e. g. Sternberg et al. 2000) necessary to adapt to, shape and/or select more effective sociotechnical integrations. More systems savvy "talent" will have a lower threshold for triggering work crafting. Technology features themselves can trigger or obscure sensemaking (e. g. Griffith 1999) related to work crafting. The NUDGE acronym (Thaler/Sunstein 2008) offers a variety of techniques for triggering work crafting across all its talent, technology and technique dimensions.

3 Networks: ISSIP

"The future is not preordained by machines. It's created by humans." – Erik Brynjolfsson

The International Society of Service Innovation Professionals (ISSIP, founded in 2012, see http://issip.org) runs workshops and Discovery Summits,[2] among other activities, to bring together global thought leaders from industry, academia, and government with an interest in better understanding service systems (enterprises, industries, cities, countries, etc.). ISSIP helps people explore how institutions and individuals can leverage the co-creation opportunities that exist at the intersections of diverse service systems for the benefit of business and society. Over the last few years, we have been studying work as a service system and exploring how the nature of work and jobs are changing in the face of rapid technological changes.

ISSIP, beginning in 2015, has hosted workshops at the annual Hawaii International Conference on System Sciences (HICSS) on Smart Service Systems with a focus on skills and the future of jobs. These workshops are in partnership with the University of Hawaii, and in collaboration with colleagues and ISSIP members from companies including IBM, Cisco, Facebook, Fujitsu; foundations such as the U.S. National Science Foundation (NSF) and Japan Science and Technology Agency (JST); and several universities.

Furthermore, ISSIP partners with NSF to help create a stronger partnership between industry and academia on these important topics. To that end, in 2017, ISSIP assembled more than 60 U.S. and internationally based industry and academic experts with diverse backgrounds to participate in a 2-day workshop[3] at San Jose State University in California to develop an industry-focused research agenda on human-machine partnership in smart service systems.

In our effort to make a broader impact globally, we have also partnered with JST jointly – holding Discovery Summits in Japan and the U.S. with a focus on promoting the Japan Society 5.0[4] initiatives.

Overall, we observe that technology mainly automates tasks not jobs, life-long learning is the key to developing in-demand skills, and service orientation enables individuals and institutions to grow and be successful in our digital economy.

Task vs. job automation

While automation will eliminate some jobs, the majority of jobs as we currently know them will be transformed due to task automation. Therefore, it is imperative that people gain the computing skills necessary to partner with machines, and to continually learn to do things that machines can't do. For this reason, we as individuals and institutions need to make investments to take full advantage of the opportunities ahead of us. Innovative institutions should be empowering workers with the skills and tools they need to reap the benefits of these new technologies and developing multiple pathways for those skills to be acquired throughout the stages of a person's working life. As individuals, we need to be committed to life-long learning across the span of our career.

2 More details about ISSIP Discovery Summits: http://www.issip.org/issip-discovery-summit/
3 http://www.servicescienceprojects.org/ISSIPNSF/
4 Japan Society 5.0 - https://www8.cao.go.jp/cstp/english/society5_0/index.html

Life-long learning
In many industries and countries, the most in-demand occupations, specialties and skills did not exist ten or even five years ago, and the pace of change is set to accelerate even more rapidly in the future. This will have a tremendous impact on how people in the future acquire and apply new skills, how companies organize work to stay nimble and competitive, and how educational institutions provide opportunities for life-long learning of citizens.

To understand, manage and thrive in this changing world, we must have both depth and breadth, and become more "T-shaped". This means that to be an excellent service professional or a data scientist, one must also be a savvy entrepreneur, have high emotional intelligence be inquisitive, develop an understanding of other disciplines, functions and industry verticals, manage complexity, value diversity of experience, knowledge and ethnicity.

Service-orientation
Service orientation and service science provide a framework for value co-creation with all stakeholders, thus expanding the opportunity horizon on how we as individuals and organizations can help solve problems and create value. We see a world empowered by AI, with access to sophisticated tools and technologies within the reach of ordinary citizens, and barriers to creativity and innovation at an all-time low. This environment suggests to us a fundamental question – in the words of Geoffrey Moore – "what opportunities unfold if we put ourselves at the service of those people we want to succeed and who want us to succeed?" This is the essence of service orientation and innovation, which guides ISSIP, and which we believe prepares us not to be just job-ready, but future-ready.

Other questions we continue to consider include:
- How is the definition of enterprise changing?
- What is the meaning of human-machine partnership and how is it evolving?
- What opportunities for life-long learning can we envision?
- What is the evolution of roles & skills?
- How can we design ethical AI?
- How does leadership manifest in future of work?
- How should policies change?
- What should we measure to create a future of work in which everyone thrives?

We invite you, the reader, to join us in this conversation!

4 Regional developments: Designing ecosystems for innovation

The future of competition happens between regions rather than between companies. This statement is both bold and old. Bold because regional strategies will matter even more as AI capabilities develop – data governance policies matters. Old because this has always been true – regions matter. Thus, regional development models have a tremendous impact on the wealth of regions as they determine the attractiveness for highly skilled employees and the context for the future of work and life. In this chapter, we thus highlight the value of regions, as they become more sustainable and increase the quality of life and opportunities for citizens. We explore an ambitious case which is the METROPOLITAN CITIES initiative in Germany. We propose a framework which organizes relevant tasks at the policy level to promote innovation work in future ecosystems.

The future of regions: A networked sustainable society
The METROPOLITAN CITIES initiative aims to create a European model metropolis with a unique character by connecting and mobilizing geographically distributed locations. Numerous companies, research institutions and the public sector have set themselves this goal for the development of Europe's 5th largest metropolitan region: the Rhine-Ruhr metropolitan region. The vision of METROPOLITAN CITIES is to remove innovation barriers in regions and to realize an economic and

ecological future concept for a digitally networked and mobile region. This includes rethinking the way people live and work in a future metropolitan region and to innovate models for new forms of work from different perspectives. The initiative gets additional inspiration and momentum by the goal to prepare the region for applying for the Olympic Games 2032. The potential of more than 300,000 students, a well-educated population, established corporations and high-tech start-ups in this metropolitan region forms the knowledge base and the economic foundation for a unique vision of METROPOLITAN CITIES: the elimination of all barriers to innovation and mobility in a region. Collaboration of people through networking and mobility, innovation through access to education and knowledge, as well as sustainability through new infrastructure concepts will be enabled and promoted. This will make the region a platform for the development of innovative products and services for the digital networked economy.

To realize this vision and initiate the transformation process, significant levers have been selected. There is a focus on an economically and ecologically sensible mobility concept which will be designed and implemented. Through digital networking of individuals and companies, communities and digital ecosystems will be promoted. The attractiveness of the region as a place to live and work will be increased by the settlement of innovative companies and the design of an attractive cultural and leisure services concept.

Digital and physical infrastructures form the basis for the region. Central prerequisites and foundations are therefore the creation of an open database of all relevant data (Regional Data Space) and an infrastructure which provides access to data, information and related knowledge.

METROPOLITAN CITIES is driven by a network of companies and institutions that are involved in the development of the overall roadmap and testing the value of projects on the basis of prototypes to further develop them into approved permanent facilities. The cooperation of local industry, research institutions and public authorities in METROPOLITAN CITIES could thus actually become a model for many European regions.

How to stimulate networked collaboration:
A societal and common task

Overcoming the challenge of digital and physical networking is a mammoth task and therefore a joint task for all stakeholders: industry, research institutions and the public sector must pursue a common goal. The software industry, the logistics industry, vehicle manufacturers, manufacturing companies, urban planners, municipalities, utilities, telecommunications companies and network operators, trading companies as well as end consumers and citizens must be provided with a framework in which they can quickly and agilely create initial prototypes, marketable products and even new business start-ups. Collaboration must already begin in the planning phase of a model of future living and economic areas such as METROPOLITAN CITIES. The various partners must develop a holistic solution that balances the interests of all parties involved. This includes the individual needs of the residents, the political aspects of infrastructure development and other regulatory tasks, and economic interests and necessities.

Against the background of the enormous opportunities, politics has a leading role because public authorities and politics can bring together the diversity of responsibilities and create the framework conditions for innovation. This should incorporate the decision-making in society, in which we all determine how we want to live and operate in the habitat
of networked cities in a region. Economic interests are the incentive for investments from industry, which are building their own successful position for the future with the METROPOLITAN CITIES initiative. Research institutions develop the basic knowledge and develop the platform for training for the professions of the future.

How to build a platform for personal interaction: Conferences and think tanks

The METROPOLITAN CITIES congress is a framework and think tank for thought leaders and actors who really want to act in order to develop and realize the roadmap for the ambitious initiative METROPOLITAN CITIES. The congress is a platform for thought leaders from business, science and politics to discuss and solve the most pressing challenges of our region. This is the only way to create a region that stands for innovative strength and quality of life in a digitally networked society. The challenges of maintaining quality of life, reducing emissions caused by particles and noise, implementing new forms of work in networked ecosystems, ensuring data security and security of supply and the qualification of experts for the professions of the future are examples. Innovations made possible by METROPOLITAN CITIES can be exported from the region to emerging countries and other industrial nations, where solutions for climate protection and supply in megacities and for coping with growth will create major markets of the future. The METROPOLITAN CITIES congress works continuously with its stakeholders on the necessary strategies and implementation.

How to provide a vision to transform: Hosting the Olympic Games 2032

With 80 percent of the necessary sports facilities and an existing infrastructure, North Rhine-Westphalia already offers excellent conditions for holding the Olympic and Paralympic Games. A unique advantage can be achieved by a symbiosis of the application for the corresponding staging in 2032 and METROPOLITAN CITIES: The necessary networking of facilities and infrastructures does not become a unique task, but part of a significantly sustainable and innovation-oriented development strategy for a region.

How to successfully work in future ecosystems: a business community's perspective

The following framework outlines high-level challenges and tasks to design ecosystems for innovation. The different layers in the model follow an inherent logic of subsequent enhancement starting from the center. The central proposition of the framework is that an achievement at each layer will increase the value generation potential in an ecosystem such as METROPOLITAN CITIES. Against the background of this paper, it outlines how knowledge-based work can be enabled and implemented in innovation ecosystems. The framework builds on the work originally published by Schuh and Gudergan (2013). The original framework is founded on the theory of service systems and explains how co-creation of value is enabled and implemented in business communities. The underlying perspectives are complementary to the service dominant logic as developed by Vargo and Lusch (2014; 2016) and its applications in many fields of service science. The framework is illustrated and described in the following.

The framework puts the knowledge of actors in the center. In order to initiate and enable innovation, access to knowledge is required. The appropriate means have to be developed and put in place at the regional level in order to allow knowledge application and recombination. At the next level, personal interaction between actors and reflection further drives creativity and innovation. Again, appropriate means to facilitate this need to be provided. These might be centers, academies or similar institutions. Thought schools provide the conceptual and theoretical legitimation, they define the standards and predominant design patterns and support sharing of insights based on a shared and accepted basis. At the next level, innovation at the level of systems and solution happens if regional policies support start-up developments and new ventures. Actions to support exposure to markets and customers and to support scaling of business through finance will lead to exploitable offerings. Roadmapping and marketing will further enhance regional development and reputation.

The future of work will happen in systems as illustrated with by means of this layered framework. Future work will be based on knowledge and determined by access to knowledge. Future work will be working in communities with a high level of interaction. The success of future work will further depend on the ability to align with emerging predominant trends and standards. The value of regions is determined by their ability to stimulate these factors and furthermore link workers and companies to markets and design appropriate high-level roadmaps and strategies to increase reputation.

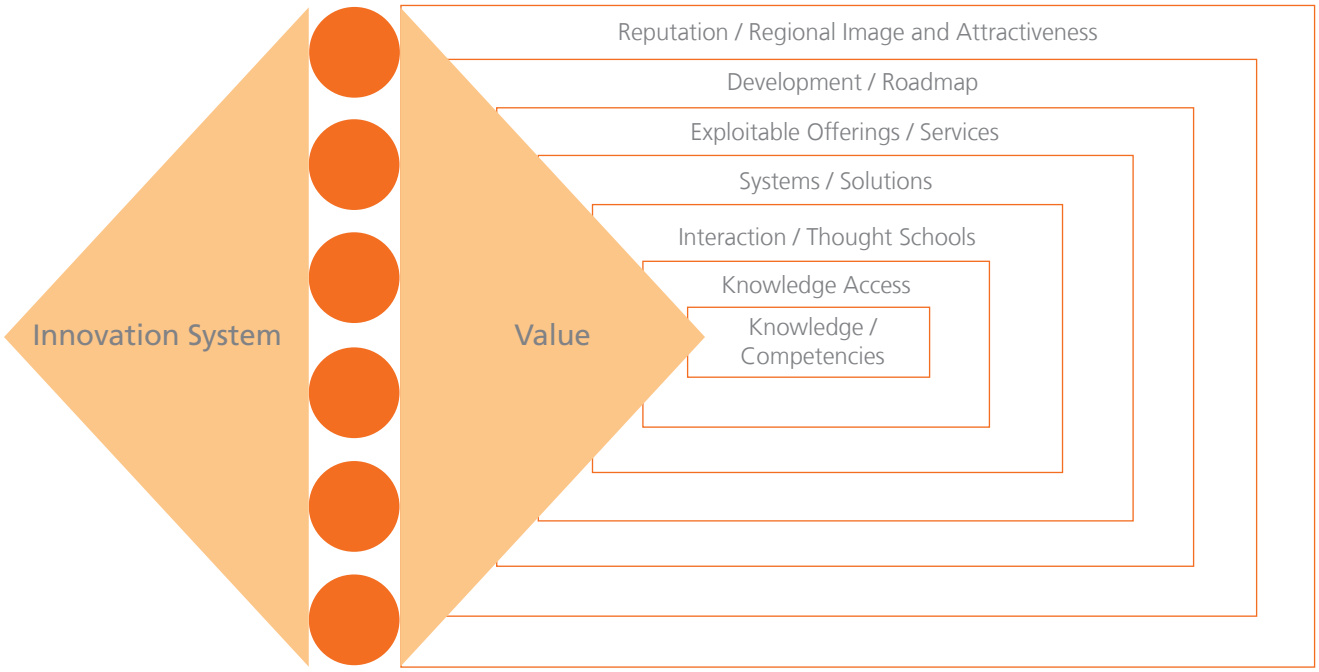


Figure 2: Framework for regional ecosystem innovation

5 Conclusions and research directions

This paper has presented three perspectives on the future of work, emphasizing management (e. g. 4 Ts), networks (e. g. ISSIP) and regions (e. g. METROPOLITAN CITIES). In conclusion, the future of work will require research directions to provide a stronger conceptual foundation connected to the evolution and design of sociotechnical systems, as influenced by increasing AI capabilities. In the remainder of this paper we briefly summarize a service science and human-side of service engineering perspectives on the future of work.

As previously mentioned, AI will impact the future of work both through automation of tasks as well as augmentation of people doing jobs/work differently (Rouse/Spohrer 2018; Pakkala/Spohrer 2019). Along with other information technologies such as augmented reality, virtual reality and blockchain for trust, advances in AI will fundamentally transform business and societal systems by accelerating the sociotechnical system design loop. This will directly impact technoextension factors for human capability which are measured across domains such as transportation, communications and much more (Kline 1995). Furthermore, AI will surely play a major role in solving the service science "discipline harmonization challenge." As defined in the [Box/APPENDIX], this challenge relates to how best to educate and prepare future service scientists across the wide range of disciplines relevant to service innovation (IfM/IBM 2018). One approach to future skills needs is to educate T-Shaped Adaptive Innovators. Someday in the next two decades, the following will be achieved – the creation of a single, low cost AI that can correctly answer nearly all of the questions in most top university textbooks, in the major languages and across the disciplines that span service science. Multitask learners have already made some progress in this direction (Wu et al. 2018), though hurdles remain (Lake et al. 2018). What are the implications of such an AI for next generation service scientists, especially with respect to the future of work? So called "super-minds" with harmonized disciplinary capabilities will augment our human-intellect far more than today's ubiquitous and indispensable smartphones (Malone 2018; Engelbart 1962). Our personalized super-minds will profoundly impact the nature of research, education and work (worthy goals) that people perform in future service systems (Baumol 2002; Spohrer et al. 2013; Freeman 2018; Gilbert 1978).

Providing a conceptual foundation for the future of work requires focusing on value co-creation phenomena between entities at multiple scales from individual people to businesses to nations. The future of work is one aspect of the Human-Side of Service Engineering (HSSE) (Freund/Spohrer 2012). The service research foundations of HSSE include Service Science, Management, Engineering, and Design (SSMED) (Spohrer/Kwan 2009), Service-Dominant Logic (Vargo/Lusch 2014; 2016), and a proposed framework for Service Innovation (IfM/IBM 2008). Recently, HSSE has also added the study of determinants of trust in adopting advanced technologies such as AI (Cellary et al. 2019). Determinants of trust (e. g. language, standards, prices, policies, etc.) are types of shared information resources that influence trust between actors and will be impacted by advances in Artificial Intelligence (AI). Members of the HSSE community are members of ISSIP who are concerned with engineering better systems in which people live and work. HSSE is concerned with human-centric issues ranging from ergonomics to public policy and the determinants of trust. The human-side and the technology-side of business and society co-evolve (Engelbart 1962; Spohrer/Engelbart 2004). As our data becomes our AI – digital workers will help people get things done.

Appendix

Definitions (based on Cellary et al. 2019):

The *Human-Side of Service Engineering (HSSE)* studies people as the primary variable in service systems, with service innovation as the main goal to invent, adapt and engineer better skills, technologies, organizations and information resources and value propositions to address the needs, wants and aspirations of diverse people in service systems (Freund/Spohrer 2012; Cellary et al. 2019). The disciplines of human factors, industrial and systems engineering, psychology, anthropology and many others are relevant to HSSE studies, which align with the broader area of study known as service science.

Service science is an emerging transdiscipline that studies the evolving ecology of nested, networked service system entities, interactions, and outcomes, their capabilities, constraints, rights, responsibilities, as well as mechanisms for value co-creation and capability co-elevation, using a wide range of disciplinary perspectives and methods from marketing, operations research, human factors and industrial engineering, design, information systems, computer science, mechanism design, management of technology, organizational development, economics, public policy, anthropology, ethics and more (Spohrer/Maglio 2010; Maglio et al. 2018).

Service systems are dynamic configurations of resources (people, technology, organizations and shared information) connected internally and externally by value propositions forming an ecology of named entities with identities, histories and reputations based on their interactions and the outcomes as judged by stakeholders (Spohrer 2011). Examples of service system entities include people, families, businesses, universities, cities, states and nations (Maglio et al. 2009).

Shared information includes language, processes, metrics, prices, policies and laws as well as standards, ethical codes, specializations (professions, disciplines, skills), value propositions and much more (Spohrer et al. 2007).

Value propositions are a type of shared information relating to capabilities and needs of entities that help shape the interactions between entities and are used to reason about win-win value co-creation outcomes (Anderson et al. 2006; Wright 2001).

Front Stage/Back Stage: The Front Stage of a service encounter refers to all interactions where any service personnel or service system elements are in direct contact with customers. Back Stage refers to all the supporting systems for a service and all employee interactions with other employees, partners, and information systems that are necessary to support a service encounter but are not in the presence of (or probably even known about) by customers (Teboul 2006).

The "discipline harmonization challenge" relates to how best to educate and prepare future service scientists across the wide range of disciplines (IfM, IBM 2018). One approach is to educate

T-Shaped Adaptive Innovators, who have enough depth in at least one discipline and enough breadth across the wide-range of disciplines, to work in teams to understand, improve and sustainably innovate the smarter and wiser service systems in which they and future generations will fill roles (Spohrer et al. 2017).

References

Anderson, JC, Narus JA, van Rossu, W (2006) Customer Value Propositions in Business Markets. Harvard Business Review. Spring. Pp. 90–99

Arthur WB (2011) The Nature of Technology: What It Is and How It Evolves. Free Press.

Arthur WB (2017) Where is technology taking the economy? McKinsey Quarterly. October 2017. URL: https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/where-is-technology-taking-the-economy

Auerswald PE (2012) The coming prosperity: How entrepreneurs are transforming the global economy. 2012 Apr 2. Oxford University Press (OUP).

Bakhshi H, Downing J, Osborne M, Schneider P (2017) The Future of Skills: Employment in 2030. London: Pearson and Nesta. URL: https://www.nesta.org.uk/report/the-future-of-skills-employment-in-2030/

Barile S and Saviano M (2013), Dynamic Capabilities and T-Shaped Knowledge: A Viable Systems Approach, in Barile S (Ed), Contributions to Theoretical and Practical Advances in Management. A Viable System Approach (VSA), ARACNE Editrice S.r.l., Roma, pp. 39–59.

Baumol, WJ (2002) Services as Leaders and the Leader of the Services. In Gadrey J, Gallouj F, Productivity, Innovation and Knowledge in Services: New Economic & Socio-Economic Approaches, Edward Elgar, Cheltenham, UK, pp. 147–163.

Bitner MJ, Brown SW, Meuter ML (2000) Technology infusion in service encounters. Journal of the Academy of Marketing Science. Jan 01, 2000; 28(1), pp. 138–49

Blocker C, Brennan D, Anderson L (2019) JSR Special Issue: Transformative Service Research and Unintended Consequences: Helping Without Harming. URL: https://journals.sagepub.com/pb-assets/cmscontent/JSR/Transformative%20CFP.pdf

Brenninkmeijer, V., & Hekkert-Koning, M. (2015). To craft or not to craft: The relationships between regulatory focus, job crafting and work outcomes. Career Development International, 20(2), 147–162.

Brundage, M., et al., 2018. The Malicious Use of Artificial Intelligence: Forecasting, Prevention and Mitigation. Oxford: Future of Humanity Institute, Oxford University.

Bruning, P. F., & Campion, M. A. (2018). A Role – resource Approach – avoidance Model of Job Crafting: A Multimethod Integration and Extension of Job Crafting Theory. Academy of Management Journal, 61(2), 499–522.

Cellary W, Freund LE, Kwan SK, Leitner C, Spohrer J (2019) The Human Side of Service Engineering: Advancing Technologies Impact on Service Innovation. Naples Forum on Service 2019 (will appear on website).

Clark C (1940/1957) Conditions of Economic Progress. Third Edition, 1957. New York, NY: Macmillan.

Davis MM, Spohrer JC, Maglio PP (2011) Guest editorial: How technology is changing the design and delivery of services. Operations Management Research. Jun 1, 2011; 4(1–2), pp. 1–5

EC (2018) Ethics Guidelines for Trustworthy AI (2018), The European Commission's High-Level Expert Group on Artificial Intelligence, Working document for stakeholders' consultation, Brussels, 18 December 2018, https://ec.europa.eu/digital-single-market/en/news/draft-ethics-guidelines-trustworthy-ai

Engelbart DC (1962) Augmenting Human Intellect: A Conceptual Framework. Summary Report, Stanford Research Institute, on Contract AF 49(638)-1024, October 1962, 134 pages. Scanned Original, Unclassified AD 289 565, Reproduced by Armed Services Technical Information Agency, 1963 Jan 04. URL: https://apps.dtic.mil/dtic/tr/fulltext/u2/289565.pdf

Freeman RB (2018) Ownership when AI robots do more of the work and earn more of the income. Journal of Participation and Employee Ownership. (2018 Jun 11). 1(1):74-95. URL: https://www.emeraldinsight.com/doi/full/10.1108/JPEO-04-2018-0015

Freund LE, Spohrer JC (2012) The human side of service engineering. Human Factors and Ergonomics in Manufacturing & Service Industries. 23(1) 2–10.

Freund L (2018) MyT-Me – Your personal T-Shape scoring system, in T-Shaped Professionals; Adaptive Innovators by Moghaddam Y, Demirkan H, and Spohrer J, Business Expert Press, New York, NY.

Freund LE, Cellary W (2017) Advances in The Human Side of Service Engineering, Proceedings of the AHFE 2017 International Conference on The Human Side of Service Engineering, July 17-21, 2017, Los Angeles, California, USA, vol. Advances in Intelligent Systems and Computing 601, Springer, ISBN 978-3-319-60485-5, DOI 10.1007/978-3-319-60486-2

Frey, C. B. & Osborne, M., 2013. The Future of Employment: How Susceptible Are Jobs to Computerisation, Oxford: Oxford University.

Friedman D (2008) Morals and Markets: An Evolutionary Account of the Modern World, Palgrave Macmillan, 2008, ISBN 978-0-230-60097-3

Gardner P, Estry D (2017) A Primer on the T-professional, Collegiate Employment Research Institute, Michigan State University. http://www.ceri.msu.edu/wp-content/uploads/2018/03/Primer-on-the-T-professional.pdf

Gilbert TF (1978). Human competence – engineering worthy performance. Performance Improvement, 17(9), 19–27.

Glushko RJ (2010) Describing Service Systems. Presented at the 19th Frontiers in Service Conference, Karlstad, Sweden.

Griffith, T. L. (1999). Technology Features as Triggers for Sense-making. Academy of Management Review, 24(3), 472–488.

Griffith, T. L. (2012). The Plugged-In Manager: Get in Tune with your People, Technology, and Organization to Thrive. San Francisco: Jossey-Bass.

Griffith, T. L., Sawyer, J. E., & Poole, M. S. (2019). Systems savvy: Practical intelligence for transformation of socio-technical systems. Group Decision and Negotiation, 28(3), 475–499.

Harari YN (2014) Sapiens: A brief history of humankind. Random House.

Hornung, Rousseau, Glaser, Angerer, & Weigl. 2010. "Beyond Top-Down and Bottom-up Work Redesign: Customizing Job Content through Idiosyncratic Deals." Journal of Organizational Behavior 31 (2–3):187–215.

Hsu, C., Spohrer, J.C. (2009). Improving Service Quality and Productivity: Exploring the Digital Connections Scaling Model. Service Technology and Management, 11(3): 272–292.

IfM, IBM (2008) Succeeding Through Service Innovation: A Service Perspective for Education, Research, Business, and Government. University of Cambridge Institute for Manufacturing, Cambridge UK.

Kazuo, I, Yasunori, K, Yosuke T, Satoru, B, Naohumi, Y (2017) JST-ISSIP Discovery Summit Report, Future Services & Societal Systems in Society 5.0–CRDS-FY2016-WR-13, Center for Research and Development Strategy, Japan Science and Technology Agency

Kline SJ (1995) Conceptual Foundations For Multidisciplinary Thinking. Stanford University Press.

Lake BM, Ullman TD, Tenenbaum JB, Gershman SJ (2017) Building machines that learn and think like people. Behavioral and Brain Sciences. 40:1-70. URL: https://cims.nyu.edu/~brenden/LakeEtAl2017BBS.pdf

Leana, C., Appelbaum, E., & Shevchuk, I. (2009). Work process and quality of care in early childhood education: The role of job crafting. Academy of Management Journal, 52(6), 1169–1192.

Levitt T (1972) Production-line approach to service. Harvard Business Review, 50(5): 41–52.

Kahneman, D. (2011). Thinking, fast and slow. New York: Farrar, Straus and Giroux.

Moghaddam Y, Demirkan H, Spohrer J (2018), T-Shaped Professionals: Adaptive Innovators. Service Systems and Innovations in Business and Society Collection. Business Expert Press.

Moghaddam, Y, Kwan, S, Spohrer, J (2018), ISSIP-NSF Workshop Report: Industry-Academe research partnerships to enable the human-technology frontier for next-generation smarter service systems, http://bit.ly/2xKicW6.

Moghaddam Y, Bess, C, Demirkan H, Spohrer J (2014), How to Thrive as IT Professionals in a Converging ICT World. Cutter IT Journal.

Moghaddam Y, Bess C, Demirkan H, and Spohrer J (2016), T-Shaped: The New Breed of IT Professional, Agile Product Management & Software Engineering Excellence Executive Update https://www.cutter.com/sites/default/files/APM/apmu1608.pdf

Maglio PP, Kieliszewski CA, Spohrer JC, Lyons K, Patricio L, Sawatani Y (2018) Handbook of Service Science, Volume II. Springer.

Maglio PP, Spohrer J (2008) Fundamentals of service science. Journal of the academy of marketing science. 36(1):18–20.

Maglio PP, Vargo SL, Caswell N, Spohrer J (2009) The service system is the basic abstraction of service science. Information Systems and e-business Management. 2009 Sep 1;7(4):395–406.

Majchrzak, A., Griffith, T. L., Reetz, D. K., & Alexy, O. (2018). Catalyst Organizations as a New Organization Design for Innovation: The Case of Hyperloop Transportation Technologies. Academy of Management Discoveries, 4(4), 472–496.

Malone TW (2018) How Human-Computer "Superminds" Are Redefining the Future of Work. MIT Sloan Management Review. 2018 Jul 1;59(4):34–41. URL: https://ilp.mit.edu/media/news_articles/smr/2018/59423.pdf

Markow W, Hughes D, Bundy A (2018) The New Foundational skills of the Digital Economy: Professionals of the Future. Burning Glass and Business Higher Education Forum Report (BHEF). URL: http://www.bhef.com/sites/default/files/BHEF_2018_New_Foundational_Skills.pdf

Meuter ML, Ostrom AL, Roundtree RI, Bitner MJ (2000) Self-service technologies: understanding customer satisfaction with technology-based service encounters. Journal of Marketing. Jul 1, 2000; 64(3), pp. 50–64

Moore, G (2011) Escape Velocity. HarperCollins Publishers.

Ng, ICL (2018) The Market for Person-Controlled Personal Data with the Hub-of-all-Things (HAT). Working Paper. Coventry: Warwick Manufacturing Group. WMG Service Systems Research Group Working Paper Series (01/18). (Unpublished)

Ortiz-Ospina E, Roser M (2019) Trust.
URL: https://ourworldindata.org/trust

Orlikowski, W. J., & Scott, S. V. (2008). Sociomateriality: Challenging the separation of technology, work and organization. In J. P. Walsh & A. P. Brief (Eds.), The Academy of Management Annals (pp. 433–474). London: Routledge.

Pakkala D, Spohrer J (2019) Digital Service: Technological Agency in Service Systems. Proceedings of the 52nd Hawaii International Conference on System Sciences. Pp. 1886–1895, URL https://scholarspace.manoa.hawaii.edu/bitstream/10125/59628/0188.pdf

Palmer A (2017 Lifelong learning is becoming an economic imperative. Special Report. The Economist. 2017 Jan;12.

Partnership on AI (2019), https://www.partnershiponai.org/

Peters, C, Maglio, P, Badinelli, R. Harmon, R, Maull, R, Spohrer, J, Tuunanen, T, Vargo, Stephen L. Welser, J, Demirkan, H, Griffith, T, and Moghaddam, Y (2016) , Emerging Digital Frontiers for Service Innovation, Communications of the Association for Information Systems: Vol. 39, Article 8.

Rouse WB, Spohrer JC (2018) Automating versus augmenting intelligence. Journal of Enterprise Transformation, 1–21. URL: http://service-science.info/wp-content/uploads/2018/08/Rouse-Spohrer-Automating-Versus-Augmenting-Intelligence-12-21-17-copy.pdf

Salas, E., Kozlowski, S. W., & Chen, G. (2017). A century of progress in industrial and organizational psychology: Discoveries and the next century. Journal of Applied Psychology, 102(3), 589.

Schuh, G.; Gudergan, G. (2013): Theorie der Leistungssysteme – wegweisend für Business Communities. In: Marketing-Kaleidoskop: Akzente und Suchfelder für ein realitätsorientiertes Marketing. Hrsg.: Reinecke, S.; Annen, E.; Belz, O.; Betz, M.; Schmitz, C.; Schögel, M.; Tomczak, T.; Zupanic, D. St.Gallen: THEXIS. S. 208.

Seabright P (2010) The Company of Strangers: A Natural History of Economic Life-Revised Edition. Princeton University Press; 2010 Apr 12.

Spohrer, JC (2011) On looking into Vargo and Lusch's concept of generic actors in markets, or "it's all B2B… and beyond!". Industrial Marketing Management 40, 199–201.

Spohrer, J., Anderson, L., Pass, N., Ager, T. (2008a). Service science and service-dominant logic, Otago Forum 2: Academic Papers, 2, 1–18.

Spohrer J, Banavar G (2015) Cognition as a service: An industry perspective. AI Magazine. 2015 Dec 1, 2015; 36(4) 71–81.

Spohrer J, Bassano C, Piciocchi P, Siddike MAK (2017) What Makes a System Smart? Wise?. In: Ahram T, Karwowski W (eds) Advances in The Human Side of Service Engineering. Advances in Intelligent Systems and Computing, Vol. 494. Springer.

Spohrer JC, Engelbart DC (2004) Converging technologies for enhancing human performance: Science and business perspectives. Annals of the New York Academy of Sciences. 2004 May 1;1013(1):50–82.

Spohrer J, Giuiusa A, Demirkan H, Ing D (2013) Service science: reframing progress with universities. Systems Research and Behavioral Science. 30(5):561-569.

Spohrer J, Kwan SK (2009). Service Science, Management, Engineering, and Design (SSMED): An emerging discipline – outline and references. International Journal of Information Systems in the Service Sector. 3(1) 1-31.

Spohrer J, Maglio, PP, Bailey J, Gruhl, D (2007) Steps toward a science of service systems, IEEE Computer, (40)1:71–77.

Spohrer J, Maglio PP (2010a) Service Science: Toward a Smarter Planet. In Karwowski W, Salvendy G (eds) Introduction to Service Engineering. Wiley, New York, pp 3–30

Spohrer JC, Maglio PP (2010b) Toward a Science of Service Systems: Value and Symbols. In: Maglio P, Kieliszewski C, Spohrer J (eds) Handbook of Service Science. Service Science: Research and Innovations in the Service Economy. Springer, Boston, MA. 157–194.

Spohrer, J., Vargo, S.L., Caswell, N., and Maglio, P.P. (2008b). The service system is the basic abstraction of service science, Proceedings of the 41st HICSS, Jan. 2008.

Sternberg, R. J., Forsythe, G. B., Hedlund, J., Horvath, J. A., Wagner, R. K., Williams, W. M., Horvath, J. A., Snook, S. A., & Grigorenko, E. L. (2000). Practical Intelligence in Everyday Life. Cambridge: Cambridge University Press.

Teboul, J. (2006) Service is Front Stage – Positioning services for value advantage. INSEAD Business Press, Palgrave McMillian.

Tien JM (2011) Manufacturing and services: From mass production to mass customization. Journal of Systems Science and Systems Engineering. 2011 Jun 1; 20(2) 129–154.

Thaler, R., & Sunstein, C. (2008). Nudge: Improving Decisions About Health, Wealth, and Happiness. New Haven, CT: Yale University Press.

Trist, E. L., & Bamforth, K. W. (1951). Some Social and Psychological Consequences of the Long-Wall Method of Coal-Getting. Human Relations, 4, 3–38.

UNDP, 2016. The Social Contract in Situations of Conflict and Fragility, New York (N.Y.): UNDP.

Valavanis, K. P., Vachtsevanos, G. J., & Antsaklis, P. J. (2007, July). Technology and autonomous mechanisms in the mediterranean: From ancient Greece to Byzantium. In 2007 European Control Conference (ECC) (pp. 263–270). IEEE.

Vargo SL, Lusch RF (2011) It's all B2B…and beyond: Toward a systems perspective of the market. Industrial marketing management. 40(2):181–7.

Vargo SL, Lusch RF (2014) Evolving to a new dominant logic for marketing. Journal of marketing. 68(1):1–7.

Vargo SL, Lusch RF (2016) Institutions and axioms: an extension and update of service-dominant logic. Journal of the Academy of Marketing Science. 44(1):5–23.

Winter, S., Berente, N., Howison, J., & Butler, B. (2014). Beyond the organizational "container": Conceptualizing 21st century sociotechnical work. Information and Organization. Information and Organization, 24(4), 250–269.

Wright R (2001) Nonzero: The logic of human destiny. Vintage.

Wrzesniewski, A., & Dutton, J. E. (2001). Crafting a job: Revisioning employees as active crafters of their work. Academy of Management Review, 26, 179–201.

Wu J, Child R, Luan D, Amodei D, Suskeve I (2018) Language Models are Unsupervised Multitask Learners. URL: https://d4mucfpksywv.cloudfront.net/better-language-models/language_models_are_unsupervised_multitask_learners.pdf

Zuboff S (2019) The age of surveillance capitalism: the fight for the future at the new frontier of power. Profile Books

Biographies

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Yassi Moghaddam is the executive director of the International Society of Service Innovation Professionals (ISSIP), a non-profit organization that promotes service innovation for our interconnected world. In this role, she has been catalyzing industry-academia collaboration to close the widening gap between education and employment to enable a thriving 21st century workforce, and to help institutions and individuals thrive through service innovation in our digital economy. Yassi is also Managing Director of Stradanet, a boutique consulting firm that helps organizations create value through digital innovation and transformation. Her clients have included VMWare, Cisco Systems, Wells Fargo, EMC, Applied Materials, Northeastern University and several startups. She holds an MBA from Columbia University, an MSc in Electrical Engineering (EE) from Georgia Tech and a BSc in EE from University of Oklahoma. Yassi is co-author of "T-Shaped Professionals: Adaptive Innovators" and a sought-after speaker.

Jim Spohrer directs IBM's open source Artificial Intelligence developer ecosystem effort. He led IBM Global University Programs, co-founded Almaden Service Research, and was CTO Venture Capital Group. After his MIT BS in Physics, he developed speech recognition systems at Verbex (Exxon) before receiving his Yale PhD in Computer Science/AI. In the 1990's, he attained Apple Computers' Distinguished Engineer Scientist and Technologist role for next generation learning platforms. With over ninety publications and nine patents, he received the Gummesson Service Research award, Vargo and Lusch Service-Dominant Logic award, Daniel Berg Service Systems award and a PICMET Fellow for advancing service science.

HOW TO TACKLE THE FUTURE OF WORK

CASE STUDY ANALYSIS OF THE STRATEGIES OF BASQUE ENTERPRISES IN RESPONSE TO WORKFORCE TRANSFORMATION CHALLENGES

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Abstract

The main objective of this study is to introduce the principal challenges faced by the global labour market and the strategies enforced in terms of the future of work, with a special focus on the local perspective of enterprises from the Basque Country, Spain. This article describes the cases of five Basque enterprises that took part in the international conference: World Virtual Tour: Future of Work, in December 2018 with an aim to summarise the local approaches to tackling work life transformations. Analysis of the case studies has unveiled organisational and territorial strategies, projects and partnerships in response to the local demand of new job roles, skills instability, talent mobility and the necessity for evolution in learning. The findings could serve as cross-country learning in the era of massive global change.

Key words
Future of Work, Talent Mobility, Learning Evolution, Technological Disruptions, Skills Instability, Lifelong Learning, Strategic Talent Management

"In the machine age, only one type of organisation will thrive: a Human One" (Seidman, 2016)

1 Introduction

Global labour markets are undergoing major transformations through rapid technological and social breakthroughs. These transformations, if managed wisely, could lead to a new age of work, good quality jobs and socioeconomic improvement, but if managed poorly, they pose the risk of widening gaps between skills, greater inequalities and broader polarization. (WEF, 2018a). Workforce transformations are no longer something of the distant future, they are now part of today's workplaces or those of the near future. Talent has become a strategic tool, the correct management of which can give an enterprise a competitive advantage. Despite this, so far, relatively few organisations have formulated comprehensive talent management strategies.

Consequently, a number of researchers, practitioners or academics have created open dialogues to share knowledge, best practices and tools but also to discuss obstacles or insecurities in order to collectively build the best strategies in order to respond to the challenges facing the global labour market. Organising the international 24-hour conference: The Virtual World Tour: "Future of Work", was one of the initiatives of cross-country learning with a view understanding various worldwide perspectives, practices and national strategies. The conference, which took place in the Basque Country (Spain), has contributed to the discussion on the future of work by discovering the approach of the Basque employers and academics which will be described later on in this article (see section 2)

This article is divided into two parts. The first part presents a brief overview of the future of work from a global perspective including socio-economic trends, workforce challenges and global strategies in response to these transformations. Part two presents findings from research conducted in 2018 by Mondragon University to detect the gap between the supply and demand of local talent in the Industry 4.0 era. In addition to this, it describes cases of enterprises from the Basque Coun-

try that attended The Virtual World Tour: "Future of Work", with the aim to detect the strategies of Basque enterprises and key recommendations in response to to challenges posed by the national labour market.

2 The future of work: Threat or opportunity?

The nature of work and the ways in which it is performed have changed multiple times throughout human history. Since the first, second or third industrial revolution, organisations have been optimising the process of economic value creation based on the most efficient division of labour between humans and machines technologically available at the time (European Commission, 2016; WEF, 2018a). Currently, the fourth industrial revolution, with automation, robotics, Artificial Intelligence and other new technologies, is having a significant impact on several industries leading to wide-ranging changes to the jobs, tasks and skills required within each sector. In addition to this, current technological changes interacting with a number of other factors, such as labour mobility and migration, demographic changes, delivery and the quality of education and skills or growing talent needs, are transforming the nature and quality of work (WEF, 2018a).

According to the global employers survey (WEF, 2018a), four specific technological advances – ubiquitous high-speed mobile Internet; Artificial Intelligence; widespread adoption of big data analytics; and cloud technology – are set to dominate the 2018–2022 period as drivers affecting business growth. Technological advances are the driver for business opportunities and growth but they can also create loops between the demands and skills of new jobs along with the displacement of entire roles when certain tasks become obsolete or automated, or new tasks are created that require job roles that have never existed before. Consequently, the disruptive potential of rapid technological development gradually leads to reforms in the educational system, investment in training systems and reskilling or upskilling strategies – and a new ethos for lifelong learning, especially among younger generations. Talent gaps stimulate talent mobility, allowing the absorption of ideas, technologies, goods and services around the world. Yet for some, the rapid labour market change can contribute to a wide-ranging feeling of disconnection and dislocation, a diminished sense of local belonging, technological and societal shocks or even fear surrounding the future of work (WEF, 2018b). The ILO's Youth and Future of Work Survey (2017) asked young people (between the ages of 19-35) how they envisioned their work life to be over the next 10 to 15 years. The majority of the global youth population (approximately 50 percent from developed countries and 40 percent from developing countries) perceive their working future "with fear" or "with uncertainty". Most of the worried respondents lived in Europe, Central Asia and in the Americas, where there has been the greatest technology diffusion. Robotics and other automation technologies are still concentrated in developed countries, whereas developing and emerging economies continue to rely mostly on low-skilled and low-cost labour.

Enterprises across all industries and regions need to formulate a comprehensive workforce strategy that is ready to meet the challenges of this new era and is geared to managing their potential but also their insecurities and uncertainties. Policymakers, educators, labour unions and individual workers alike have much to gain from a deeper understanding of the new labour market where proactive preparation can change the threats of the future into new opportunities, either within organisations or in the global economy as a whole.

2.1 The global forecast of talent challenges

According to the World Economic Forum Reports (WEF 2018a, 2018b) and ILO (2018) and OECD (2017), trends including *emerging new roles, growing skills instability, talent mobility and learning evolution* are considered to be critical factors challenging future scenarios of workforce transformations.

Emerging new roles due to technological disruptions such as automation, Artificial Intelligence or robotics are likely to lead to the structural decline of certain types of jobs by 2022

(WEF, 2018a). Nevertheless, the shift between job decline and the emergence of new professions is predicted to be counterbalanced (11 percent growth and 10 percent decline). The WEF Report (2018a) reveals that, apart from workforce shifts, the majority of businesses expect modifications in the composition of their value chain and changes in their geographical base of operations which will affect the quality, location, format and permanency of job roles. The jobs expected to become increasingly redundant by 2022 are routine-based, middle-skilled, white-collar roles – such as data entry clerks, accounting and payroll clerks, secretaries, auditors, bank tellers and cashiers. Among the range of roles that are set to experience increasing demand in the period up to 2022 are established ones such as those of data analysts and scientists, software and applications developers, and ecommerce and social media specialists. Also expected to grow are roles that leverage distinctively "human" skills such as customer service workers, sales and marketing professionals, training and development, as well as innovation managers. Moreover, the WEF analysis (2018a) finds extensive evidence of an increasing demand for a variety of completely new specialist roles related to understanding the latest emerging technologies: AI and machine learning specialists, big data specialists, information security analysts or user experience and human-machine interaction.

Growing skills instability due to constant technological updates is challenging enterprises in filling skills gaps. Interestingly, the fact that certain tasks or even job roles can be fully or partially performed by technology also means that time is "freed up" for workers to perform other tasks and create added value. (European Commission, 2016; WEF, 2018a). Therefore, proficiency in new technologies is only one part of the forecast regarding 2022 skills; It is estimated that growing emphasis will be placed on skills which are more difficult to automate such as creativity, originality and initiative, critical thinking, persuasion and negotiation (WEF, 2018a; OECD, 2017). According to the European Commission (2016), empathy, emotional intelligence and adaptability will also gather importance in the coming years. On the other hand, skills that have so far been considered very human-based, such as reasoning or decision making, will be gradually automated (WEF, 2018a). The required skill set of the future workforce still remains uncertain but the average of global skills stability is expected to be 58 percent, meaning a shift of 42 percent of skills in a global workforce between 2018 and 2022 (WEF, 2018a).

The talent mobility projection of ILO (2018) for 2055-2065 predicts the size of migration flows in Europe to be over 12 million. Mobility within countries may be affected by the availability of economic opportunity, travel regulations or crises and conflict, and could have a significant impact on labour markets in different geographies. It is predicted that high-skilled talent could flow to places where the most lucrative opportunities are to be found – often concentrated in large metropolises around the world. This will help local urban businesses to access the best talent and enhance knowledge transfer, but at the same time it will increase competition between workers at all skill levels, as well as shortages of talent across less urban regions (WEF, 2018b, ILO 2018).

The *learning evolution* of the global working population and their ability to acquire the right skills to carry out the tasks required of them in the workplace is one of the most impactful and uncertain variables for the future of work. Educational systems have to respond to changes in the labour market by developing updated and agile curricula in basic, vocational and higher education programmes, yet the majority of schools or universities still follow the traditional programmes. Enterprises need to make retraining opportunities available to the current workforce; however, many enterprises still rely on hiring workers with new skills rather than reskilling or upskilling their current ones (WEF, 2018a). Students and workers need to change their mindset and increase their willingness towards lifelong learning but the majority of them are still used to stable job positions, stable tasks and have a rather fixed mindset. Learning evolution, if performed correctly, can lead to enhanced creativity and productivity contributing to develop-

ment across a range of industries and sectors. However, investments in high-skilled talent may also lead to restrictions in migration as many economies could become reluctant to lose said talent (WEF, 2018b).

2.2 Global strategies to tackle the future of work

There are a number of potential courses of action that governments, businesses, universities and other actors could take to respond to labour market challenges and to prepare to enhance the likelihood of an enterprise where workers affected by changes to the labour market are supported through transitions and where growth is *human-centred* (WEF, 2018b). On the basis of the review of the latest reports (World Economic Forum 2018a, 2018b, 2019; European Commission, 2016; ILO, 2018 and OECD, 2017) a few leading strategies have been highlighted in order to respond to global labour market challenges. The strategies used by Basque enterprises will be described below (see section 2).

More and more companies are searching for new talent management strategies where the focus is not only on individuals filling roles attached to a fixed job architecture, as this model no longer fits and career paths are seldom linear and will be less so in the future. The current marketplace demands that businesses operate with greater agility and capacity in order to recognise the best talents and a range of potential skilling trajectories (WEF, 2019; WEF, 2018c).

In this age of decreasing mobility barriers and transparency of data belonging to potential workers due to online job platforms, the labour market is becoming more and more competitive, challenging companies to attract and retain the top talent (WEF, 2018b). Organisations need to apply internal and external employer branding strategies that will effectively differentiate the employer from other opportunities vying for the new talent's interest, and that will create a proper employee experience and work culture that meets the needs of the current workforce.

Additionally, businesses are implementing talent mapping to analyse the scale of the occupational change that is underway and document emerging and declining job types, or to track the evolution of job-relevant skills and prepare transition pathways between job roles. This helps businesses to understand and meet the emerging demand in terms of skills and to empower individuals to learn, unlearn and relearn skills (WEF, 2019; WEF, 2018c).

Education programmes from early-childhood, primary and secondary education to vocational training and higher education need to refresh their curricula and evolve in response to the changing workplace. Policy makers, enterprises and education providers should work together to improve basic skills in the fields of science, technology, engineering and mathematics, and put a new emphasis on human-centred skills such as creativity as well as on critical and system thinking. For everybody, developing agility, resilience, and flexibility will be important at a time when everybody's job is likely to change to some degree (McKinsey, 2017). In addition to this, educational institutions need to rethink how education is delivered by combining offline and online methods, professionalising and enhancing the role of teachers, recognising and accrediting skills and developing better and more inclusive systems for lifelong learning (WEF, 2018b).

Companies are starting to search for cross-sectoral partnerships as a form of collaborative and proactive response to workforce transitions. According to the latest reports (WEF, 2018a; 2018b) more and more enterprises are searching for support outside of their organisation, considering professional service firms, academic experts, local or international educational institutions or associations with other enterprises within their industry (WEF, 2018a; European Commission, 2016).

There is also evidence for the increasing viability of what a number of experts have called an "augmentation strategy". It has been suggested that businesses can look to utilise the automation of some job tasks to complement and enhance

the human workforces' comparative strengths and, ultimately, to enable and empower employees to harness their full potential and competitive advantage. Tighter integration with technology will free up time for human workers, including managers, from routinised, repetitive tasks so that they can focus more fully on activities to which they bring skills that machines have yet to master (WEF, 2018a; McKinsey, 2017).

3 The future of work in the Basque Country – overview

The future of work is different in every country. Work transformations are related to the national economies, therefore this section describes the economic situation in the Basque Country to provide a better context for trends, transformations and specific circumstances affecting local enterprises.

The Basque economy is one of the most competitive in Spain. According to the Regional Competitiveness Index from 2016, published by the European Commission in February 2017, the Basque Country is second among all Spanish regions (just after Madrid) and 119th out of 263 regions in the EU-28 in terms of competitiveness (European Commission, 2017). In 2017, the GDP per capita increased to 33,088 euros, placing the Basque Country in 51st position in the RCI ranking.

In 2017, the GDP reached 71,743 million euros which represents 6.2 percent of the country's GDP and makes the Basque Country the fifth largest Autonomous Community in Spain in terms of GDP. The economic structure of the Basque Country differs significantly from that in the rest of Europe, and is, characterised by greater industrial development and a lower presence of services and public administration (Basque Government, 2018).

This significant importance of industry in the Basque economy makes it especially sensitive to the transformation derived from the fourth industrial revolution. For example, digitalisation is progressively penetrating industry, causing a shift from a traditional approach towards servitisation, questioning the border between industry and the service sector.

However, the Basque Country also faces social and demographic challenges similar to those of other developed regions. Its population of just over 2 million inhabitants is increasingly ageing. Those over 65 years old already account for 21 percent of the population, which reduces the availability of talent for organisations. In fact, Basque organisations are already claiming that they are finding it difficult to incorporate talent. Equally, the Basque population is characterised by high levels of education and the Basque Country is in 30th place among the 263 EU-28 regions in terms of higher education and lifelong learning rates. This said, companies are still having difficulty finding certain profiles.

Interestingly, the Basque Country does not have excessive migratory movement rates. In 2018, only 9.4 percent of the population was of foreign origin, which is below the average for Spain (13.6 percent) (Ikuspegi, 2018).

Currently, the Basque industry is making efforts to adapt to the 4.0 environment. At the same time, Basque public institutions are also making an effort to accompany Basque enterprises in the task of tackling the transformations by activating initiatives such as Basque Industry 4.0 or designing a new Industrialisation Plan 2017-2022 (Basque Government, 2017) to keep up with the paradigm of Industry 4.0.

The first studies involving the adaptation of the Basque economy to the 4.0 environment have indicated that Basque companies are in the early stages of digitalisation and automation of production activities (Basque Government, 2017). Moreover, its current major challenges are not solely technological (Navarro and Sabalsa, 2016), but are found in non-technological aspects such as the adaptation of business models to the 4.0 environment or a better client approach (Navarro and Sabalsa, 2016).

In addition to this, the Basque Country can't ignore the human aspect in the era of labour market transformations. Firstly, the demographic imbalance resulting from the ageing population could limit the potential growth of the economy and, secondly, even though its population has high levels of education, it must face the evident imbalance between labour supply and demand that, despite the unemployment rate being around 12 percent, means that organisations are finding it difficult to cover certain jobs. At the same time, training centres are not finding sufficient demand for the technical training offering (Basque Government, 2017), increasing the need for reskilling and upskilling strategies.

3.1 Basque talent transformations: Demand vs. supply of talent

Due to the wave of Industry 4.0 and technological changes affecting the local labour market in the Basque Country, enterprises, in cooperation with Mondragon University, have carried out research in order to detect a skill gap and proactively prepare for the upcoming talent challenges. The research was carried out in the period of March-September 2018, and involved 41 local enterprises (mainly from the manufacturing or services sector) and 287 students and workers entering into the labour market or with a few years of experience from generation Z (21 percent), generation Y (76 percent) and generation X (3 percent). Data from enterprises was gathered in the form of responses from human resources directors (48 percent) and other HR managers or specialists (42 percent).

The surveyed enterprises collectively agreed that technological disruptions will mostly affect the changes in job roles and provoke a growing necessity for constant retraining. Additionally, the majority of those questioned (73 percent) predicted a strong need for an attitude of polyvalence and flexibility among the future workforce. Interestingly, the research unveiled significant transformations in the forecast of the local demand for skills over the next ten years. It is predicted that cognitive, knowledge, process, social and system skills will grow in importance in the future, especially in job positions such as technicians or operators. What's more, the data presents a common future trend of changes in the content of skills that will become gradually more similar among various job roles within the next ten years. It indicates more flexibility in job role shifts within the company ladder; however, it also demands new skills from HR directors. Consequently,, Basque enterprises have estimated that by 2028, the need for skills in the comprehensive management of people, time or resources will increase by 40 percent.

On the other hand, Basque students and workers (76 percent from the Millennial generation) perceive their future work life with confidence (48.2 percent), rather than with fear (42 percent). This could be connected with their positive outlook towards the influence of technological changes that will increase communication and networking and decrease mechanical repetitive work for humans. Nevertheless, only 33 percent of the surveyed Basque population assessed their attitude towards work as flexible or polyvalent, which is contrasts with the requirement of enterprises and might cause problems in the future.

The gap between the supply and demand of skills does not seem to be very critical in the examined sample, as many skills overlap (such as critical thinking, decision making, cognitive flexibility or problem solving). However, the level of proficiency required differs. The working population estimates the majority of their skills to be of a medium or high level, while enterprises demand very high levels, which might indicate a need for upskilling in the future. Interestingly, 47 percent of respondents admitted that a good working atmosphere was the most important factor when it came to determining their choice of future workplace, something that which should be taken into consideration in talent retention strategies. Besides this, young Basque generations show a preference for working in large multinational corporations rather than small ones which are restricted to Spain, which might generate a future risk of the loss of skilled talent and, at the same time, a need for enhanced talent attraction strategies. Nevertheless,

in relation to the origin of the company, they prefer Spanish companies to those of foreign origin, which might be a sign of social capital and indicate a sense of belonging that could inhibit future talent mobility.

The conducted research unveiled some key findings that may be significant for the proactive response of local enterprises. These related in particular to the skill content of various job positions that is predicted to become more similar in the coming years, the differences in required level of skills proficiency between enterprises and working population or the risk of talent mobility due to workers looking for opportunities in multinational companies.

3.2. Challenges & strategies for tackling the Basque future of work: The case studies

This section focuses on analysing case studies of Basque enterprises with the aim to detect the local strategies used to tackle common challenges related to current work transformations, such as emerging new roles, skills instability, talent mobility and learning evolution (see below). To this end, the cases presented at the round table held at the International Conference: The World Virtual Tour: "Future of Work", in 2019, have been analysed, including Mondragon Group, Lantek, Bizkaia Talent and Mondragon University.

a. Brief description of cases

Mondragon Corporation[1] was represented by Talent Management Practice Leader. Mondragon Corporation is the embodiment of the co-operative movement that began in 1956 with the creation of the first industrial cooperative in Mondragón in the province of Gipuzkoa (Basque Country). It's currently the leading Basque business group and the tenth largest in Spain, with 266 cooperatives and companies and over 80,000 employees. In terms of organisation, it is divided into four areas: Finance, Industry, Distribution and Knowledge.

The People Development Director of Lantek also took part in the round table. *Lantek*[2] is an information technology company specialised in self-developed software solutions. Lantek was founded in 1986 and its headquarters are located in the province of Alava (Basque Country). Since then, it has continued to expand worldwide and is now considered the world leader in CAD/CAM software for oxyfuel, plasma, laser, waterjet, punching and the pioneer of the on-demand management software solutions (MES/ERP). As a result, it currently includes around 200 professionals and more than 17,000 customers in over 100 countries.

The Basque educational institutions were represented by MTA Team Coach from *Mondragon Unibertsitatea*[3], which is a cooperative university located in the Basque Country that belongs to the Mondragon Corporation, with a clear human vocation and a commitment to its environment, society and time. The Mondragon University teaching model involves a relationship system with the educational system as the central theme. It aims to involve companies and institutions in the area of education in order to guarantee social accessibility, the combination of work and study, the implementation of research and the provision of continuous lifelong education.

Finally, *Bizkaia Talent*[4], represented by its General Director, participated as a representative of the territorial institutions that work in the attraction and loyalty of talent from a macro perspective. It was established in 2005 as a non-profit organisation with the clear mission of fostering and facilitating the implementation of the necessary conditions in order to attract, connect and retain highly qualified workforce in the areas of knowledge and innovation.

b. Collection of strategies

The representatives of the Basque cases revealed some of their strategies in dealing with local labour market transformations. The examples that they provided have been collected and presented below with relation to specific labour market challenges.

1 Mondragon Corporation: https://www.mondragon-corporation.com/en/
2 Lantek: https://www.lanteksms.com/world/home.asp
3 Mondragon Unibertsitatea: https://www.mondragon.edu/en/home
4 Bizkaia talent: https://www.bizkaiatalent.eus/en/?cl=1

Emerging new roles

Basque organisations must face changes in the demand for professional profiles derived from technological disruptions. As stated in the round table, some positions are disappearing while new ones are being created for which it is difficult to find talent. Basque companies are increasingly aware of the need for strategic talent planning. In this sense, organisations have begun to carry out strategic planning of the most professional talent. For example, the Mondragon Group has launched a talent observatory that studies the main trends likely to affect the supply and demand of talent in the strategic sectors of the Group. This initiative provides a global vision of the reality in which the Mondragon Group should develop. In parallel, each organisation or group of organisations belonging to the Mondragon Group carries out strategic planning of the talent connected to its concrete sector industry, which allows their management to create comprehensive talent management strategies.

Growing skills instability

Technological disruption has brought about important challenges for organisations as they now need to incorporate new talent that is not currently easy to obtain and to reskill and upskill their current workforce. Certain roles are starting to become obsolete and, as stated by the Mondragon Group: *"There are workers who do not have the skills required to respond to current needs. Normally, they are older people with a low digital profile and who occupy routine tasks"* (Mondragon Group). Consequently, local enterprises are starting to launch reskilling projects to enable them to re-incorporate workforce with obsolete skills. The reskilling projects are mainly based on training programmes adapted to the needs of the obsolete profiles, providing them with the knowledge and skills needed in the new digital environment.

Importantly, the high tech sectors are obliged to incorporate the latest technological knowledge in order to maintain their competitiveness. In organisations from the technological sectors, such as Lantek, "there is a need for professionals who are continually willing to learn new technologies and skills in order to continue creating value for their organisation and avoid obsolescence". For these situations, as proposed by Lantek, there is a need for upskilling projects focused on updating the knowledge and skills of the critical profiles in the organisation.

Talent mobility

Although the Basque Country is an economically active and socially stable region, organisations are suffering the first signs of the war for talent. In fact, they are having serious problems when it comes to incorporating specific profiles into their organisations.

Different projects have been set up, some at a regional level and others at an organisational level, to improve the capacity to attract talent. Bizkaia Talent carries out activities to attract and re-attract talent to the Basque Country, showcasing work and development opportunities in the Basque Country. They also organise international meetings and initiatives to connect Basque companies with Basque talent abroad in order to try to attract them back to the Basque Country. At an organisational level, different companies have launched projects to attract talent. For example, Lantek has been working on its Employer Branding strategy, adapting its value proposition to both local and international candidates, and has digitalised part of the recruitment process to reach candidates it was not able to reach before. Additionally, it has a large network of collaborators, such as universities, public institutions, associations and their workers, who assist with implementing the strategy of attracting and retaining talent. Within its employer branding strategy, Mondragon Group has launched a platform called Mondragon People that aims to be an employment channel. This is also part of the Mondragon DUAL project, which incorporates students into the Group's organisations to enable them to acquire certain skills and knowledge in a working environment with a possibility for further employment.

In order to prevent the "flight" of talent, organisations have incorporated talent loyalty strategies to ensure higher talent

retention. Work models based on decentralisation, cooperation, participation and transparency contribute to the loyalty of talent. Both Lantek and the Mondragon Group have opted for these routes. On a territorial level, Bizkaia Talent tries to enhance the image and visibility of Basque regions and employment or development possibilities among potential candidates.

Learning evolution

As the experts of Mondragon Unibertsitatea affirm: *"It is necessary that the workers of the future have different competencies from those of the machines, such as creativity, empathy, critical and global thinking, teamwork, leadership and flexibility"*. To acquire these new competencies, educational institutions need to adapt their methodologies to this new context, using active and innovative methodologies where learning is a continuous process throughout life, and is based on reality. Therefore, Mondragon University implements work-based learning in variety of fields, dual education where students are in close cooperation with companies, learning by doing or team-based learning methodology. Apart from that, at a time when soft skills are deemed to be important, Mondragon University is applying new tools based on the personal development of students, rather than only on knowledge and technical skills. Additionally, Mondragon University is constantly modifying or creating innovative educational programmes that will make it possible to meet the need for new job roles such as a wide range of data specialists or data analysts.

However, it is not enough for education entities to adjust what they offer to the needs of organisations. It is necessary for society to be aware of what the profiles needed in the future will be and to instil in young people and adolescents an interest in the knowledge, skills and abilities that will be required by organisations. Aligning the interests of future workers with the requirements of organisations will help to reduce the current gap between supply and demand of talent.

3.3. Recommendations from the Basque experience

Based on the of case study analysis, several key recommendations can be derived from the Basque experience in response to future-of-work challenges.

The future of work should be managed in an ecosystem that includes workforce, companies, universities and society and is aimed at building awareness of labour market transformations, so as to cooperatively anticipate potential challenges that can already be tackled with the help of proactive strategies today. In addition, building participatory, cooperative and democratic organisational cultures can in itself be a strategy for building organisational and workforce strength in response to future challenges. Importantly, companies and universities should focus on cultivating and developing skills that differentiate us from machines. In particular, the concept of fixed job roles and a fixed mindset should be replaced by a high degree of cognitive flexibility and lifelong learning among the current and future workforce as well as organisations. Universities should offer work-based learning and close cooperation with the labour market in order to constantly update the demand for skills or knowledge and eliminate obsolete methodologies. Companies should invest in reskilling and upskilling programmes and team-building strategies, as the future of work can be better tackled in teams than individually. Interestingly, intergenerational teamwork helps in the transition of knowledge and skills gaps fulfilment among workers. Last but not least, creativity and team creativity will be in high demand, not only to respond to the commonly known challenges of the future but also to unexpected changes, or to create entirely new scenarios of the future of work.

4 Conclusions

We are in an era of massive change, the world is facing important global challenges that affect all countries, organisations and individuals. The rapid digitalisation we are experiencing is transforming work environments and the tasks to be carried out within organisations. The competencies, skills and knowledge demanded are changing very rapidly and organisations are having difficulty reclassifying and incorporating talent. Basque organisations are also affected by this reality and they are adopting different strategies for strategic talent management.

Basque society has always had a proactive attitude towards new trends. Historically, it has been able to anticipate changes by adapting to new contexts in an agile and fast manner. However, in recent years the speed of change has increased considerably, which means that organisations must equip themselves with professional tools in order to anticipate change. Familiarising themselves with talent analytics tools could help Basque companies to better adapt to market requirements.

Although many Basque companies are internationally competitive, it should not be forgotten that they are also world leaders in promoting people participation in their organisations. The long tradition of the cooperative and participative model in Basque society gives organisations a competitive advantage when it comes to managing the human side of organisations, which has significant importance in the context of the future of work, where apparently technological changes affect the human factor the most.

References

Basque Goverment, 2017, Plan de Industrialización 2017–2020 "Basque Industry 4.0". Retrieved from http://www.euskadi.eus/contenidos/plan_gubernamental/04_planest_xileg/es_def/adjuntos/certificadoCG%20PLAN%20INDUSTRIALIZACI%C3%93N%2018%20julio.PDF

Basque Goverment, 2018, Basque Country Sustainability Bond, Public Document. Retrieved from:http://www.euskadi.eus/contenidos/informacion/7071/es_2333/BASQUE%20COUNTRY%20SUSTAINABLE%20BOND.pdf

European Commission, 2016, The Future Of Work, Skills and Resilience for a World of Change, European Political Strategy Centre, Issue 13. Retrieved from:https://ec.europa.eu/epsc/sites/epsc/files/strategic_note_issue_13.pdf

European Commision, 2017, European Regional Competitive Index. Retrieved from: https://ec.europa.eu/regional_policy/sources/docgener/work/rci2016_scorecards.pdf

ILO, 2018, The Future of Work Literature Review, Research Department, Working Paper No. 29. Retrieved from: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---inst/documents/publication/wcms_625866.pdf

McKinsey, 2017, Global Institute, A Future that Works: Automation, Employment and Productivity. Retrieved from https://www.mckinsey.com/~/media/mckinsey/featured%20insights/Digital%20Disruption/Harnessing%20automation%20for%20a%20future%20that%20works/MGI-A-future-that-works-Executive-summary.ashx

Navarro, M. , Salbalza, X. (2016), "Reflexiones sobre las Industria 4.0 desde el caso vasco", Ekonomiaz nº 89, 1 semestre, pp. 143–173

Observatorio Vasco de Inmigración (2018). Retrieved from: www.ikuspegi.eus

OECD, 2017, Future of Work and Skills, Paper presented at the 2nd Meeting of the G20 Employment Working Group 15–17 February 2017 Hamburg, Germany. Retrieved from: https://www.oecd.org/els/emp/wcms_556984.pdf

World Economic Forum, 2018a, The Future of Jobs Report, Centre for the New Economy and Society. Retrieved from http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf

World Economic Forum, 2018b, Eight Futures of Work, Scenarios and their Implications. Retrieved from: http://www3.weforum.org/docs/WEF_FOW_Eight_Futures.pdf

World Economic Forum, 2018c, Towards a Reskilling Evolution, a Future of Jobs for All, in collaboration with The Boston Consulting Group. Retrieved from: http://www3.weforum.org/docs/WEF_FOW_Reskilling_Revolution.pdf

World Economic Forum, 2019, Strategies for the New Economy, Skills as the Currency of the Labour Market. Retrieved from : http://www3.weforum.org/docs/WEF_2019_Strategies_for_the_New_Economy_Skills.pdf

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THE FUTURE OF WORK WITH PROJECT MANAGEMENT

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Abstract

Trend studies point to more flexible, less formal, more temporary, more technology-focused, and more network-connected ways of working in the future. These characteristics are typical of project works. Work organized through projects seems to be a steady trend and deserves further developments. The focus of this text is Project Management of the Future (PMF): trends, proposals and recommendations. We employ a review of the literature on the subject, interviews with project managers and a survey. We introduce a conceptual model for PMF, focusing on the project business. We present recommendations for the qualification of future project managers. We discuss professional competencies for project managers and the role of universities and independent training courses. We introduce challenges for future research on PMF.

Key words
Future of Work. Project Management, Business Analysis, Modern Project Management, Future of Project Management.

1 The future of work: Introduction

Among the practical reasons for studying the future of work, three stand out:

- Identifing future opportunities to generate more value with less resource expenditure;
- Planning the appropriate qualification for professionals of the future;
- Developing more knowledge on the subject.

The first reason stems from market interests, while the second focuses on teaching, and the third boosts applied research.

Recent studies reveal some typical scenarios for the work of the future: less formal, though more flexible, temporary, solution-oriented, technology-based and networked ways of working (Aston 2019). These results are fully identified with project-based work. The interest and relevance of studies on project management of the future (PMF) derive from this reality.

The challenge for PMF is to ensure more value (Kerzner; Saladis 2009) for project business – that is, for the project's raison d'être.

The organization of project management (PM) in modern times (since the 1950s) has aimed at techniques, processes and skills. More recently (in the present century), new contributions have prioritized agility, simplicity and informality. These developments have been well received by the professional community (because of the economic advantages they provide) and the academic community (with the definitive insertion of project management as a discipline in university courses and research).

For future scenarios, uncertainties about the trends in project management emerge (Hoffmann; Schelle 2002), such as:

- More intensive use of information technology;
- Broader job qualification;
- Greater connection with supply management;
- Alignment of PM with project business.

These uncertainties can be summarized by the following research question:

"How can project management of the future better contribute to the project business?"

To answer this question, the following instruments are used:

- A bibliographic research
- In-depth interviews
- A survey
- A conceptual model

The first three instruments reveal and organize knowledge about the present and the future situation of PM, while the last proposes a conceptual model to support PMF.

2 Relation to existing theories and practices

Current project management can be considered a relatively new discipline (Kerzner, 2017). Although its foundations date back millennia, it has only been organized in a manner similar to today's standards for approximately two decades. In 1989, the first version of PRINCE2® was published by OGC; in 1996, the first version of PMBOK® by PMI; and also in 1996, the first version of ICB® by IPMA. These institutions which publish guides and other texts with knowledge on PM are currently the most widespread references. They are enshrined in both the professional and academic communities. Among their publications there are many affinities, although PMBOK focuses on processes, while ICB is based on the *competencies* of project managers (Schelle et al 2006) and PRINCE2 targets the project product.

Since the mid-1990s, alternative visions of traditional project management have emerged as being lighter and easier to use. We highlight the Agile methodologies (Cohn 2009), the Critical Chain (Goldratt 1997) and, more recently, the Project Model Canvas (De Reuver et al 2013). In addition, PM modules have been adapted and integrated into broader management systems, such as ERP (Franz 2015) and PLM (Stark 2011), among others.

Today, the project management discipline is associated with dozens (if not hundreds!) of methods, work philosophies, ideas, models and flows to generate useful solutions for successful project planning, execution and control (Roberts 2013). Some of these associations occur with Design Thinking, Blockchain, Scrum, Kanban, Business Analysis, Adaptative Framework, Six Sigma etc. (Aston 2019).

This increasingly dynamic diversity of project management makes it difficult for universities to keep pace with new developments in the discipline – and even harder to anticipate them. In practice it is very difficult and time-consuming to create disciplines – or even to adapt their content – at the speed with which new work tools on the subject are emerging. This difficulty has immediate consequences for the labor market, since universities also play the role of training professionals. Thus, PMF research work is valuable in properly preparing the qualification of future project managers.

3 Interview with project managers

In April 2019, we interviewed professionals from three large companies and three medium-sized companies from various sectors (bank, automotive industry, home appliance industry, consulting and computer science) to identify trends in PMF. The interviews revealed the following results (in no particular order of importance):

- Remote work;
- More flexible working hours;
- Increased support for technology;
- Professionals with more varied skills;
- More temporary work;
- Higher professional qualifications;
- More compensation for results;
- Better remuneration;
- More focus on soft skills;
- Less project, more management;
- More transparency in management;
- More teamwork;
- Greater interdisciplinarity;
- Greater professional proactivity;
- More alignment with strategic objectives;
- Greater autonomy for project managers;
- More internationalization.

These results were helpful in designing a follow-up survey.

4 A survey with project managers

While interviews with project managers provided generic trends relating to PMF, more focused research was conducted with a survey. It was directed at project managers from various sectors of the economy and with different levels of professional experience.

In 15 scaled questions, the respondents indicated their beliefs about issues related to PMF. Two extreme situations were associated with each theme, separated by a scale of 1 to 10 points. The objective was to measure the respondent's personal conviction about the future of PM. The results are shown in Table 1.

It stands out that the means found in the responses are not close to the left or right extremities. This indicates that the questions were not obvious. It is also notable that the standard deviations of the responses were slightly high, because opinions about the future tend to be naturally scattered. The number of responses was sufficient to guarantee the desired level of confidence in the results.

The findings in the interviews and in the survey bring to light three main trends for for the PMF:

- Greater autonomy of project managers;
- Greater strategic importance of supplies;
- Products more closely related to actual project objectives.

These trends have guided the proposal of a conceptual model to represent PMF as shown in the next section.

Element	m	sd
1.....project professionals will have more affinity with: entrepreneurship 1 2 3 4 ★ 5 6 7 8 9 10 supply management	4.3	2.9
2.....the activities of the project managers will be more: in teams 1 ★ 3 4 5 6 7 8 9 10 individual	2.6	2.3
3.....the work of the project professionals will be more: temporary 1 2 3 ★ 5 6 7 8 9 10 permanent	3.8	2.5
4.....the autonomy for decisions of project managers will be: bigger 1 2 3 4 5 6 ★ 8 9 10 smaller	7.1	2.1
5.....the remuneration of project managers in reaction to other functions will be: bigger 1 2 3 4 5 6 ★ 8 9 10 smaller	6.7	1.9
6.....the employment of information technology will be: bigger 1 2 3 4 5 6 7 8 ★ 10 smaller	9.0	1.3
7.....the functions of the project manager, compared to today, will be more: administrative 1 2 3 ★ 5 6 7 8 9 10 technical	4.7	2.5
8.....the dependency on the supply management, compared to today, will be: smaller 1 2 3 4 5 ★ 7 8 9 10 bigger	6.4	2.4
9.....the qualification of project managers will be more: multidisciplinary 1 ★ 3 4 5 6 7 8 9 10 focused	2.9	2.2
10.....the duration, in hours, for the professional qualification in PM will be: longer 1 2 3 4 5 6 ★ 8 9 10 shorter	7.5	2.1
11.....management methods and techniques tend to be more: complex 1 2 3 4 5 6 ★ 8 9 10 friendly	6.8	2.8
12.....communication between different management areas will be: easy 1 2 ★ 4 5 6 7 8 9 10 difficult	3.4	1.9
13.....assessing the impact f supplies on project objectives will be: more difficult 1 2 3 4 5 ★ 7 8 9 10 easier	6.7	2.3
14.....learning of Project Management will be: complex 1 2 3 4 5 ★ 7 8 9 10 simple	5.8	2.8
15.....the main challenges for project managers will be with: technology 1 2 3 4 5 ★ 7 8 9 10 administration	6.5	2.9

Table 1: Survey results (May 2019) – 104 responses – (m; sd) = (mean; standard deviation)

5 A conceptual model for PM in the future

PMF trends - identified in the bibliography, interviews and survey – shows the need to expand the scope of project management beyond the predominantly technical areas. Based on this premise, a conceptual model is proposed with a focus on project business. The term "business" refers to the real motive that generated the project, having no specific connotation of transactions and profit.

In the business-oriented approach, the function of any project is to build solutions, rather than just products. The success of a project is then measured by the capability of its results to contribute to project business (see Figure 1 and Table II).

Each element of Figure 1 has a specific meaning, explained in Table II. A "solution" is the product that can solve the stakeholders' problems. "Resources" are the available or accessible capabilities for purchasing or hiring. And "requirements" are interests that can be described objectively (preferably, measurable). Stakeholder interests encompass not only customer needs, but also project constraints, such as: organization guidelines, laws and regulations, benefits to the project contractor, ethical customs and requirements, threat of competing products, etc. At each level of the diagram in Figure 1, the outputs on the right side (*) must be able to satisfy the inputs on the left side. Based on the discrepancies between them, the success of the project at each level of management is assessed.

The model represents a typical variety found in the management of virtually any project. For example, when applied to the project of building a house, these management levels are assigned to professionals with different functions and backgrounds:

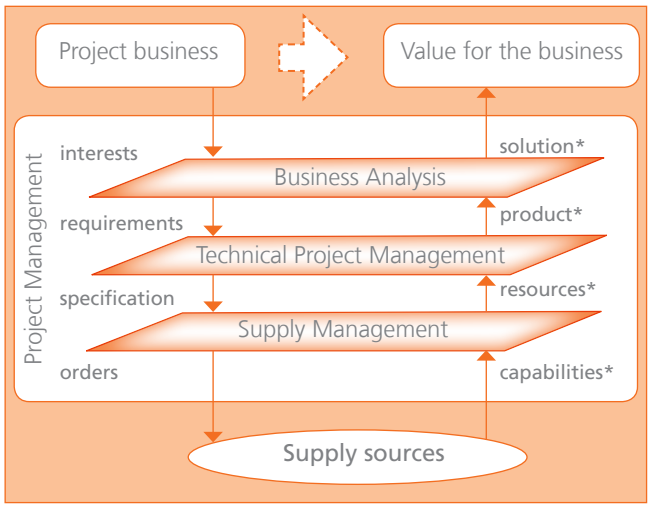


Figure 1: Business-oriented project management (Source: the author)

Element	Description
Interests	What stakeholders subjectively expect from a project
Requirements	More objective than interest, preferably measurable
Specifications	Characteristics of the product's components
Orders	List of acquisitions - for purchase or contract
Capabilities*	Means or advantages accessible to build a product
Resources*	Set of resources actually acquired
Product*	Tangible and intangible result of a project
Solution*	A product capable of satisfying stakeholders' needs

Table 2: Elements of the model

(= deliverables resulting from a management level)*

- The architects: translate the explicit and implicit interests of stakeholders into objective requirements. They are responsible for generating the solution capable of satisfying the buyer, technical standards and other stakeholders.
- The civil engineers: plan and execute the work and draw up a list of the necessary resources. They build the physical product (the house), which will be customized as a solution by the architect.
- The buyers: acquire the specified resources from the market, the organization or the partners. They employ their capabilities to buy or hire resources.

Each level of management can be assigned to a person – as is usual in complex projects. In many projects, a single person can manage two or even all three levels.

6 Critical analysis

The model makes communication between the strategic, operational and logistic levels of project management easier. It allows us to evaluate the success of the project based on the real contribution that its results bring to the project business (Kezner and Saladis 2009).

It also highlights the role of supplies in project management. If an acquired resource is different from the one specified, it is possible to assess the impact of the divergence on the project's customer satisfaction.

Another relevant benefit is the ease of managing project changes. Any change in scope can be communicated immediately to the three levels of management and is addressed in a fast, integrated and clear way.

There are some requirements for the three-level PM to work well in practice. One is the ability for the general coordinator of a project to separate project management into three management levels and coordinate those levels accordingly. Some additional training is also required for the project team so that its members work in alignment with the same concep-

tual bases. Finally, competence is required to conduct tradeoff analysis between project goals (IPMA 2006).

One limitation of the model is the requirement for more information and more preparations than management focused only on the project product or processes. This requirement implies more time and expense for the project.

The model in Figure 1 has been tested in real applications. Its validation has been carried out in three stages:

- Conceptual validation: based on bibliographic studies and trend analysis (Kerzner 2017);
- Simulated validation: based on simulations;
- Field validation: based on real applications.

All three stages have presented satisfactory results. In the latter, some training was needed to facilitate communication in teams.

7 Use case

The concepts presented above were applied in a project to expandf the bicycle network in a city in southern Brazil.

Surveys had indicated the population's interest in more urban mobility at low cost. The proposed solution* was the construction of more cycle routes with paths that competed with bus transport.

In order to design the new bicycle routes (product* of the project), requirements were established for the length of the stretches, the type of pavement, afforestation, signaling, expropriation, etc.

Designers developed technical specifications for procurement – for example, a strong-color paint for the pavement. The accessible resources* showed some disagreement with the specified materials - for example, the paint on the pavement did not offer the desired durability.

Purchase orders were issued to suppliers after intense negotiations on quality, price, deadlines and payment terms. The sources of the supplies represented an important capability* of the project, since they allowed access to exclusive and specific resources, negotiated under privileged conditions.

In summary, the management of this project considered three distinct levels: (1) the mobility analysis (2) the planning & execution of the work and (3) the acquisition of resources.

The success of the project was evaluated with reference to the proposed solution. As the purchased paint did not meet the technical specifications for durability, there was some loss in the solution of the project (which was urban mobility and its long-term sustainability).

Three-level project management has provided the following benefits:

- Predictability of success for stakeholders;
- Transparency and visibility for project management;
- Agility of work with decentralization of management.

8 Conclusion and reccomendations

The interviews and the survey carried out in Sections 3 and 4 revealed the tendency of a broader organization of PMF to integrate several areas of management. This trend has been reinforced by renowned publications on PM: the 2013 version of PMBOK® strengthened stakeholder management and the 2017 version reshaped resource management.

The model proposed in Section 5 permits managing projects according to the future vision indicated in the bibliography and in the research procedures of Sections 3 and 4.

Some recommendations derived from the results achieved are listed below.

1. For universities:
   - Be prepared to qualify students with a more open and integrated PM vision;
   - Organize the PM discipline in a less technical and less procedural way;
   - Explore greater integration with other disciplines;

2. For professionals seeking PMF qualification: understand the differences between PM certification and a university qualification in PM – and the respective advantages of each alternative;

3. For quick PM qualification courses: expand the scope of PM disciplines to consider PMF.

4. For organizations: assess the advantages and disadvantages of adopting PM aligned more closely with project business strategies (competitive advantages).

These conclusions and recommendations lead to new challenges, which are discussed below.

9 Challenges for future research work

Project management of the future has the potential to be broader and more integrated with the support of more advanced technologies and new disciplines. However, some challenging questions arise:

- How to use decision support systems and algorithms based on Artificial Intelligence in PM management models;
- How to more objectively assess the impact of the resources actually acquired in the success of project business;
- What will be the ideal profile of the project manager of the future, depending on the type and particular conditions of each project;
- How to use smartphones and devices of the future more intensively to make communication and project management simpler and more agile;

Since the PM field is very broad and stimulates growing interest in academic and professional communities, we assume that it will receive much attention from researchers and market professionals in the coming years.

References

Aston, B. "Prepare for these 7 project management trends". https://thedigitalprojectmanager.com/project-management-trends-2019/ in May 2, 2019.

Axelos (2017). "Managing Sucessful Projects with PRINCE2®". Axelos.

Cohn, M. (2009). "Succeeding with Agile: software development using Scrum". Addison Weley.

De Reuver, M.; Bouwman, H.; Haaker, T. (2013) "Business model roadmapping: A practical approach to come from an existing to a desired business model". International Journal of Innovation Management 17(01).

Franz, M. (2015) "Project Management with SAP Project System". Galileo.

Goldratt, E. (1997) "Critical Chain". North River.

Hoffmann, K.; Schelle, H. (2002) "Die Zukunft des Projektmanagements". Projektmanagement. 4(11), 11–15.

IPMA (2006). ICB3® - IPMA Competence Baseline, version 3.0. The Netherlands: IPMA.

Kerzner, H. (2017) "Project Management: A Systems Approach to Planning, Scheduling, and Controlling" – 12th ed. Wiley.

Kerzner, H.; Saladis, F. (2009) "Value Driven Project Management". Wiley.

PMI. (2017) "PMBOK® Guide" – 6th ed. Newtown Square, PA: PMI.

Schelle, H.; Ottmann, R.; Pfeifer, A. (2006) Project Manager. GPM.

PMI. (1999) "The future of Project Management". Newtown Square, PA: PMI.

Roberts, P. (2013) "Guide to Project Management: getting it right and achieving lasting benefit" – 2nd ed. The Economist.

Schmidt, T. (2009) "Strategic Project Management Made Simple". John Wiley & Sons.

Stark, J. (2011) "Product Lifecycle Management" – 2nd. ed. Springer

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THE USE OF HYBRID MEETING FORMATS TO INCREASE INTERNATIONAL COLLABORATION IN SCIENTIFIC RESEARCH

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Abstract

The following article considers two examples that illustrate how digitalization is changing the way in which scientific conferences and similar events are run. It begins with a description of the Virtual World Tour, which formed part of last year's Future of Work Conference, and of the follow-up symposium, which likewise incorporated digital elements. The staging of hybrid and virtual events presents conference management with a raft of new challenges and organizational issues. Not least of these is the question of how best to combine analog and digital forms of interaction.

Key words
Digital Events, Hybrid Events, Virtual World Tour, Blending of Virtual and Physical Meetings

1 The impact of digitalization on the form of scientific conferences

The Fraunhofer-Gesellschaft focuses on applied research. Its central mission is to ensure that insights from the worlds of science and technology are put to practical use by profit and nonprofit organizations. The Fraunhofer Institute for Industrial Engineering IAO studies the interaction between humans and technology in order to design better and increasingly efficient ways of working. The organization of conferences and workshops forms a key part of the work done at Fraunhofer IAO. This provides an opportunity to share project findings with a specialist audience and to promote a productive exchange of knowledge at the interface of research and industry. It is becoming increasingly evident that the conference industry is particularly affected by the changes brought about by digitalization. As a result, there is now a growing tendency to blend the conventional, face-to-face conference experience with digital forms of communication.

The conference industry is undergoing significant transformation. Examples of such change include the leveraging of social media and the Internet to advertise events in advance and process applications for registration, the use of dedicated conference apps to provide information and conduct interactive surveys during the actual event, and the provision of multimedia documentary material after the event. In line with this trend, Fraunhofer IAO recently staged the two events described in more detail below. Both were organized with the aim of expanding the international research network that is investigating the future of work. Both can, according to current definitions, be classified as "hybrid events."

Hybrid events consist, on the one hand, of a "classic event as a real, dialogue-based, experience-based forum for communication between companies, brands and their stakeholders." On the other, they also feature "all the new communication channels, technologies and appliances that people now use in order to enter into contact with one another" (Dams and Luppold, 2016, p. 1).

Permanent connectivity and continuous knowledge-sharing are two key factors that drive new research within the global scientific community. The design of new meeting formats adapted to different target groups now represents a field of research in its own right.

In their model "Hybrid events and return on investment," Dams and Luppold describe five factors with specific benefits (2016, p. 12):

(1) **Return on involvement:** this assumes, inter alia, that greater involvement by real and virtual participants makes it more likely that they will engage more thoroughly with an event's program and its message.
(2) **Return on interaction:** this assumes that hybrid elements result in noticeably more interaction between event participants and event objects.
(3) **Return on Interactivity:** this regards interactivity as the totality of all individual interactions that occur between event participants and event objects via the available channels of communication. Maximum interactivity can be achieved through the use of virtual elements, interfaces and feedback channels.
(4) **Return on Insights:** unlike classic events, hybrid events generate communications that leave behind countless trails in the digital sphere. Using modern tracking software, these trails can be traced, mapped and operationalized.
(5) **Return on investment:** initially, the inclusion of virtual forms of communication requires event participants to adapt. However, in the medium to long term, hybrid events tend to save money rather than generate extra costs: not only is the degree of interaction frequently more intense; hybrid events are also able to reach a wider range of participants and are not subject to the temporal constraints that limit physical events.

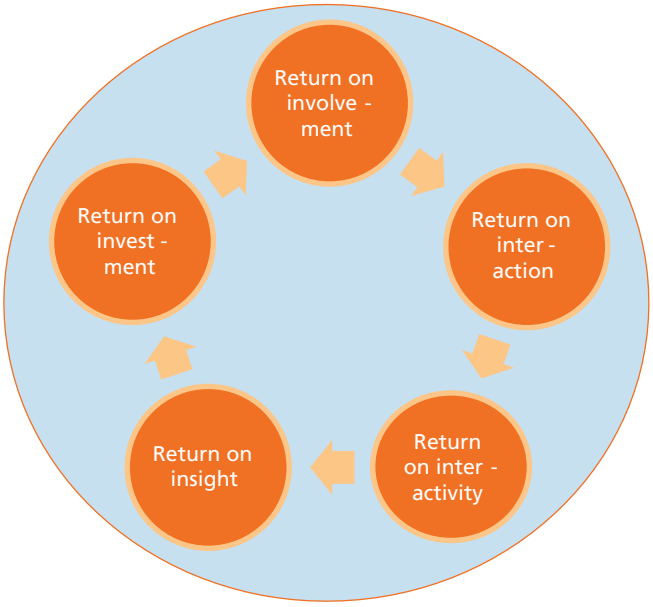


Figure 1: Hybrid events and return on investment (cf. Drams and Luppold, 2016)

As in other spheres of digitalization, here, too, it is vital to achieve a balanced mix of digital elements precisely tailored to the topic and aims of the hybrid event as well its target group. The following describes the experience gained during the organization and realization of two hybrid events at Fraunhofer IAO.

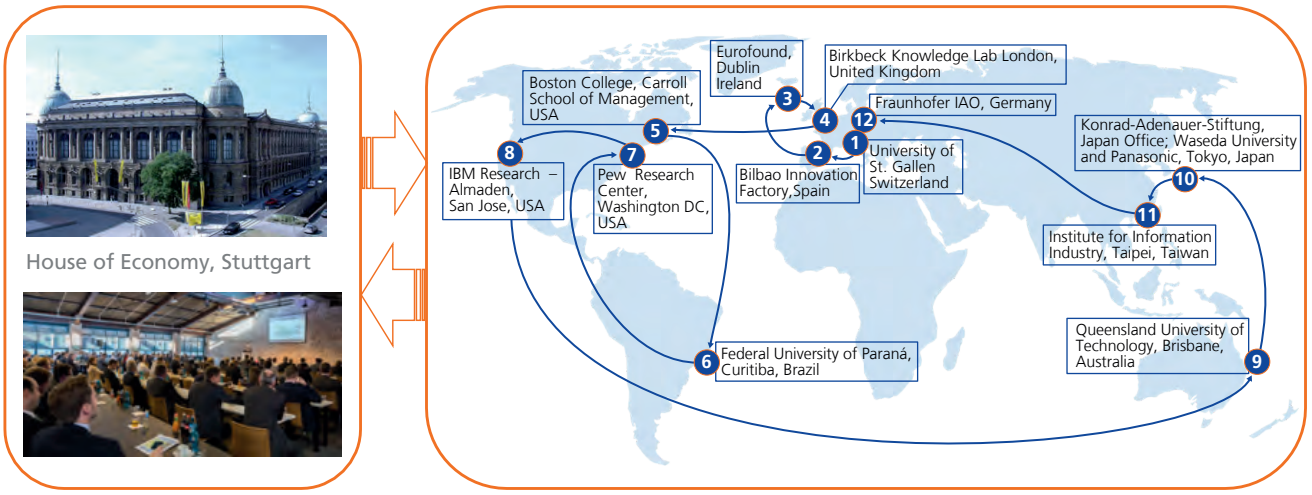
2 Two examples of digital conference formats at Fraunhofer IAO

2.1 Example 1: The Virtual World Tour as a digital element of the Future of Work Conference held in December 2018

Background

To mark the end of Germany's Science Year 2018, Fraunhofer IAO was commissioned by the Federal Ministry of Education and Research (BMBF) to stage a conference on the future of work, which was held on December 4–5. The physical conference took place in Stuttgart's Haus der Wirtschaft and was attended by around 500 participants. In line with the conference slogan – "Future of Work" – both the BMBF and Fraunhofer IAO were eager to ensure that the event would not only present innovative topics but also feature an innovative format. This gave rise to the idea of a Virtual World Tour that would accompany the physical conference and provide an insight into the latest research, around the world, on the future of work.

For a period of 24 hours – in parallel to the physical conference in Stuttgart – a total of 12 research institutes in eight time zones around the world would each have the opportunity, in the course of a two-hour live stream, to present their latest research on the future of work. A variety of formats were employed for the various sessions.



Physical conference in Stuttgart
c. 500 "real" participants

24-hours Virtual World Tour
c. 500 "virtual" participants

Figure 2: Link between the physical conference in Stuttgart and the Virtual World Tour (author's own graphic)

The Virtual World Tour opened at midday on December 4 with a live broadcast of the beginning of the first session. It was launched before the entire conference in the Haus der Wirtschaft. In this way, the physical event "coalesced" with the virtual one, thereby drawing conference participants in Stuttgart into a parallel "virtual happening." The following day, December 5, the closing part of the final session was also broadcast in the Haus der Wirtschaft, from 11:30 a.m. to 12:00 noon. In the course of the entire webcast, a 12-minute video wrap-up was produced, resuming the highlights from each of the 12 sessions and providing conference participants in Stuttgart – as well as online viewers at a later date – with a compact summary of the virtual tour.

The chief aims of the Virtual World Tour were to broaden the scientific dialog on the future of work and to help draw up an international knowledge map identifying the whereabouts of various trends and disciplines within the field of industrial engineering. This will not only help reduce redundancy in future tendering for national research programs but also enhance the opportunities for synergies on the international level.

In addition, the conference presentations and discussions were also made available for viewing, either live or with a time delay, by a specialist audience. For the Federal Ministry of Education and Research, as the commissioning body, a problem-free webcast of the Virtual World Tour, and the positive media coverage it received both before and after the conference, were both key factors in the success of the conference as a whole.

The format of the Virtual World Tour

Various types of hybrid event have now emerged. The Virtual World Tour was essentially a so-called one-way livestream, which was also retrievable as a video file after the conference. An essential aspect of any virtual meeting is that it permits some form of interaction between the various participants. A recent development has been the emergence of technology enabling online participants to interact with, or actively take part in, either "real" or "virtual" events. The Virtual World Tour focused on enabling interaction within each of the individual sessions streamed from the research institutes. The majority of livestreams from the 12 research partners consisted of presentations, round tables and guided tours. The participating institutes were as follows:

(1) University of St. Gallen, Switzerland
(2) Bilbao Innovation Factory, Spain
(3) Eurofound, Dublin, Ireland
(4) Birkbeck Knowledge Lab, London, United Kingdom
(5) Boston College, Carroll School of Management, USA
(6) Federal University of Paraná, Curitiba, Brazil
(7) Pew Research Center, Washington DC, USA
(8) IBM Research – Almaden, San Jose, USA
(9) Queensland University of Technology, Brisbane, Australia
(10) Konrad-Adenauer-Stiftung, Japan Office; Waseda University and Panasonic, Tokyo, Japan
(11) Institute for Information Industry, Taipei, Taiwan
(12) Fraunhofer IAO, Future Work Lab, Stuttgart, Germany

A number of partners engaged in live chats with "virtual" viewers during their livestream session. On the whole, the discussion of a topic specific to an individual partner was limited to the participants of that partner's own session. Figure 3 shows the classification of the Virtual World Tour within a schema of digital events in terms of the "type of virtualization" and the "degree of interaction" between online participants.

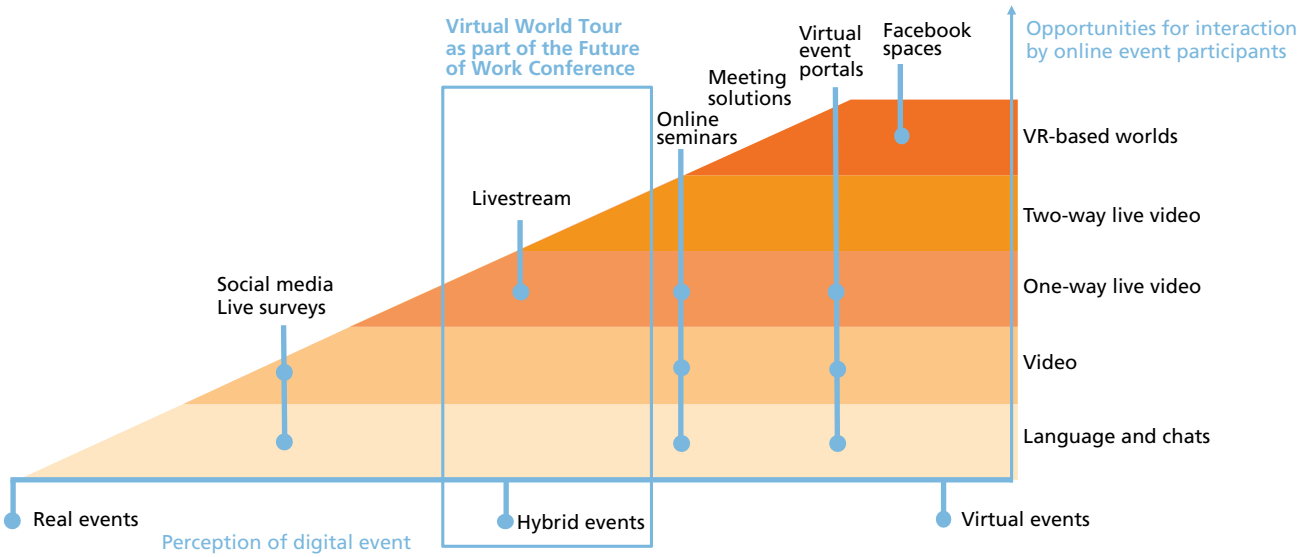


Figure 3: Classification of digital event formats with regard to event type and degree of interaction of online event participants (own graphic based on the classification of digital events in "Der Unterschied zwischen Realen, Hybriden und Virtuellen Events"[1]

Experience gained during the organization and realization of the Virtual World Tour

Once the idea had emerged to stage a virtual event in parallel to the real conference, preparations began. This work was divided up into the following eight project phases:

(1) Fleshing out the idea of the Virtual World Tour and coordinating the selection of topics
(2) Choice of webcast/videocast provider
(3) Acquisition of 12 international partners
(4) Definition of roles and responsibilities
(5) Clarification of livestream formats with partners
(6) Technical checks with all partners
(7) Advertising for the Virtual World Tour
(8) Moderation of the Virtual World Tour and its integration within the physical conference

All in all, it took around six months to organize the Virtual World Tour, starting with the hiring of the service provider to actual realization. The following lists the key tasks and main challenges at each phase of the project.

Phase 1: Fleshing out the idea of a Virtual World Tour and coordinating the selection of topics

At the early conception stage, one of the first ideas was to use Google Hangouts in order to realize the Virtual World Tour. In the course of further elaboration of the format, however, it quickly became evident that without full service support such a tool would be unfit for the purpose of producing a professional webcast in a polished TV format with high-quality picture and sound, and featuring an online moderator to provide continuity between the individual sessions. In addition to the identification and acquisition of international partners for the Virtual World Tour (phase 3), it therefore proved necessary to find a suitable service provider. Meanwhile, work continued to narrow down suitable topics on the future of work with which to supplement the program of the physical conference.

1 Accessed July 29, 2019, www.it4greenevents.de.

Phase 2: Choice of webcast/videocast provider

In the course of the draft concept stage, the following requirements were identified with regard to a professional webcast/videocast provider:

- Technical facilities for the production and broadcast of a livestream at each of the 12 partners around the world over a period of 24 hours, including own broadcasting studio
- Experience in the realization of virtual events of a complex, international character; provision of consulting on content and technical requirements
- Development of a production, moderation and communication schedule as well as a webcast concept
- Production of a teaser for advance promotion of the event
- Inclusion of a concept for viewer interaction
- Technical supervision in the Haus der Wirtschaft and, if necessary, at individual partners, both at the start and finish of the Virtual World Tour
- Production of a video wrap-up for the presentation of highlights to the full conference in the Haus der Wirtschaft directly after completion of the Virtual World Tour
- Guaranteed compliance with data-protection regulations
- Ensuring a smooth livestream broadcast through the provision of back-up solutions in the event of technical problems
- Option of creating a virtual forum for further exchange between the project partners
- Reference projects with BMBF

Phase 3: Acquisition of 12 international partners

On the basis of Fraunhofer IAO's international network of contacts – supplemented with online research – a number of respected research institutes with projects in relevant fields were identified and invited to take part in the Virtual World Tour. Bilateral contact was established with those that expressed an interest in taking part. This was followed by consultation on potential topics and livestream formats.

Here, attention focused on which of the institutes had research interests that best suited the topics selected for the forthcoming conference in Stuttgart. Organizational and logistical considerations prevented chosen research partners from being invited to attend the physical conference. As such, the Virtual World Tour not only broadened the range of topics on offer at the physical conference but also made them available to a wider international audience.

Following the selection of the livestream partners, talks were held to specify relevant research topics and to determine the requirements and precise details of the webcast. In parallel, the partners were classified according to time zone, so that a running order could be drawn up with livestreams to fill all 12 slots throughout the 24-hour period.

The following table provides an overview of the 12 partners and their respective time zones.

	Stuttgart (CET)	Institution	Country	Local time	Time difference
1	12:00–14:00	University of St. Gallen	Switzerland	12:00–14:00	+/-0
2	14:00–16:00	Bilbao Innovation Factory (BBF)	Spain	14:00–16:00	+/-0
3	16:00–18:00	EUROFOUND, Dublin	Ireland	15:00–17:00	-1h
4	18:00–20:00	Birkbeck Knowledge Lab, London	UK	17:00–19:00	-1h
5	20:00–22:00	Boston College, Carroll School of Management	USA	14:00–16:00	-6h
6	22:00–00:00	Federal University of Paraná, Curitiba	Brazil	19:00–21:00	-3h
7	00:00–02:00	Pew Research Center, Washington DC	USA	18:00–20:00	-6h
8	02:00–04:00	IBM Research – Almaden, San Jose	USA	17:00–19:00	-9h
9	04:00–06:00	Queensland University of Technology, Brisbane	Australia	13:00–15:00	+9h
10	06:00–08:00	Konrad-Adenauer-Stiftung, Japan Office; Waseda University and Panasonic, Tokyo	Japan	14:00–16:00	+8h
11	08:00–10:00	Institute for Information Industry, Taipei	Taiwan	15:00–17:00	+7h
12	10:00–12:00	Fraunhofer IAO, Future Work Lab, Stuttgart	Germany	10:00–12:00	+/-0

Table 1: The Virtual World Tour partners and their respective time zones

The following table provides an overview of the topics covered in the 12 sessions:

Tuesday, December 4, 2018, 12:00–00:00 CET			
Time (CET)	12:00–14:00	14:00–16:00	16:00–18:00
Country	Switzerland	Spain	Ireland
Institution	University of St. Gallen	Bilbao Innovation Factory	Eurofound, Dublin
Thematic focus	Coworking: Current research and practice in work(space) and learning design	Strategic talent management in the digital era	The future of manufacturing and game-changing technologies, and new forms of employment and platform work
Time (CET)	18:00–20:00	20:00–22:00	22:00–00:00
Country	United Kingdom	USA	Brazil
Institution	Birkbeck Knowledge Lab, London	Boston College, Carroll School of Management	Federal University of Paraná, Curitiba
Thematic focus	Artificial Intelligence in education and work	Managing work, life and learning in 2030: Impacts of a digital workforce, freelance economy and fractal education	Smart farming and agro 4.0
Wednesday, December 5, 2018, 00:00–12:00 CEST			
Time (CET)	00:00–02:00	02:00–04:00	04:00–06:00
Country	USA	USA	Australia
Institution	Pew Research Center, Washington DC	IBM Research – Almaden, San Jose	Queensland University of Technology, Brisbane
Thematic focus	The future of work in the United States	The future of work in the area of Artificial Intelligence	Thriving in the digital economy
Time (CET)	06:00–08:00	08:00–10:00	10:00–12:00
Country	Japan	Taiwan	Germany
Institution	Konrad-Adenauer-Stiftung, Japan Office; Waseda University and Panasonic	Institute for Information Industry, Taipei	Fraunhofer IAO, Future Work Lab, Stuttgart
Thematic focus	Demographic challenges and solutions regarding nursing and care for the elderly in Japan	Collaboration between the two brains: Digital transformation of new workforce models in Taiwan	Industrie 4.0 work design with the Future Work Lab

Table 2: Topics of the 12 sessions

Phase 4: Definition of roles and responsibilities

One of the key challenges facing the project was how to manage communication and coordination with not only the many partners at Fraunhofer but also the various people who were to be responsible for livestream content and technical issues at each of the 12 partners of the Virtual World Tour. Following the selection of digital events specialist meetyoo, as the service provider, a kickoff meeting was held in order to assign responsibilities among the people involved in the project at Fraunhofer IAO, the meetyoo company and meetyoo's technical services provider.

Fraunhofer IAO

- Coordination between meetyoo, meetyoo's technical services provider and Virtual World Tour partners
- Communication with the 12 partner institutes on organizational and content-related matters; guidance with format design for the 12 livestream sessions
- Design of the interface between the physical conference in Stuttgart and the Virtual World Tour, in collaboration with the technical services provider
- Documentation for, and coordination of, the video wrap-up of the Virtual World Tour, in collaboration with meetyoo's technical services provider

meetyoo GmbH (provider for virtual events) and its technical services provider

- Conceptual design of livestream formats and modes of interaction, including verification of technical feasibility and guarantee of professional webcasting standards with, for example, high picture and sound quality
- Technical checks in direct consultation with technicians at the Virtual World Tour partners
- Provision of a webcast studio, including professional and appropriately qualified moderation
- PR work in collaboration with external agencies and the Fraunhofer IAO press department

Phase 5: Definition of the formats with partners

The idea of the Virtual World Tour was uncharted territory for all concerned. In the course of establishing contact with the international partners, the chief task was to ensure that the formats chosen for individual sessions were compatible with the technical infrastructure and the thematic structure. Partners were encouraged to incorporate not only classic forms of presentation, along with existing film material and guided lab tours, but also interactive elements in their two-hour sessions. Recommended formats here included round tables, group discussions and interviews with experts. Partners were given a free hand to design their own livestream format, provided it was compatible with their technical infrastructure and the thematic structure.

From the very beginning, the Virtual World Tour was conceived as a one-way webcast of livestream sessions – i. e., without any systematic interaction with a theoretically unlimited number of virtual participants. Any interaction with virtual participants took place merely in a limited form via the partners' own social-media channels. This, however, was not centrally coordinated or incorporated in any immediate way in the individual livestream sessions.

Phase 6: Technical checks with all partners

One of the most difficult tasks of the entire project lay with the technical services provider. This was to verify with the 12 partners that they each possessed the appropriate technical infrastructure along with the requisite know-how to record and broadcast a livestream. This task was performed across eight different time zones and included last-minute technical checks in the immediate run-up to going live. Overall, the checks covered not only a general assessment of the technical facilities on the ground but also specific verification of the following aspects:

- **Cameras:** need for high-quality rather than standard webcams
- Microphones: recommended use of clip-on or headset microphones and avoidance of boundary microphones
- **Graphic sources:** need for a computer/laptop to display – in addition to the camera picture – graphic content such as PowerPoint presentations on a separate display.
- **Location:** recommended use of facilities such as labs, development centers, workshops, forums and auditoriums; partners were also encouraged to decorate such locations with posters, banners, screens and prototypes, and to switch locations during the live session

In the event that a partner's technical infrastructure was deemed to be potentially unreliable, there was also the option of using a prerecording rather than a live transmission. In all, this option was taken by 3 of the 12 partners.

In order to enable a limited form of interaction with virtual participants, partners were each encouraged to set up a dedicated email address, where incoming questions could be filtered by an editor and, where appropriate, introduced into the live discussion.

Phase 7: Advertising for the Virtual World Tour

A variety of advertising was used to publicize the Virtual World Tour as an innovative digital add-on to the Future of Work Conference in Stuttgart. This included not only standard Fraunhofer IAO channels (newsletter, website, social media) but also a teaser to present the concept and each of the partners involved. A dedicated login page with free registration was created to provide access to the livestream. In total, 500 virtual participants from 38 countries registered. Generally speaking, the number of virtual participants is one of the chief criteria by which the success of a virtual event is measured. With the given personnel capacities, it was not possible to explore the potential of a targeted advertising to increase the number of registrations for the Virtual World Tour.

Phase 8: Presentation of the Virtual World Tour and its integration within the physical conference

The driving idea behind the Virtual World Tour was to broaden the reach of the physical conference in Stuttgart through the addition of a virtual element that would facilitate the inclusion of international research perspectives on the future of work. A number of key factors informed the design of the interfaces – or "points of coalescence" – between the livestream sessions of the Virtual World Tour and the physical conference in Stuttgart:

- Selection and briefing of a professional online moderator
- Drawing up a precise schedule for the moderation online and at the physical conference in Stuttgart, including coordination between the online moderator and the conference moderator
- Explanation of the concept of the Virtual World Tour to participants of the physical conference
- Erection of screens to show the livestreams at the conference in Stuttgart
- Production of a video wrap-up in parallel to the webcast in order to provide a compact summary of the virtual tour



Figure 4: Moderation of the Virtual World Tour at the conference in Stuttgart

The following graphic provides a summary of the challenges involved in organizing the Virtual World Tour:

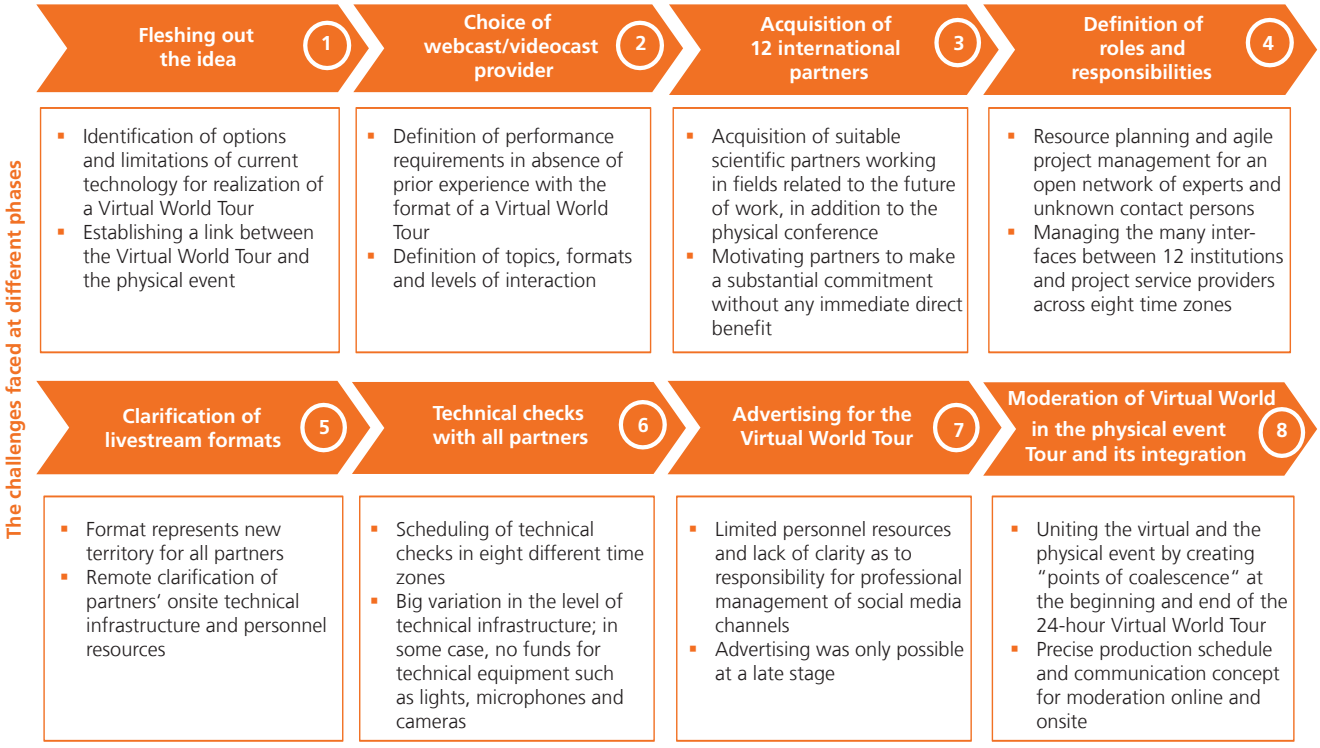


Figure 5: Challenges faced at different phases during organization of the Virtual World Tour (author's own graphic)

2.2 Example 2: Hybrid elements of the International Scientific Symposium on the Future of Work (July 2–3, 2019)

The International Scientific Symposium on the Future of Work had a number of aims. Firstly, it sought to acknowledge the efforts and achievements of the partner institutes that took part in the Virtual World Tour, from December 4–5, 2018. Secondly, it served to expand the international research network in this field, map out common interests and identify potential for joint research activities. All the Virtual World Tour partners were invited to attend, along with other institutes working in similar fields of research as Fraunhofer IAO. In total, 37 people took part. It was an opportunity not only to discuss current research but also to meet up in person and share ideas in a more relaxed atmosphere. The latter was facilitated by group dinners and visits to local attractions (Esslingen, a producer of sparkling wine) and innovative companies in the region (Stuttgart Airport Ground Service GmbH, in Echterdingen; and Festo's Scharnhausen Technology Plant).

The symposium format

Although organized as a classic face-to-face event, the symposium also included a number of hybrid elements (cf. fig. 6):

- Livestream of keynotes
- Recording of interviews
- Use of a Mentimeter feedback tool
- Website postings of keynote and interview recordings

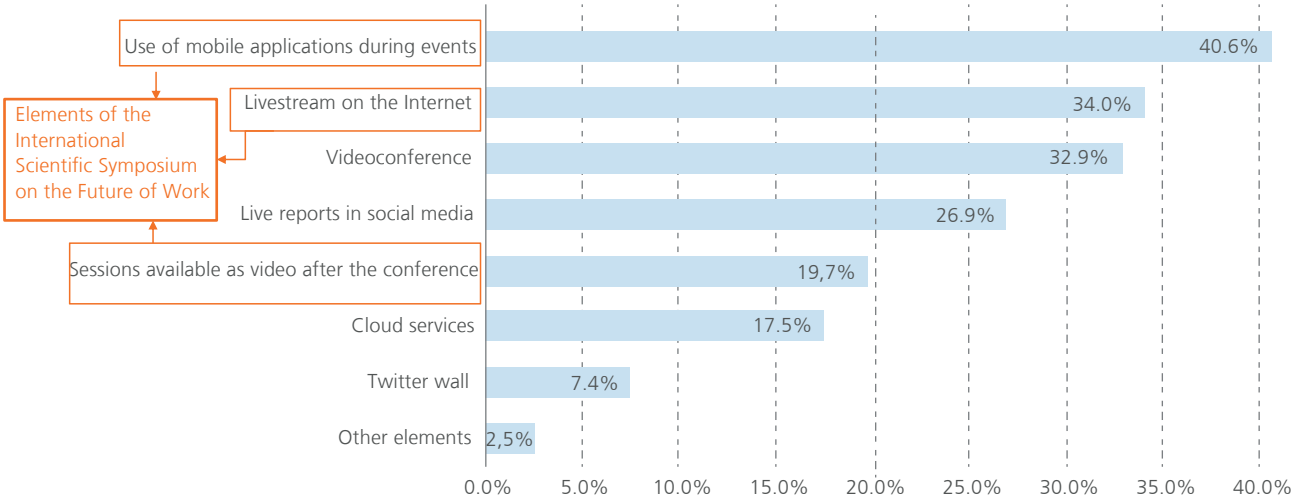


Figure 6: Survey of which hybrid elements were used at events organized (author's own graphic based on Europäisches Institut für Tagungswirtschaft 2019, p. 26)

Symposium keynotes

All of the symposium presentations and keynotes were recorded and broadcast as livestreams. In addition, a summary of the livestreams was produced and made available, along with all the symposium presentations as well as five short interviews with experts, on the website of the Conference "Future of Work"[2].

Topics addressed at workshops and the World Café

The following topics were discussed at workshops and the World Café; three key questions framed the debate:

	Question 1: What are the challenges for business?	**Question 2:** What are the challenges for research and development?	**Question 3:** What are characteristic national approaches and initiatives?
Topic 1: Artificial Intelligence and work			
Topic 2: Training and learning			
Topic 3: Human-machine collaboration			
Topic 4: Impact of digitalization on transformation and culture			

Structure for an international knowledge map as a platform for processing the results of the 2018 Future of Work Conference and the 2019 International Scientific Symposium on the Future of Work.

Table 3: Summary of topics and key questions discussed at workshops

The four topics correspond to the core areas of research covered by current projects at Fraunhofer IAO. One of the key aims of this meeting of international experts was to facilitate a discussion of the differences and similarities between characteristic national research topics and approaches employed in investigations into the future of work.

2 https://www.arbeitsforschungstagung2018.de/index.php/international-symposium

Use of interactive presentation software

At the conclusion of the symposium, interactive presentation software featuring an online feedback tool was employed to record participants' response to three selected questions and to then compare their answers to the results of a previously conducted survey[3]. Using a Mentimeter software tool, participants were able to answer questions via smartphone. Their answers were then being immediately displayed onscreen by the presentation software.

In response to three questions, symposium participants were asked to provide an assessment on a scale of one to five (1 = very small; 5 = very high). A comparison between the results of a written survey of 305 companies and the answers provided by symposium participants yielded the following differences:

Question 1 (cf. fig. 7): How much of an impact will Artificial Intelligence (AI) have on the division of labor between humans and machines over the next five years?

- In the case of all sub-questions in this category, the assessment of symposium participants (15 people) lay 0.3–0.5 points lower than in the written survey. In the eyes of symposium participants, therefore, the impact of AI on the division of labor between humans and machines over the next five years will be slightly lower than that suggested by the results of the survey.

Question 2: How high will the demand for specialists be at your company over the next five years?

- In the assessment of symposium participants, the demand for experts capable of explaining and providing training in the use of AI systems will be 0.4 points higher than that recorded in the written survey. Symposium participants assessed the demand for experts able to proficiently use AI systems at 0.4 points lower, and the demand for experts in the ethics of AI systems at 0.4 points higher, than in the written survey.

Question 3: How much of an impact will Artificial Intelligence have on personnel management and leadership in your company over the next five years?

- The assessment of symposium participants largely corresponded to the results from the written survey, with a variance of 0.1–0.2 points. The only exception here was in their assessment of the impact that AI will have on "cooperation with and among employees." Here, the impact was assessed at 2.7 points – 0.4 points higher than in the written survey.

The complete survey and results are presented in the study Künstliche Intelligenz in der Unternehmenspraxis, published by Fraunhofer IAO (Baur et al., forthcoming).

3 Bauer et al. (eds.), Künstliche Intelligenz in der Unternehmenspraxis (Stuttgart: Fraunhofer, forthcoming).

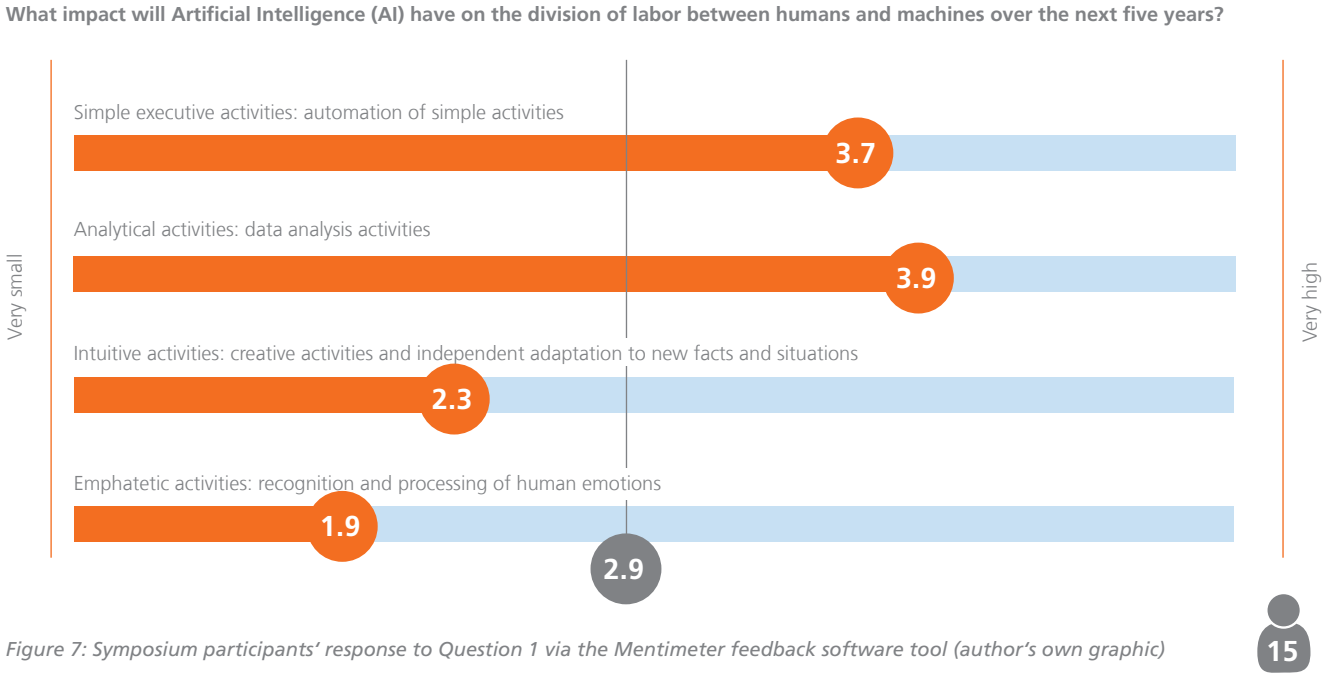


Figure 7: Symposium participants' response to Question 1 via the Mentimeter feedback software tool (author's own graphic)

3 Outlook

According to the latest "Meeting- & EventBarometer" from May 2019, the figures indicate an increasing heterogeneity of event formats (cf. EITW, 2019)[4]. This diversification also includes an increasing use of digital elements, new marketing tools and greater internationalization. On average, event organizers put the proportion of hybrid events at 10.4 percent. This marks an increase on 2017 of 2.3 percentage points. In 2016, an earlier "Meeting- & EventBarometer" study surveyed future trends in this area (cf. fig. 8). All of the companies surveyed thought it was very likely (60 percent) or likely (40 percent) that real events would remain a constant feature despite the growth in digitalization. All in all, 95 percent thought it was very likely (35 percent) or likely (60 percent) that real events would be supplemented by virtual elements. And 75 percent of the companies surveyed said that they would like to participate virtually in an event should it prove impossible to attend in person.

The experience gained from the Virtual World Tour should provide inspiration for new experiments, not least those investigating combinations of analog and digital forms of interaction in "many-to-many" communication scenarios across institutions spread around the globe. This should also include a consideration of formats that incorporate a direct dialog with an open online community.

In the words of an innovation manager from our collaborative partner meetyoo[6], the future will offer "an even better digitalization of physical experience. However, the problem is that whenever you digitalize a physical event, you're always competing with a physical experience. One consequence of this might be that we need to completely rethink virtual meetings, so that they no longer remind us of a physical event."

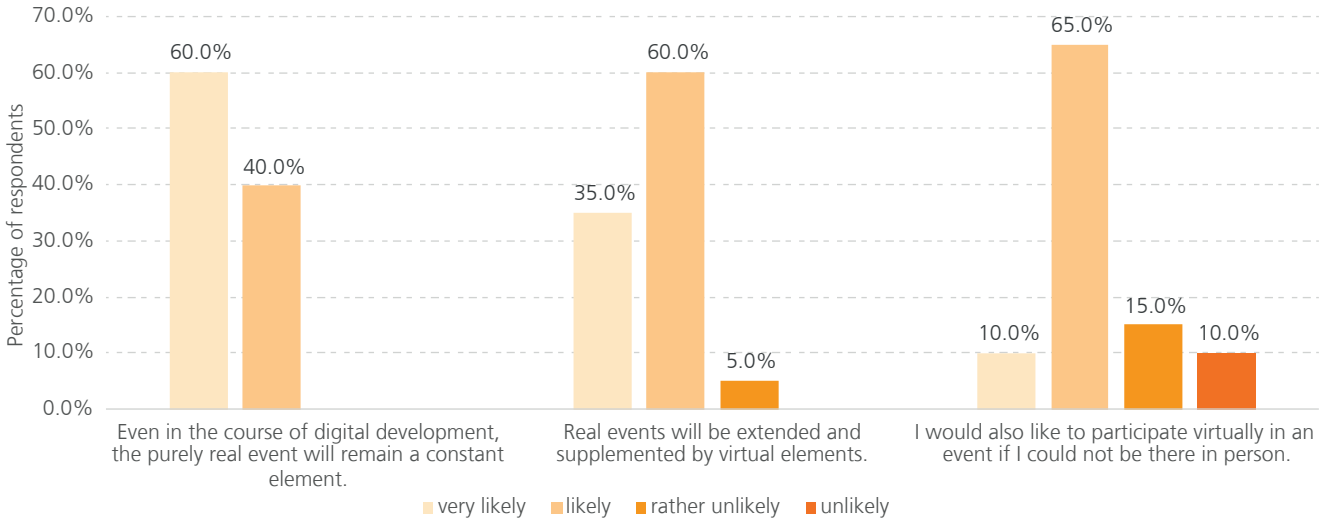


Figure 8: Survey of event organizers worldwide on their attitudes to virtual events, 2016 (source: Statista)[5]

4 https://www.gcb.de/fileadmin/GCB/Discover_Germany/MEBA/190516_MEBa_ManagementInfo_2019.pdf (accessed August 26, 2019).
5 https://de.statista.com/statistik/daten/studie/649738/umfrage/umfrage-unter-veranstaltern-weltweit-zu-virtuellen-veranstaltungen/.
6 Interview with Tim Gutsche and Michael Schirmer from meetyoo GmbH, July 24, 2019.

Ever since the emergence of webconferencing tools, developers have been investigating the technology required to facilitate communication between participants of meetings in virtual space and those of meetings in physical space, and looking at ways of making this dialog user-friendly and interactionally beneficial. Research from a number of years ago already showed that participants of virtual meetings often communicate more actively than in face-to-face meetings, not least when the discussion is moderated in a professional manner (Allmendinger and Hamann, 2008). A key research question remains how best to combine online and face-to-face meetings with regard to the appropriate levels of virtualization and interaction. The emergence of new technology has now placed this question in a new dimension: "The use of collaborative formats during the actual event, such as "blog parades" or virtual round tables, or social-media platforms such as Twitter, turns participants into active agents and propagators. The result is that physical and temporal boundaries dissolve, giving way to open, interactive and virtually collaborative 4.0 events" (Knoll, 2017, p. 4).

Despite this dissolution of boundaries and the acceleration of communication on virtual levels, we must also remember that there are neuronal and psychological limitations to the human capacity to absorb and process information.

In other words, there is now a broad field for future experimentation into new types of event and ways of connecting international research communities such as the Future of Work research network. This could well involve the creation of online working groups in order to further explore the topics examined in the symposium. At the European Conference on the Future of Work, held in October 2020 in Bonn, a collaborative virtual space or holodeck – "a room that provides holographic simulations for recreation, training etc."[7] – might offer one way of providing an attractive extension to the physical conference facilities.

7 https://www.definitions.net/definition/holodeck.

References

Allmendinger, K.; Hamann,K.: "Synchrone Online-Kooperation: Interaktionsmöglichkeiten, Nutzungsszenarien und Auswirkungen auf die Zusammenarbeit." In Kooperation konkret, edited by C. Clases and H. Schulze, 13–23. Lengerich: Pabst Science Publishers, 2008.

Bauer, W.; Ganz, W.; Hämmerle, M.; Renner, T. (eds.): Künstliche Ingelligenz in der Unternehmenspraxis (Authors: Claudia Dukino, Michaela Friedrich, Walter Ganz, Moritz Hämmerle, Falko Kötter, Thomas Meiren, Jens Neuhüttler, Thomas Renner, Sven Schuler, Helmut Zaiser). Stuttgart: Fraunhofer Verlag, 2019 (forthcoming).

Dams C.M.; Luppold, S.: Hybride Events. Zukunft und Herausforderung für Live-Kommunikation. Wiesbaden: Springer Gabler, 2016.

German Convention Bureau: "Umfrage unter Veranstaltern zu virtuellen Veranstaltungen 'Wie stehen Sie zu folgenden Statements bezüglich Hybriden Veranstaltungen?'" In Meeting- & EventBarometer Deutschland 2015/16, 44, https://de.statista.com/statistik/daten/studie/649738/umfrage/umfrage-unter-veranstaltern-weltweit-zu-virtuellen-veranstaltungen/, accessed July 29, 2019.

Europäisches Institut für Tagungswirtschaft. Meeting- & EventBarometer. Management-Info Mai 2019. https://www.gcb.de/fileadmin/GCB/Discover_Germany/MEBA/190516_MEBa_ManagementInfo_2019.pdf, accessed August 26, 2019.

"Green IT & ICT in der Eventbranche." www.it4greenevents.de, accessed July 29, 2019.

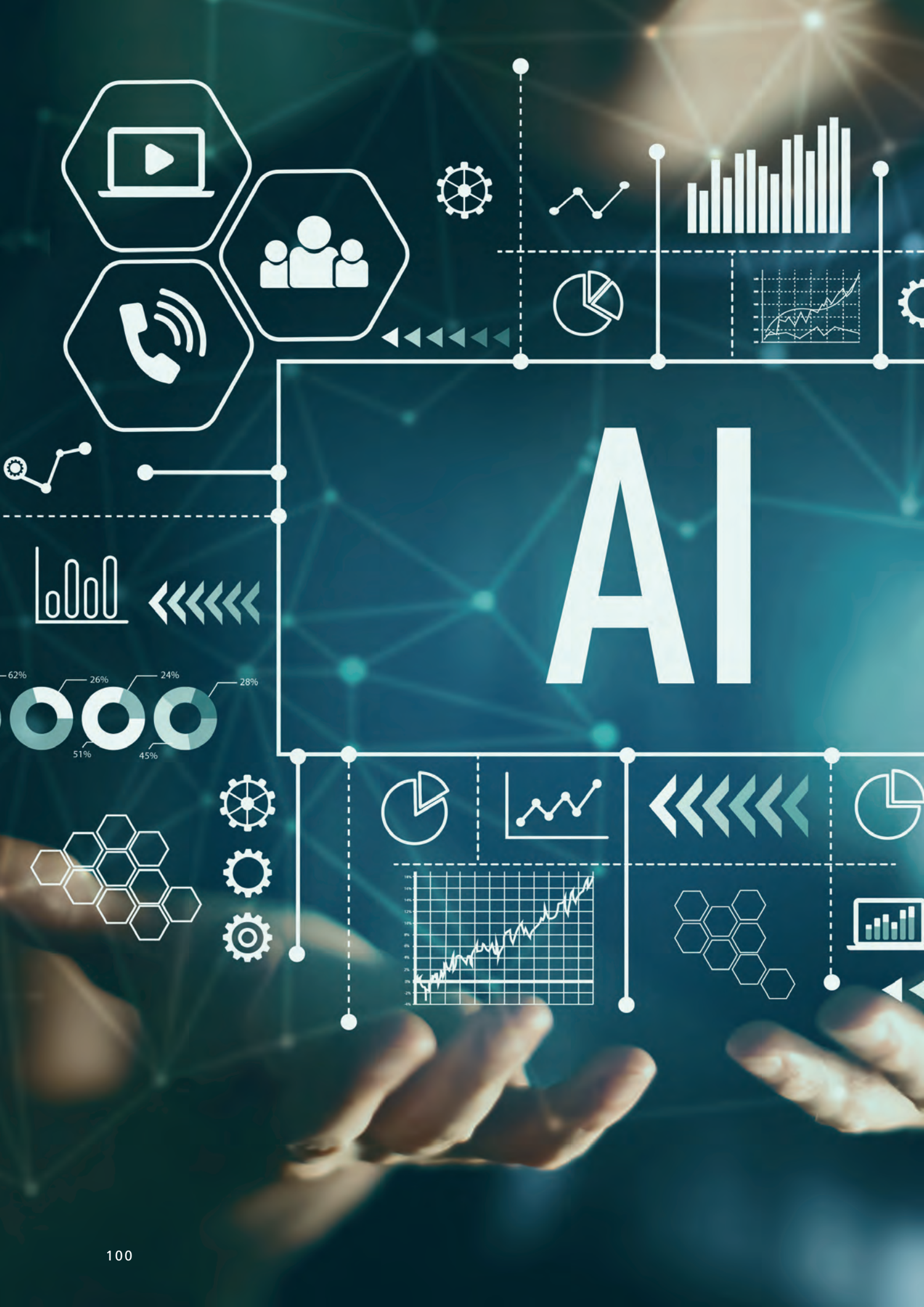
Hamann, K.: "Requirements for web conferencing at the European Medicines Agency." In Professional Training Facts Conference 2011. Stuttgart: Fraunhofer Verlag, 2011.

Knoll, T.: "Die Veranstaltungsbranche im digitalen Wandel." In Veranstaltungen 4.0. Konferenzen, Messen und Events im digitalen Wandel, edited by T. Knoll, XX–XX. Wiesbaden: Springer Gabler, 2017.

Biography

Karin Hamann joined the Fraunhofer Institute for Industrial Engineering IAO, Service and Human Resources Management department, in Stuttgart in 2001. She received her MBA in Psychology in 1999 from the Eberhard Karls Universität in Tübingen. From 2008 to 2011, she worked for the European Medicines Agency in London as a national expert on virtual communication and E-Learning. Her work focuses on designing learning environments based on digital technologies, accompanying the introduction of new communication concepts and supporting the design of knowledge-sharing in international networks. She is currently working amongst others on a research project about internationalisation of vocational training and education with one focus on China.

THE USE OF HYBRID MEETING FORMATS TO INCREASE INTERNATIONAL COLLABORATION IN SCIENTIFIC RESEARCH


AI
62%
26%
24%
28%
51%
45%

2

ARTIFICIAL INTELLIGENCE AND WORK

SmartAIwORK – DESIGNING A BRIGHTER NARRATIVE OF THE FUTURE OF WORK

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Abstract

Work design and competence development are of great importance for a success of Articial Intelligence (AI) strategies. The importance of work design for future work in AI systems comes clear when an increasingly favoured view advocates to tap performance increasing potentials of human-AI collaboration. This by gearing the perspective towards changes in tasks and procesesses by AI and designing human-technology interfaces in a way to make potentials of human-AI collaboration useable. The Fraunhofer IAO led project SmartAIwork elaborates a framework model for tapping these potentials in clerc work processes and applies it to pilot projects with three companies. As first lessons learned from the running project, the following aspects seem especially important for the implementation of AI-work-systems in companies: a. developing a joint understanding of AI; b. analysing work processes closely for a performance increasing mutual adaptation with AI technolgy; c. analysing AI induced changes of job profiles and developing competencies. Together, an implementation of sustainably performance increasing AI-work-systems is possible by an intgrated design of work processes, AI technology, and job profiles.

Key words
Artificial Intelligence, Work Design, Competence Development, Human-AI Collaboration, SmartAIwork, Algorithms, Representation

1 Introduction

Artificial Intelligence (AI) is currently one of the most topical issues also in German politics, business and media. In this context, the focus is on socio-political, economic and research-policy challenges, opportunities and risks of the use of AI (cf. Bitkom; DFKI 2017). Numerous studies highlight the potential for innovation and value creation offered by Artificial Intelligence (cf. Chen et al. 2016, PwC 2018). Particular attention is given to how the economic potential of Artificial Intelligence can be tapped successfully and how politics, business and research can contribute. The German Federal Government has not only developed an AI strategy in this context, the German Federal Ministry of Education and Research (BMBF) has also dedicated the Science Year 2019 to "Artificial Intelligence" to draw special attention of the media and the scientific community to this subject.[1] "Artificial Intelligence is being dreaded, overrated, praised to the skies or demonised. It is hard to assess its real potential and limitations at present" (Brynjolfsson, McAfee 2017, p. 24).

However, it was found at an early stage that the design of work and the development of competencies are of decisive importance for the economic and social success of the implementation of AI strategies. This is emphasized, for example, on the "Plattform Lernende Systeme (PLS)" (Self-learning Systems Platform) with the working group "Future of Work and Human-Machine Interaction."[2] Similarly, a working group addressing in particular the subjects of "AI, Labor, and the Economy" was also established in the international "Partnership on AI".[3]

1 Cf. "Strategie Künstliche Intelligenz der Bundesregierung" (ed. November 2018). https://www.bmbf.de/files/Nationale_KI-Strategie.pdf, https://www.wissenschaftsjahr.de/2019/english/
2 For information about the working group "Future of Work and Human-Machine Interaction", refer to "Plattform Lernende Systeme (PLS)": https://www.plattform-lernende-systeme.de/wg-2.html
3 For information about "Partnership on AI", refer to https://www.partnershiponai.org/about/
4 Cf. Ethics Guidelines for Trustworthy AI. High-Level Expert Group on Artificial Intelligence. European Commission, Brussels, 8 April 2019, p. 14. https://ec.europa.eu/futurium/en/ai-alliance-consultation

In addition to the multi-faceted debate about potential reciprocal effects between Artificial Intelligence and the world of work/employment, the potential implications of AI for society as a whole are in the focus of the public as evidenced, for example, by the "Ethics Guidelines For Trustworthy AI" of the High-Level Expert Group on AI of the European Commission[4]. These guidelines specify requirements for "trustworthy AI":

- Human agency and oversight (including fundamtental rights, human agency and human oversight),
- Technical robustness and safety (including resilience to attack and security, fall back plan and general safety, accuracy, reliability and reproducibility),
- Privacy and data governance (including respect for privacy, quality and integrity of data, and access to data),
- Transparency (including traceability, explainability and communication),
- Diversity, non-discrimination and fairness (including the avoidance of unfair bias, accessibility and universal design, and stakeholder participation),
- Societal and environmental wellbeing (including sustainability and environmental friendliness, social impact, society and democracy),
- Accountability (including auditability, minimisation and reporting of negative impact, trade-offs and redress)

Ayanna Howard also recognizes the need for these guidelines: "The longer take is that although standards are not sexy stuff, they are critical for making AI not only more useful but also safe for consumer use … According to a 2019 report from the Center for the Governance of AI at the University of Oxford, 82 percent of Americans believe that robots and AI should be carefully managed. Concerns cited ranged from how AI is used in surveillance and in spreading fake content online (known as deepfakes when they include doctored video images and audio generated with help from AI) to cyberattacks, infringements on data privacy, hiring bias, autonomous vehicles, and drones that don't require a human controller. AI has already shown itself very publicly to be capable of bad biases which can lead to unfair decisions based on attributes that are protected by law. There can be bias in the data inputs, which can be poorly selected, outdated, or skewed in ways that embody our own historical societal prejudices. Most deployed AI systems do not yet embed methods to put data sets to a fairness test or otherwise compensate for problems in the raw material" (Howard 2019).

2 Additional focus required

A particularly strong subject of debate in public and science is the question of whether the more and more widespread use of Artificial Intelligence will involve a major loss of jobs. According to the introduction to a recent interview of Thomas Malone, Malone holds "that AI, robotics, and automation will destroy many jobs – including those of high-skilled knowledge workers – while at the same time creating new ones" (MIT Technology Review 2019). There are studies estimating a high rate of substitution of human labour by automation (cf. Frey; Osborne 2013). There are also studies about probabilities of automation focusing on jobs that predict much lower probabilities of automation (cf. Bonin et al. 2015). Employment market forecasts considering numerous other factors in addition to probabilities of automation show nearly stable employment market balances (cf. Vogler-Ludwig 2018). "The Future of Jobs Report 2018" of the World Economic Forum (WEF), which expressly includes Artificial Intelligence, even assumes a positive development of employment until 2022 (cf. WEF 2018). There is no doubt that the increasing use of Artificial Intelligence will drive the automation of certain jobs, particularly routine jobs. Nevertheless a recent publication of the IAB points out that although it is true that "new technologies may lead to a reduction of jobs in certain occupations or industries, new technologies simultaneously create new jobs in other occupations and industries" (cf. Gartner, Stüber, 2019, p. 8). All in all, the empirical findings about the impact of Artificial Intelligence on employment still seem to be very contradictory.

The above mentioned and rather macro-analytical assessments and forecasts about the impact of AI on employment dominate the public discussion in the media today. However, an increasingly favoured view is that "the most significant impact of AI won´t be on the number of jobs, but rather on job content" (Shook, Knickrehm, 2018, p. 13). It suggests to not only consider the quantitative aspects of the impact of AI on employment but also the qualitative impact on work itself. For this reason, it seems to be necessary to bring the opportunities and risks of the use of AI at company level to the foreground of discussion, develop design recommendations for the use of AI and take a look at the new potentials of human-machine collaboration. For in these days of conversion of operative processes, AI systems, rather than replacing humans en masse, are "amplifying our skills and collaborating with us to achieve productivity gains that have previously not been possible." (Daugherty, Wilson 2018, p. 16). However, the authors also refer to the "missing middle", deploring that there is too little discussion and research to close this gap (cf. figure 1). With the concept of "missing middle", they emphasize particularly the opportunities of how humans and machines can be complementary to each other and how AI can actually help augment human capabilities. Each party (human and machine) does what he/she/it is best at. Considering the "missing middle" also involves looking at the decision-making architecture of the working system (division of work by type or quantity) as a whole and utilizing the potentials of the new human-AI collaboration for the development of new processes. In addition to the question of how work tasks or jobs are allocated to humans and machines, a special challenge seems to be the design of reciprocal learning of humans and machines.

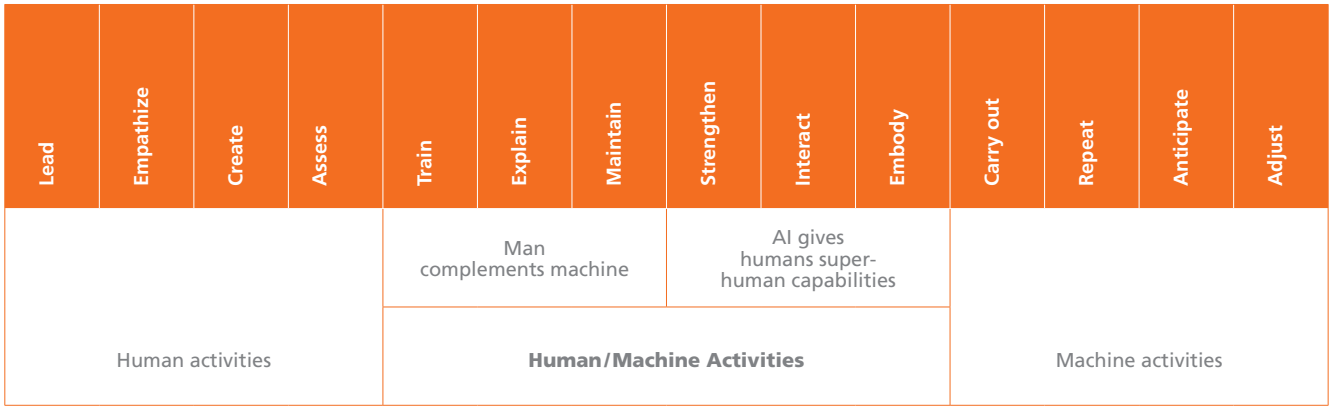


Figure 1: The Missing Middle. Source: Daugherty, Wilson 2018, p. 16.

With a view to utilizing and maintaining the problem solving competencies of human beings, it is possible to design human-technology interfaces in such a way that technology supports humans in decision-making in varying degrees. Support may mean, for example, that AI analyses all data available and provides tailored information to the employees not only about current conditions but also about predicted developments (cf. Peissner et al. 2019, p. 11). In addition to plain support for decision-making, digitalization and to an even greater extent Artificial Intelligence offer the opportunity to individualize jobs in terms of adjusting the nature and degree of support to the needs of the individual, the job situation and the work task. However, this requires a detailed job analysis which helps to identify the value-creating and creative parts of the work tasks, explore the potentials for support by AI (in terms of the missing middle) and automate routine activities wherever this seems economically useful. "AI will change the way we work – and the division of work, too. However, first of all it will not replace human skills but augment and complement them" (Wilson, Daugherty, 2019, p. 6).

3 What is Artificial Intelligence and where are we today

It should be noted in this context that "Artificial Intelligence" is not a new subject. The Dartmouth Conference is considered to be the hour of birth of the special field of Artificial Intelligence, where the assumption was made "that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it" (McCarthy et al. 1955, p. 2). Since the hardware and software capabilities were insufficient at the time and the complexity of the issues to be solved had been underrated, the initial success of the first few years was followed by a period referred to as the "AI winter" from about 1970 to about 1975. In the second half of the seventies, initial practical success was achieved with the AI systems MYCIN for the diagnosis of blood diseases and R1 for the configuration of computer systems. After "Deep Blue" had defeated the world chess champion Garry Kasparov in 1997 and the DARPA Grand Challenge, an autonomous vehicle competition through the desert, had been finished successfully in 2005, IBM Watson demonstrated its jeopardy capabilities in 2011. In 2017, a professional Go player was defeated by AI for the first time (cf. Peissner et al. 2019, p. 10).

There is no generally accepted definition of "Artificial Intelligence" yet. Various attempts to provide a definition that can be found in literature highlight common characteristics and properties. Artificial Intelligence is "a branch of informatics aiming at realizing cognitive skills such as learning, planning or problem solving in computer systems using algorithms. (…) The concept of AI at the same time relates to systems that show a behaviour which is generally assumed to require human intelligence. The goal of present-day AI systems (…) is to enable machines, robots and software systems to process and solve tasks and problems described in an abstract manner autonomously without requiring that every step is programmed by humans" (cf. Plattform Lernende Systeme).[5] All attempts at defining AI have in common that AI systems are able to learn, trained with data and perform a defined task autonomously and efficiently without having to program every step initially or reprogram the system after any changes. The rules followed by the AI system during processing are not predefined explicitly by humans.

Within the research project titled "SmartAIwork – Sachbearbeitung zukunftsorientiert gestalten durch Künstliche Intelligenz" (SmartAIwork – Designing Clerk Work for the Future Using Artificial Intelligence) all project partners agreed to the following working definition of AI: "Artificial Intelligence" refers to "IT solutions and methods completing tasks autonomously, where the underlying rules for processing are not explicitly predefined by humans. Previously these tasks required human intelligence and dynamic decision-making.

5 https://www.plattform-lernende-systeme.de/glossar.html, term entry "Künstliche Intelligenz (KI)"

Now this function is performed by AI, which learns from data to perform tasks and workflows more efficiently."[6]

Meanwhile there are numerous examples in literature showing in which areas Artificial Intelligence is applied in practice. There are examples for nearly all functional areas of companies (cf. Allianz Industrie 4.0 Baden-Württemberg 2019). Nevertheless, taking into account the numerous empirical studies, there is still a long way to go until AI will have attained a wider diffusion in business, particularly in small and medium-scale enterprises. When we present some of our empirical findings below, we will see that also these data substantiate that there is still a big need to catch up regarding the use of AI particularly among small and medium-scale enterprises.

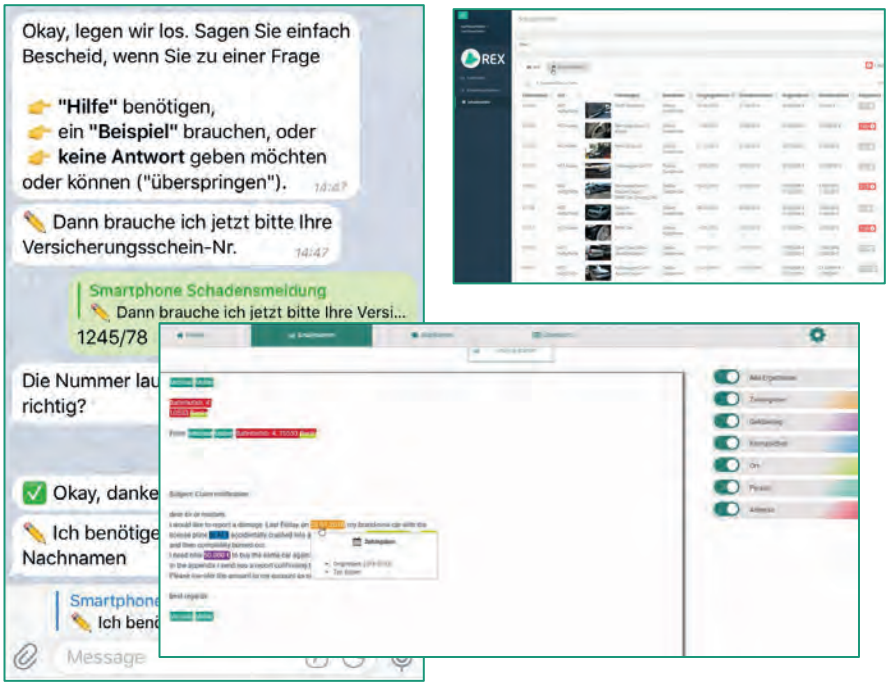
Let us have a quick look at some AI applications. Particular attention on the part of the media has been drawn recently to the examples from human resource management, especially regarding the AI support in the recruitment of new employees. A recruitment process usually requires substantial efforts for all parties involved. "Software using methods of Artificial Intelligence can provide support in many business areas. For example, self-learning chatbots can be used in recruiting to make the selection processes for applicants much more efficient" (cf. Eisenkrämer 2017). It is not surprising that the potential general challenges of AI are discussed specifically in the context of potential AI applications in human resource management, for example, "non-discrimination and fairness (including the avoidance of unfair bias)". However, potentials for the use of AI are not only seen in recruiting. It is no longer a mere vision of the future that employee control by machines becomes possible. The cyberboss – i. e. algorithms functioning as superiors – seems to be technically possible. "The use of Artificial Intelligence at management level promises to achieve efficient employee control. Productivity can be raised, personnel costs reduced… The concept of a cyberboss lets us hope for objective performance appraisal and treatment without subjective bias" (Günther 2017). The challenges faced in practice are in the areas of the legal framework and acceptance by the employees in the opinion of the author.

Customer communication has meanwhile become a very popular field of application of AI. For example, Kawamura et al. (2016) presented an AI assistance system based on IBM Watson: Frequently recurring phrases are identified by "voice mining". Subsequently, the machine makes suggestions for the further course of the conversation to the customer service personnel based on the record of previous conversations. For example, the system may suggest to initiate the address changing process when the customer says the "relocation" keyword. Furthermore, the system can assist data input, for example, by an automatic summary of the conversation. Speech recognition is already used with digital assistants as a basis or in combination with expert systems. Recently, applications such as AI-supported chatbots have become popular. These are programs that can have a conversation with users. Social chatbots operate in social networks such as Facebook and Twitter (cf. Edwards 2016). Fields of application include, without limitation, purchase orders (e. g. pizza service), responses to customer inquiries about processes (parcel services) and complaint processing. Recommendation systems are the most widespread applications of machine-learning technologies, supporting businesses in communicating with customers in a more personal manner. This also includes the use of AI to create micro-segmented customer personas and communicate with these according to their specific preferences.

As we can see, AI offers many opportunities and potentials for innovative new product offerings, the design of better and more efficient processes and accelerated customer communication. These opportunities are also utilized by Fraunhofer IAO with the ARPOS system (automated rule-based process control for on-line handling of damage cases). The ARPOS service

6 https://www.smart-ai-work.de/

portal simplifies and automates processes, resulting in substantial cost savings, for example, in automobile insurance claims settlement. Since the focus is on utilization by customers, the development started by analysing, standardizing and evaluating business rules in the field of automobile insurance claims settlement. After implementing the most important business rules in a rule-based software system, they were verified and adjusted in an extensive testing phase.[7] The automotive market, customer behaviour and the legal framework conditions are subject to frequent changes and make it necessary to regularly adjust the rules of the expert system. For this reason, AI techniques such as machine learning were adopted to generate new classification rules continuously.



REX
System for fraud detection

ARPOS
Chat bot for damage report

Textominado
Text document analysis

All projects focus on directing the employees' focus towards essential value creating tasks.

Figure 2: AI Projects at Fraunhofer IAO Stuttgart

7 See https://www.digital.iao.fraunhofer.de/de/leistungen/KI/ARPOS.html

Intelligent assistants perform tasks previously performed by humans. The employees' focus is directed towards essential value-creating tasks. REX is a software prototype for fraud detection in the automobile and property insurance business. It combines rule-based techniques (including fuzzy logic) with machine learning techniques to detect suspicious damage cases as efficiently as possible. It is able to analyse both structured and non-structured data (scanned documents, photographs). Textominado is a platform for text document analysis. It also uses rule-based techniques and machine-learning techniques to annotate names of persons, addresses, time data, amounts of money etc. automatically in texts. Textominado also offers functions to make manual annotations in texts and make sensitive data anonymous automatically (e. g. personal data).

Artificial Intelligence will change business as much as previous universal technologies in the opinion of Brynjolfsson and McAfee (cf. Brynjolfsson, Mcafee, 2017). "The impact of AI will multiply in the next decade, when industry… gear their core processes and business models to the use of AI" (cf. ibid., p. 24).

4 Still room for growth

As already mentioned, meanwhile numerous studies have been published which try to reflect the expectations regarding Artificial Intelligence and the status of practical realization of these expectations in business. Gartner found out in his study that only 4 percent of those interviewed stated that they "already have invested in and deployed" AI initiatives (cf. figure 3). As we can see, there is still ample room for growth. In summary, it is emphasized that "CIOs view making progress with AI initiatives as one of their top-five priorities for 2018. Gartner's latest CIO survey among 3,160 CIOs from 98 countries found that 25 percent of CIOs are already piloting AI initiatives or have short-term plans for them. Another 21 percent have medium- or long-term plans." (Goasduff, 2017).

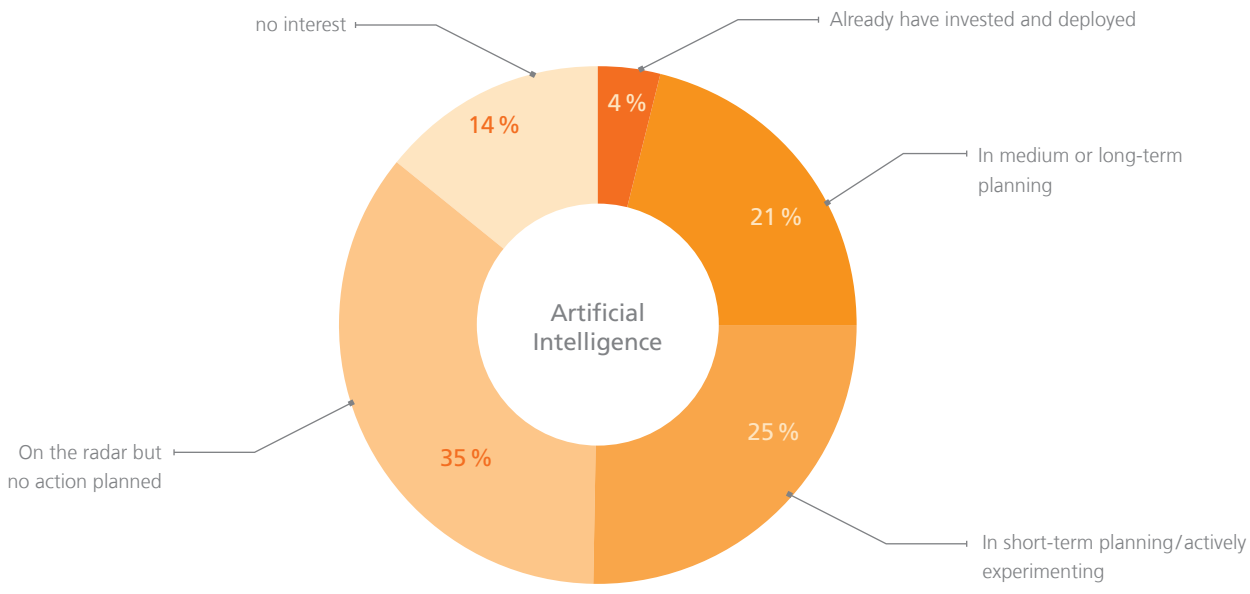


Figure 3: Deployment of AI Initiatives in 2018, Goasduff 2017.

The Computerwoche journal and the IDG Research Services found in their joint study (cf. Computerwoche, 2018) that about a quarter of the companies interviewed intend to address the issue of AI intensively in the short term. One quarter of the larger companies interviewed had AI already deployed, contrasting with only 15 percent of the smaller companies. In the study titled "Reworking The Revolution" published by accenture strategy (cf. Shook, Knickrehm, 2018), the authors also point to the gap between the plans of companies to deploy AI and the actual rate of implementation. Many companies currently seem to be in the exploration or experimental phase. "Only a few are embarking on the third stage: large-scale application" (ibid., p. 4). An MIT study also highlights the gap between high expectations and state of action. "Despite high expectations, business adoption of AI is at a very early stage: There is a disparity between expectation and action" (Ransbotham et. al., 2017, p. 7, cf. figure 4).

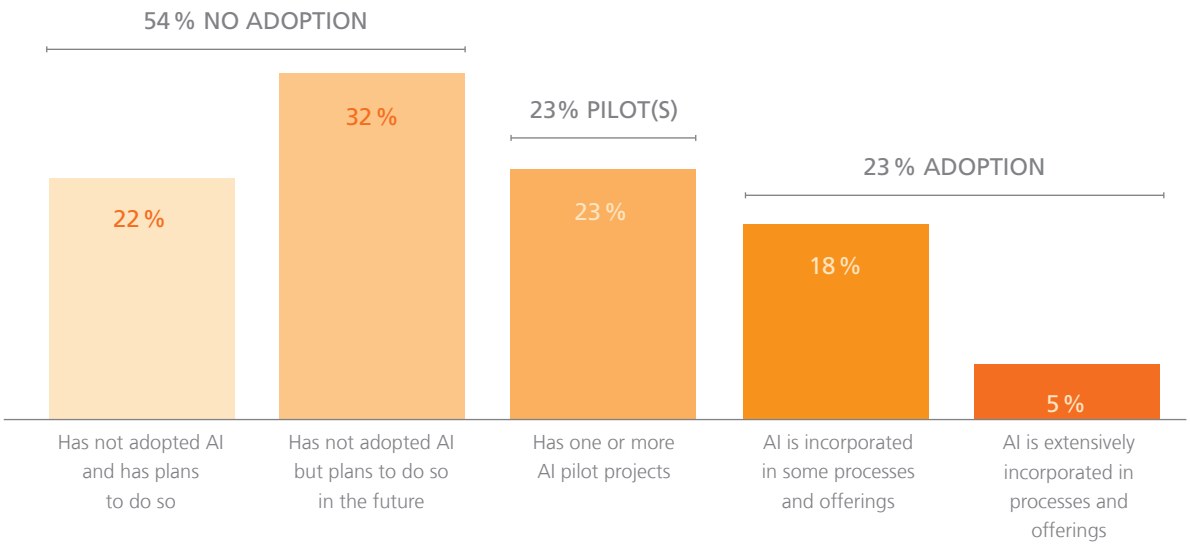


Figure 4: Only about a quarter of all organizations have adopted AI so far. Source: Ransbotham et al. 2017: Reshaping Business with Artificial Intelligence. MIT Sloan Management Review, in collaboration with BCG

All in all it can be stated that the various studies show that companies are beginning to address and experiment with AI more and more intensively. Still there are very few real applications. This is not really surprising since companies do ask themselves where the use of AI is appropriate and perhaps even necessary for reasons of competition. The introduction of new AI solutions still involves a substantial technical and organizational effort. Furthermore, the question of the acceptance of AI systems has not yet been answered in many enterprises. Ultimately, AI applications are required in practice which do not only increase the labour productivity but also meet with acceptance and trust among customers and employees.

In spring of 2019, the Fraunhofer IAO also conducted a survey among enterprises on the subject of AI and work which yielded results that were similar to those of the Computerwoche journal (cf. Bauer et. al., 2019). We also asked about the deployment of AI. Only 16 percent of the companies interviewed said that they already had at least one AI application deployed, another 14 percent are in the phase of planning deployment (cf. figure 5). Nearly half of the companies address the issue of AI, with a substantial number of the companies interviewed being only in the phase of gathering information. In spite of the numerous published application examples described above, there is a substantial gap of implementation between the assessment of the potentials and the implementation of applications. Of course, the big difference in deployments between larger and smaller companies was less surprising. Only about every tenth of the smaller companies (less than 250 employees) had stated that it had at least one AI application deployed. This was true for as much as a quarter of the larger companies (more than 250 employees). It should be noted that expectations are high but the degree of implementation is lower.

Which level of experience with artificial intelligence does your company have?

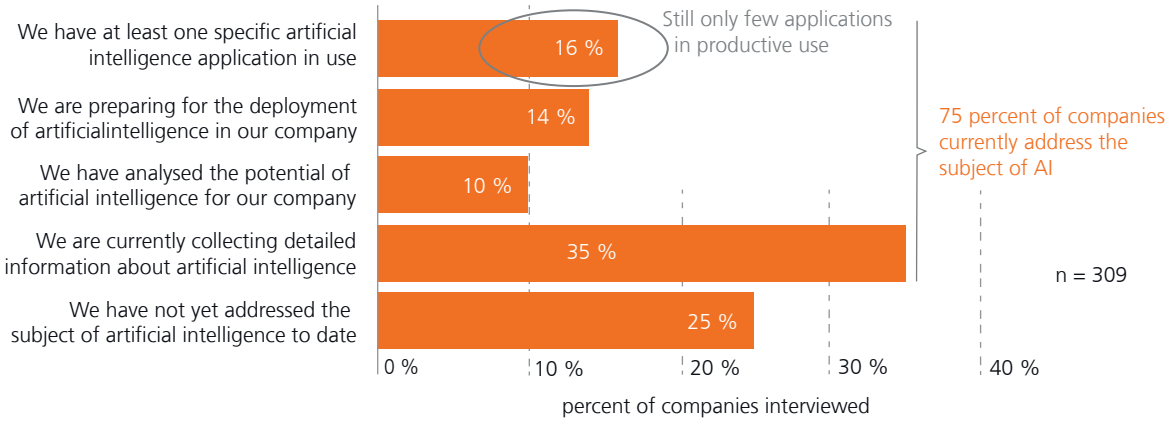


Figure 5: Taken from IAO Study Bauer et al.: Künstliche Intelligenz in der Unternehmenspraxis (AI in Practice), 2019.

What are the obstacles keeping companies from adopting AI? The customers and a lack of application options do not represent obstacles, but the requirements regarding privacy and data security curtail the ambitions to adopt AI. Moreover, companies are looking for tailor-made solutions and fear the high costs of introduction. The companies interviewed also refer to a lack of competency in the organization and the high requirements regarding the volume and quality of data. It is true that the effort involved for data processing should not be underrated. Equally true is the "probably most underrated positive fact that perhaps it does not need so much data at all to be able to utilize machine learning productively… if success already manifests itself by improving the performance, sufficient data may often be found surprisingly easily" (Brynjolfsson, McAfee, 2017, p. 30). To reduce the obstacles for the adoption of AI, it is suggested to begin with use cases optimizing analytical processes relating to potential pilot areas to collect experience, experiment, make initial results quickly visible and build up competencies by step-by-step learning. The domain experts from the technical departments should be intensively involved in AI projects since only the technical staff know the processes and can provide important input to the AI experts. In service enterprises, for example, low-cognition and low-interaction processes are suitable for the start of implementation. In production enterprises, machine data related use cases could be used for a start and subsequently extended to employee data related AI use cases. It is important to "experiment and learn at a fast pace" (Brynjolfsson, McAfee, 2017, p. 34).

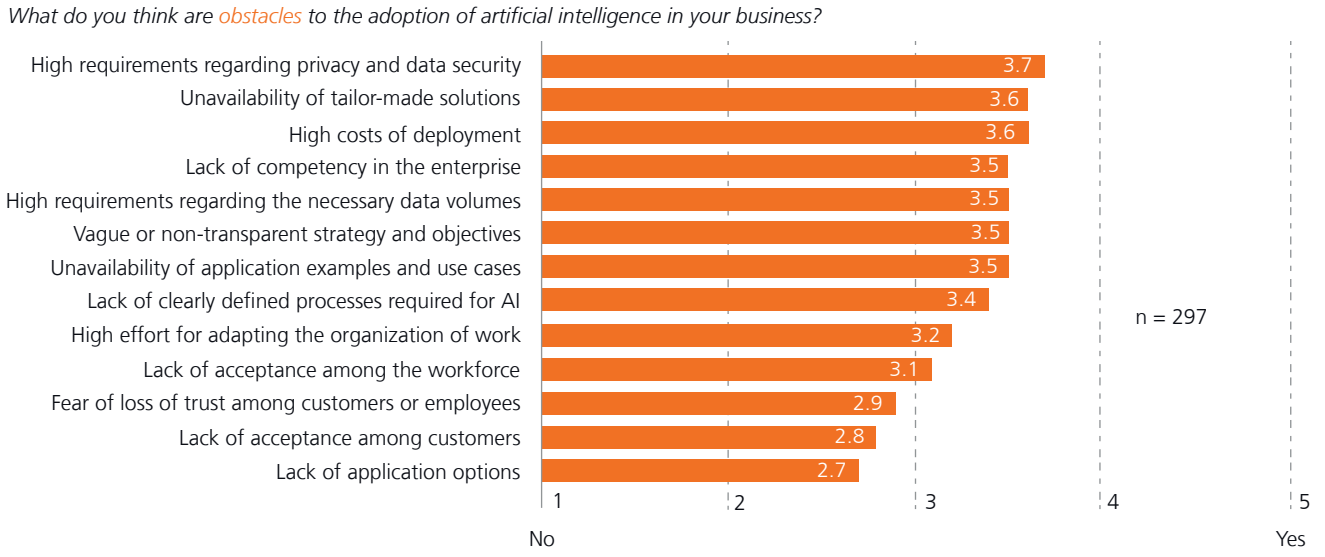


Figure 6: Taken from IAO Study Bauer et al.: Künstliche Intelligenz in der Unternehmenspraxis (AI in Practice), 2019.

According to the study of the Computerwoche journal, the expectations of companies regarding AI are very much focused on the optimization of internal processes (cf. Computerwoche, 2018, p. 16f). This has also become apparent from the Frauhofer IAO study. The majority of companies see the biggest potential of AI applications in the acceleration of processes and increase in labour productivity.

Surprisingly, the customer and employee related AI impact and/or potentials that are mentioned frequently in literature as briefly described above are not rated as highly in the IAO survey. However, the data could perhaps be interpreted in such a way that the employee-related aspects had already been included when considering the "increase in labour productivity". Nevertheless an in-depth examination of the empirical data gives the impression that the new potentials and opportunities of the human-machine (AI) cooperation are not yet really perceived by the companies.

Those companies which had implemented at least one AI application were also asked about whether their expectations regarding the benefit had been met. The majority stated that the quality of decision-making had improved and the processing and lead times had been reduced. There was a consistent relation between the benefits to be achieved and the expected optimization of processes and/or improvement of productivity by the use of AI. A striking aspect was the ambivalent feedback of these users regarding their view of whether a "reduction of personnel costs" and/or an "upgrading of the jobs affected" was achieved. This does not seem to have been achieved successfully. Nevertheless the reasons for this kind of response are open to speculation. One might think that the reduction of jobs is not an important goal for the users, but rather the change of content and tasks of work. Perhaps they were still unable to tap the ratio potential since they are still in an exploration or experimental phase. Similar views are also reflected in the MIT study, where "contrary to recent

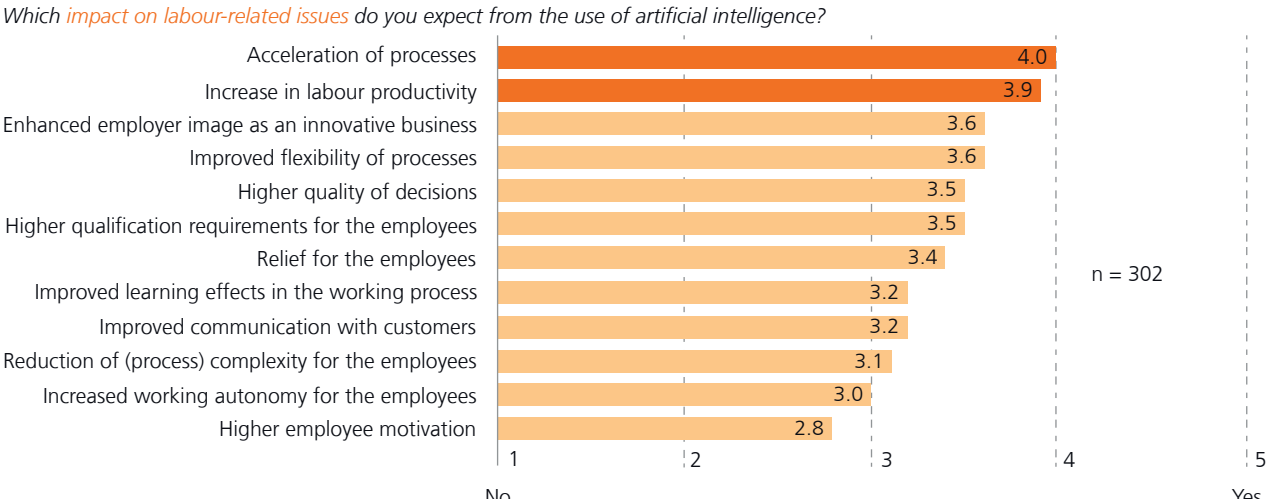


Figure 7: Taken from IAO Study Bauer et al.: Künstliche Intelligenz in der Unternehmenspraxis (AI in Practice), 2019.

dire predictions about AI's effect on employment, our survey suggests cautious optimism. Most respondents, for example, do not expect that AI will lead to a reduction of jobs at their organization within the next five years" (Ransbotham, et.al., 2017, p. 19). Maybe the result of the survey with regard to the view about the "upgrading of the jobs affected" reflects the fact that really only few companies are actively filling the "missing middle" described by Daugherty and Wilson (2018).

5 Redesigning work

Of course, the IAO study also intended to obtain views about how AI drives the transformation of work. As already mentioned above, there are voices pointing out that jobs – particularly those with a high share of routine activities – will probably be lost by the use of AI. At the same time, more and more voices demand gearing the perspective more strongly towards changes in tasks and processes by AI and towards the enabler potentials for employees. For example, Shook and Knickrehme demand a shift in focus "from workforce planning to work planning" (cf. Shook, Knickrehm, 2018, p. 13). To highlight their thesis of "How is AI elevating workers to add more value", they have compiled examples to illustrate this change and the potentials AI offers for employees (cf. figure 8).

A **drilling technician** drills multiple test holes, **manually preparing the drill, calculating and entering correct pressure and speed for the drill.**	AI tells the drilling technician which oil deposits to target and **intelligent drills** calculate speed, pressure and depth.
A **pharmacovigilance scientist combs trough vast volumes of documents** in order to assess safety issues related to drugs.	AI, using **Natural Language Processing and Machine Learning,** helps free scientists to work on higher risk cases and cater to growth in Adverse Event cases.
A **software developer** spends time each week identifying new spam flags **manually writing rules for spam detection.**	**Machine intelligence identifies new spam keywords and updates detection rules,** freeing the employee from work unrelated to new software development
A **aerospace engineer** designs a new plane component making **manual calculations** to produce strong and light designs.	**Generative Desing** mimics nature´s evolutionary approach to consider millions of possible designs and tests for strength and lightness.
A **long-haul driver controls the vehicle** on the road, in charge of the speed, braking and steering	The driver becomes an **"in-cab manager,"** performin high-level technical work, such as monitoring diagnostics systems and optimizing routing tasks

Figure 8: The Evolution of Work and the Elevation of Workers (Source: Accenture Future Workforce Ethnographic Study 2017 according to representation in Shook and Knickrehm 2018, p. 15.

The companies were also asked in the IAO study how far Artificial Intelligence will change the division of work between human workers and technology in the next five years. As evident in figure 9, the results match the expectations. The use of AI for the analysis of data to improve the preparation of decisions is in the foreground. AI can support unbiased decisions very well. It is little surprising that the use of AI aims at driving the automation of simple or routine tasks. The potential for the support of intuitive and empathic activities is (still) rated to be low. Those parties interviewed who have already an AI application deployed were also asked about the degree of autonomy of the application. Only a minority thinks that the autonomy of AI in their application is high, so that AI performs tasks autonomously without human intervention. The majority answered that Artificial Intelligence performed tasks under human control.

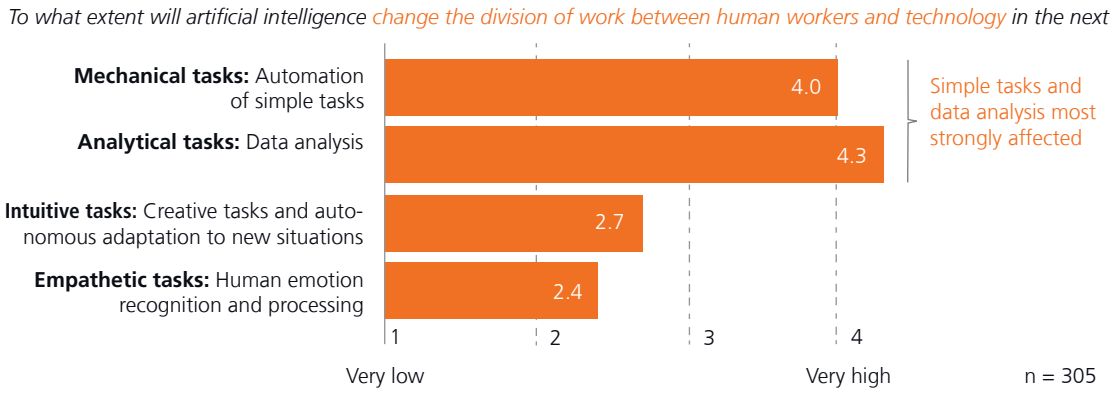


Figure 9: Taken from IAO Study Bauer et al.: Künstliche Intelligenz in der Unternehmenspraxis (AI in Practice), 2019.

Of course, the survey could not ignore the views of the companies regarding the required qualifications and competencies when using AI. As already evident in figure 6, many companies regret that they do not have in-house competencies for the use of AI. The AI users in the IAO random survey also pointed out that the requirements regarding the competencies of the employees affected changed and that much more "digital basic competencies" such as data handling (data analysis) and competencies for utilizing the potential of AI are required. The opinion that, for example, specialized data scientists, interface designers and systems engineers are in demand is highlighted time and again in many studies and in the public debate. There seems to be consensus about this but not about how this shortage of specialists can be solved as quickly as possible.

With regard to competency-related requirements, however, it is not yet possible to say how these will change exactly by the deployment and development of Artificial Intelligence or which ones will exactly evolve in addition. Nevertheless, the initiatives for digitalization launched by the companies have already shown that the competencies to analyse and process data and handle information systems as well as competencies related to processes and systems become increasingly important (cf. Kunz 2015; Zinke 2019). With a view to utilizing and maintaining the problem solving competencies of human beings, it is possible to design human-technology interfaces in such a way that technology supports humans in decision-making in varying degrees. For example, AI may analyse all data available and provide information to the employees not only about current conditions but also about predicted developments (cf. Peissner et al. 2019, p. 11).

It is undisputed that digitalization and the increasing use of AI makes it necessary to increase the efforts to meet the necessary qualification and competency requirements by advanced training arrangements. For this reason, the German Federal Government has meanwhile initiated the "Nationale Weiterbildungsstrategie – gemeinsam für eine neue Weiterbildungskultur" (National Advanced Training Strategy – Together for a New Advanced Training Culture) to emphasize the significance of advanced training for the future (cf. BMBF press release no. 063/2019 dated June 12, 2019). Lynda Gratton also summarizes after her attendance in Davos: "It is vital that we create fast upskilling and reskilling" (Gratton, 2019, p. 2). Nevertheless her view has also a critical cue when she states that "there is a wide agreement that we need a massive push to prepare people for new jobs and skills, but right now, no one is doing enough to prepare people for those skills" (ibid., p. 2). A similarly critical view is also found in the accenture strategy study. "Even though almost half of the business leaders in our survey identify skills shortages as a key workforce challenge, only three percent say, their organization plans to increase investment in training programs significantly in the next three years. This low level of commitment will radically curtail their ability to deploy AI at scale" (cf. Shook, Knickrehm, 2018, p. 8). The goal should be to instil a greater readiness into companies to invest in advanced training.

Meanwhile there are also empirical indications of new job profiles or roles that are generated with a certain probability by the development and application of Artificial Intelligence (cf. figure 10). "More specifically, our research reveals three new categories of AI-driven business and technology jobs. We label them trainers, explainers, and sustainers. Humans in these roles will complement the tasks performed by cognitive technology, ensuring that the work of machines is both effective and responsible – that it is fair, transparent, and auditable." (Wilson et al. 2017, p. 14).

TRAINERS	
Customer language tone and meaning trainer	Teaches AI systems to look beyond the literal meaning of a communication by for example, detecting sarcasm.
Smart-machine interaction modeler	Models machine behavior after employee behavior so that, for example, an AI system can learn from an accountant's actions how to automatically match payments to invoices.
Worldview trainer	Trains AI systems to develop a global perspective so that various cultural perspectives are considered when determing, for example, whether an algorithm is "fair".
EXPLAINERS	
Context designer	Designs smart decisions based on various factors such as business context, process task, individual, profession, and culture.
Transparency analyst	Classifies the different types of opacity (and corresponding effects on the business) of the AI algorithms used and maintains an inventory of that information.
AI usefulness strategist	Determines whether to deploy AI (versus traditional rules engines and scripts) for specific applications.
SUSTAINERS	
Machine relations manager	Evaluates the noneconimic impact of smart machines, both the upside and downside.
Machine relations manager	Evaluates the cost of poor machine performance.
Machine relations manager	"Promotes" algorithms that perform well to greater scale in the business and "demotes" algorithms with poor performance.

Figure 10: The Jobs That Artificial Intelligence Will Create. (Source: Wilson et al., 2017, p. 16)

It is out of the question that these specialists are increasingly needed and they face new job opportunities. However, it would be desirable beyond this that other employees acquire the fundamental knowledge and competency for using AI. "The greatest benefits in expanding insights, however, can come from broadening the population that can perform sophisticated machine learning analyses. Data scientists are typically difficult to hire and retain, and can be a limiting factor to insight generation even with greater productivity. In addition, business analysts with only moderate quantitative skills often understand the business and customer needs better than many data scientists. For these reasons companies are attempting to expand the population of users of machine learning beyond data scientists" (Davenport; Kuder 2019, p. 2–3).

6 Artificial Intelligence in clerk work: a framework model for AI readiness in enterprises

As already mentioned, the use of AI is not only about the question to which extent routine tasks can be automated or the productivity of processes improved. This will happen. It is also about the question of how AI can be used to design new "adaptive processes" and thereby increase operational flexibility. "This adaptability is not based on a predefined sequence of steps but rather on real-time data" (cf. Daugherty, Wilson 2018, p. 14). Moreover it is expected that the new possibilities of human-AI collaboration can unfold a new quality of collaborative intelligence in ever more complex working and value addition processes (cf. also Malone, 2018). This expectation and finding is not entirely new. Winfried Hacker

states in the publication titled "Menschengerechtes Arbeiten in der digitalisierten Welt" (Hacker, 2018) – Human-centered Working in the Digitalized World – that the principle of socio-technological design introduced as early as in 1951 "… is still (waiting) for its widespread sustained implementation". It is also deplored there that existing knowledge for human-centred working system design is fairly much unknown and hardly accessible with regard to content and practical use.

This is the point where the above mentioned project titled "SmartAIwork – Sachbearbeitung zukunftsorientiert gestalten durch Künstliche Intelligenz" (SmartAIwork – Designing Clerk Work for the Future Using Artificial Intelligence) comes in.[8] A consortium comprising science, small and medium-scale production, service and craftsman's enterprises as well as management and labour organizations explores how AI can be introduced successfully for use in clerk work. The research project is based on a holistic perspective on people, technology and organization (cf. figure 11) and the experience and findings of "Human Centered Design" and "User Experience Research" (cf. Strohm, Ulich 1997, Oviatt 2006, Guszcza 2018). The model reflects in a generic way the three relevant fields for the analysis and design of specific solutions for the use of Artificial Intelligence in clerk work. In the SmartAIwork project, clerk work is defined as the work of people in predominantly structured, standardized, recurring and rule-based workflows which typically has a high share of routine activities. Clerk work occurs in all functional areas. Often it is embodied in formalized office work with a high share of routine tasks. However, clerk work may also include qualified knowledge work and range from assistance tasks to management tasks for a defined subject area.

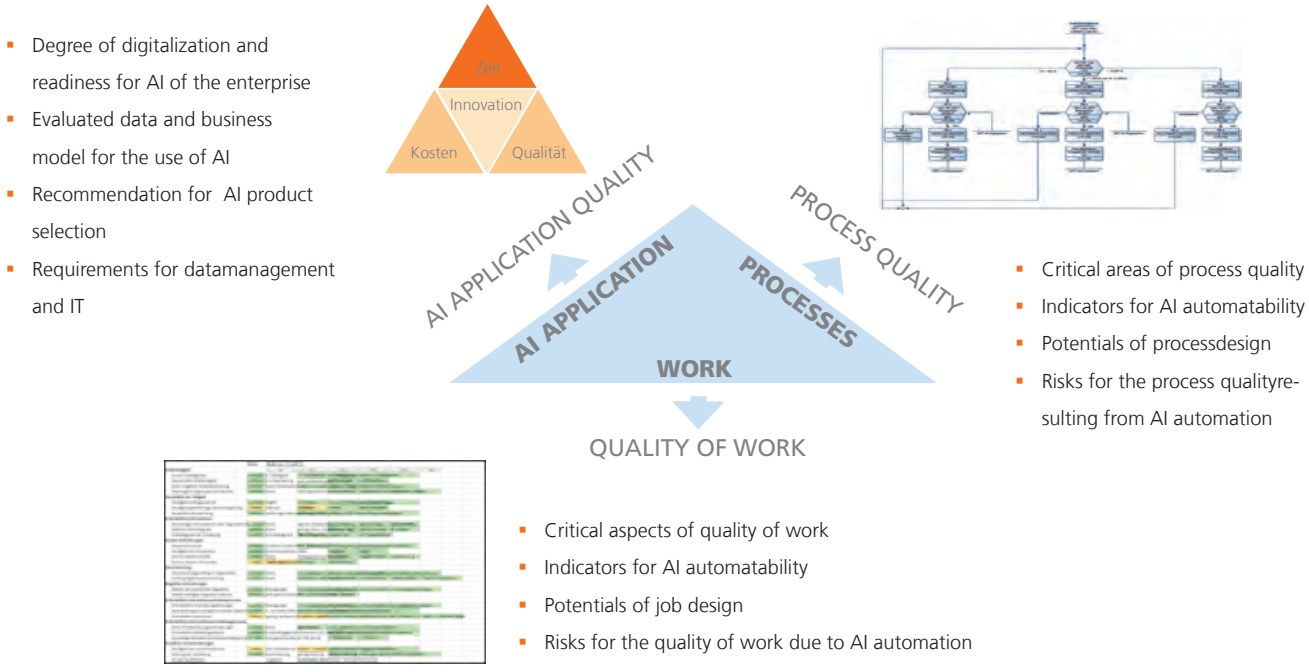


Figure 11: Framework Model for the Analysis and Design of Clerk Work with AI (IAO figure)

8 https://www.smart-ai-work.de/

Since clerk work may range from simple routine activities to certain knowledge work, there are also lower or higher cognitive requirements. Based on the classification established by Hacker (2016), clerk work may range from reproductive thinking in repetitive working activities to the lower limit of productive thinking involving innovative working activities. The core area of routine clerk work involves algorithmic, i. e. controlled thinking, while the non-routine clerk work also involves algorithmic thinking with incompletely predefined rules and non-algorithmic thinking with the use of finding aids. A simple classification of both aspects according to interactional requirements and cognitive requirements can be illustrated as follows (cf. figure 12).

In the current literature on the use of Artificial Intelligence at work, there is a general consensus that company and task specific knowledge about the existing actual processes and their appropriate further development is a decisive success factor for tapping the potentials of AI-supported work. At the same time, it is emphasized that substantial potentials of digitalization and, beyond this, the application of Artificial Intelligence in working processes are found in productivity increases achieved by the automation of routine activities as well as in the penetration of Artificial Intelligence applications into the complex domains of mental work and thus the fields of activity of knowledge and innovative work. Making clerk work accessible to good design with the use of the new possibilities of Artificial Intelligence requires gathering the

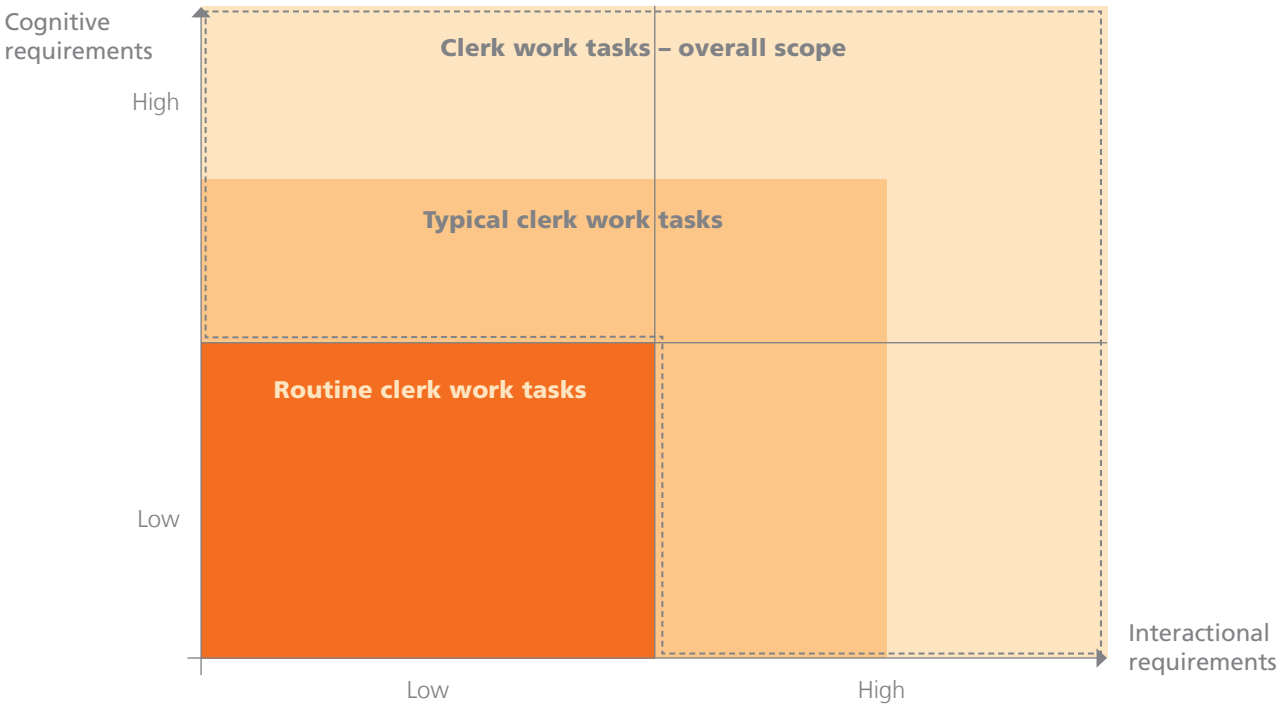


Figure 12: Requirement Scopes in Clerk Work (IAO figure) – Routine = Relatively low cognitive and interactional requirements

ACTUAL states on a context-specific basis in each of the three design areas described in figure 11 to develop realistic TARGET states based on a synopsis of the specific status quo. The focus is on the redesign of processes, on the question of which tasks should remain with the employees alone, which tasks could be automated and ultimately on whether it is possible to address also the "missing middle". It is not yet possible to answer these questions within the project since the phases of analysis with the partnering companies have just been completed and now the planning phase for pilot development starts. Nevertheless, the initial learning experience is outlined here by way of the example of one of the partnering companies in the SmartAIwork project (cf. figure 13).

SmartAIwork Cooperative Project – Pilot

- **Problem description:** Relieving employees in the complaint management process
- **Objective:** Standardization of the corporate complaint management process
  - Inter-departmental digital interlocking
  - Identification of the appropriate contact person
  - Quality assurance
  - Traceable and plausible decisions
- **Method of resolution:** Creating a digital workflow using AI
  - Clustering of complaints
  - Automatic forwarding to the appropriate technical departments
  - Identifying similarities among complaints
  - Providing text blocks for responses
  - Automatic responses to standard complaints





Figure 13: WSW Wuppertaler Stadtwerke GmbH – Improving Complaint Management Using AI (IAO figure)

SmartAIWORK – DESIGNING A BRIGHTER NARRATIVE OF THE FUTURE OF WORK

The objective of the AI project of the Wuppertaler Stadtwerke GmbH is to improve productivity in complaint management and also relief the employees from routine and simple tasks. At first glance, this seems to be a simple use case, however, the phase of analysis has shown that various departments are involved when processing complaints. The workflow and the decision-making architecture for complaint processing are more complex than expected, for example, how to handle certain types of complaints. This is not the only company where it was found that there are discontinuities regarding the media used in the workflow and the degree of digitalization can be improved. To be able to introduce AI-based working systems, a high need for support is seen particularly for small and medium-scale enterprises to achieve the required degree of digitalization. This is also highlighted in a McKinsey study: "Make progress on your digital journey. The results confirm that digitalization is a prerequisite and critical enabler for deriving value from AI… Without a strong digital backbone, a company's AI systems will lack the training data necessary to build better models and the ability to transform superior AI insights into behavioral changes at scale" (Chui and Malhotra, 2018, p. 10). Not only in this company there was a "lack of clearly defined processes required for AI" (cf. figure 6). For this reason, a very detailed process analysis was conducted together with this company to obtain precise transparency about all actual working steps that provide indications for the optimization of the processes and/or inspiration for a redesign of complaint management. Hence, the project of Wuppertaler Stadtwerke aims at developing, implementing and testing an AI-based pilot process for complaint management. For this purpose, the creation of a digital workflow using AI is to be driven and similarities of complaints are to be identified. This is complemented by automatic forwarding to the appropriate technical departments and automatic responses to standard complaints. Complex cases continue to be handled by employees. Also business partners were asked: Are there sufficient data available and what is the quality of the data that permit the use of AI? Although the statement of Brynjolfsson and McAfee (2017) is correct that "sufficient data may often be found surprisingly easily", companies find it hard to handle data management; this is particularly true for small and medium-scale enterprises (SME), since in many cases the required competency (cf. figure 6) is not available within the company.

The SmartAIwork project elaborates a framework model for a three-perspective design space of digital transformation of work, selecting the example of clerk work. An analysis of potential explores AI technologies for clerk work, functional activities and process configurations for the use of AI. A company-specific matching process compiles the facts and potentials from all of the three design fields to permit a realistic assessment of opportunities and risks of the use of Artificial Intelligence to support selected clerk work types. This also includes the attempt to tap not only the efficiency potentials of existing processes by Artificial Intelligence but also to develop and pilot scenarios for new processes together. The three-perspective findings are used to develop a "How-To-Do" to support the introduction of AI in clerk work, will be didactically compiled in the form of a toolbox at the end of the project and made available to other companies in a transfer process.

7 Fields of research and action

As the current discussion about the use of AI shows, various core challenges arise in the development and implementation of AI systems. These core challenges include, for example, how to safeguard non-discrimination, privacy and data security, traceability of AI decisions and how to handle ethical and legal challenges successfully. (Cf. Ethics Guidelines For Trustworthy AI of the EU, 2019).

We would like to briefly highlight three aspects of the use of AI that seem very important to us for the implementation of AI projects in companies:

a. Developing a joint understanding of AI
b. Developing competencies and qualifications to tap the potentials of AI
c. Designing the future of work with AI

a. Developing a joint understanding of AI:
Even though Artificial Intelligence has become the new catchword for digitalization and experiences an enormous hype in the media, a standard definition has not yet been established. However, a common understanding of Artificial Intelligence is necessary to implement AI projects successfully in a company. It is important for such a common understanding to reflect on some myths about Artificial Intelligence and state what Artificial Intelligence is not:

- Artificial Intelligence does not need any inherent understanding of the tasks it performs.
- Artificial Intelligence does not have any consciousness.
- Artificial Intelligence cannot be smarter than its data basis.
- Artificial Intelligence does not develop itself any further (cf. Dukino, 2019).

The above mentioned working definition of AI was eventually developed in several iteration loops within the "SmartAIwork" research project. This was helpful to develop a uniform understanding of AI among the project partners. However, it was even more important that this understanding was critical for the communication and cooperation with the staff in the cooperating companies to develop scenarios and use cases for the use of Artificial Intelligence and combine domain and expert knowledge. It is important to develop a transparency about the understanding of Artificial Intelligence and the functionalities and potentials in the companies across all hierarchical levels and thereby raise the acceptance among the employees in the companies. Fountaine et.al. (2019) also highlight this fact in their publication. "Leaders have to provide a vision that rallies everyone around a common goal. Workers must understand why AI is important to the business and how they´ll fit into a new, AI-oriented culture. In particular, they need reassurance that AI will enhance rather than diminish or even eliminate their roles" (ibid., p. 65). Experience with discourses on AI in companies, particularly in SMEs, has shown that it helps a lot if specific examples of deployment can be outlined that illustrate the benefit of using AI. For this reason, it is envisaged to install AI demonstrators in both the Future Work Lab and the ServLab of the Fraunhofer IAO institute in Stuttgart to be able to demonstrate AI applications and use cases particularly to small and medium-scale enterprises and let them experience the potentials it offers.

b. Developing competencies and qualifications to tapthe potentials of AI:
The development of suitable employee competencies is critical to be able to tap the potentials of Artificial Intelligence. A special challenge for companies is the fast pace of technological change and the related adoption strategies. For this reason, one of the most important requirements of digitalization is the readiness and ability to change of organizations and employees. With regard to the development of competencies, the most promising approaches seem to be those which permit learning incentives on the job (cf. Dworschak; Zaiser 2017, p. 274). New digital learning formats may be used for this purpose, for example, digital learning games, also called serious games (cf. Gronau et al. 2015). Specifically for the

simulation of exercise scenarios in virtual environments or using digital assistance systems, Artificial Intelligence offers additional possibilities to personalize learning processes and take different learning speeds of learners into account (cf. Peissner et al. 2019).

c. Designing the future of work with AI:

In addition to the quantitative challenges, i. e. which and how many jobs may be lost by the use of AI, it is essential to consider two other aspects. As already mentioned, the use of AI offers potentials regarding the improvement of efficiency of processes, product innovation and development of new business models. It will certainly be necessary to examine the impact of these new business models (induced by AI) on the design of work and employment in more depth in the future. Today, the qualitative effects of the use of AI should increasingly be considered in the design of new working systems. The concept of qualitative effects relates to whether ergonomic and human-centred workplaces can be designed successfully using AI. When using AI, it is no longer sufficient to distinguish routine and non-routine activities. It seems to be necessary to get to a more differentiated view of activity profiles, since AI also has the potential to automate non-routine activities to some extent. Currently we are in a phase of AI development where simple tasks, activities and processes can be automated. The imminent AI wave will focus very strongly on the augmentation of working environments. This relates to augmenting human skills, strengthening strong points and compensating for weak points. In principle, it is about designing the decision-making architectures between humans and machines and the development of support and assistance systems. Assistance systems are (computer-based) systems supporting humans in collecting information (perception), information processing (decision-making) and performance of working steps. Self-learning assistance systems are systems that are able to respond to certain situations autonomously and thereby adjust individually to the employee. This can be achieved by utilizing real-time data conditioned by algorithms or Artificial Intelligence. The goal of self-learning assistance systems from the perspective of industrial science is to generate optimum synergy effects between technological and human capabilities. The development of technological assistance systems shows, for example, that we are on the way towards tapping the potentials for the "missing middle".

In addition to the specific operational design aids used in the deployment of Artificial Intelligence to create processes and structures that are conducive to learning, it is certainly necessary to form a positive idea or vision of the "future of work" with Artificial Intelligence as a contrasting element to the "job killer" images frequently portrayed in the media. "We're already seeing indications that this brighter future is achievable. Augmenting, not replacing. The first part of the counter-narrative tells the story of how the most forward-looking organizations are using technology to augment (not replace) humans, freeing up their capacity to leverage what makes them truly human" (Titus, A.; Ackerman, C.; Clugage, J. 2019, p. 2).

References

ALLIANZ INDUSTRIE 4.0 Baden-Württemberg (2019): Einsatzfelder von Künstlicher Intelligenz im Produktionsumfeld. Kurzstudie im Rahmen von "100 Orte für Industrie 4.0 in Baden-Württemberg". https://www.i40-bw.de/wp-content/uploads/Studie-Einsatzfelder-KI-im-Produktionsumfeld.pdf, last verified on June 11, 2019.

BAUER, W.; GANZ, W.; HÄMMERLE, M; RENNER, Th. (eds.): KÜNSTLICHE INTELLIGENZ IN DER UNTERNEHMENSPRAXIS (Authors: Claudia Dukino, Michaela Friedrich, Walter Ganz, Moritz Hämmerle, Falko Kötter, Thomas Meiren, Jens Neuhüttler, Thomas Renner, Sven Schuler, Helmut Zaiser). Stuttgart: Fraunhofer Verlag, 2019 (forthcoming).

BITKOM; DFKI (Bundesverband Informationswirtschaft, Telekommunikation und neue Medien; Deutsches Forschungszentrum für Künstliche Intelligenz) (Hrsg.) (2017): Künstliche Intelligenz. Wirtschaftliche Bedeutung, gesellschaftliche Herausforderungen, menschliche Verantwortung. https://www.dfki.de/fileadmin/user_upload/import/9744_171012-KI-Gipfelpapier-online.pdf, last verified on June 12, 2019.

BONIN, H., GREGORY, T., ZIERAN, U. (2015): Übertragung der Studie von Frey/Osborne (2013) auf Deutschland. ZEW Kurzexpertise Nr. 57. ftp://ftp.zew.de/pub/zew-docs/gutachten/Kurzexpertise_BMAS_ZEW2015.pdf, last verified on September 25, 2019.

BRYNJOLFSSON, E.; MCAFEE, A. (2017): Von Managern und Maschinen. In: Harvard Business manager Heft 11/2017, p. 22–34.

CHEN, N.; CHRISTENSEN, L.; GALLAGHER, K.; MATE, R.; RAFERT, G. (2016): Global Economic Impacts Associated with Artificial Intelligence. Analysis Group. https://www.analysisgroup.com/globalassets/uploadedfiles/content/insights/publishing/ag_full_report_economic_impact_of_ai.pdf, last verified on May 26, 2019.

CHUI, M.; MALHOTRA, S.: AI adoption advances, but foundational barriers remain. Mc Kinsey & Company, Survey 2018. https://www.mckinsey.com/featured-insights/artificial-intelligence/ai-adoption-advances-but-foundational-barriers-remain, last verified on September 29, 2019.

Computerwoche, CIO, TecChannnel und ChannelPartner (2018). Studie Machine Learning / Deep Learning.

DAUGHERTY, P. R.; WILSON, H.J. (2018): Human + Machine. Künstliche Intelligenz und die Zukunft der Arbeit. München: dtv.

DAVENPORT. H; KUDER, D. (2019): Automated machine learning and the democratization of insights. https://www2.deloitte.com/content/dam/insights/us/articles/5179_davenport-automated-machine-learning-essay/DI_Davenport-automated-machine-learning-essay.pdf, last verified on June 13, 2019.

DUKINO, C. (2019): Was ist Künstliche Intelligenz? Eine Definition jenseits von Mythen und Moden. https://blog.iao.fraunhofer.de/was-ist-kuenstliche-intelligenz-eine-definition-jenseits-von-mythen-und-moden/, last verified on June 13, 2019.

DWORSCHAK, B.; ZAISER, H. (2017): Kompetenzentwicklung in und für die Industrie 4.0 – Ein Konzept. In: Spöttl, G.; Windelband, L. (Hrsg.): Industrie 4.0. Risiken und Chancen für die Berufsbildung, Bielefeld: wbv, S. 261–278.

EDWARDS, C. (2016): Why and how chatbots will dominate social media. TechCrunch, 20.7.2016.

EISENKRÄMER, S. (2017): Wie Künstliche Intelligenz im Recruiting helfen kann, 11.12.2017 https://www.springerprofessional.de/recruiting/kuenstliche-intelligenz/wie-kuenstliche-intelligenz-im-recruiting-helfen-kann/15292586, last verified on September 28, 2019.

FOUNTAINE, T.; McCARTHY, B. SALEH, T.: Building the AI-Powered Organization. In. Harvard Business Review, July–August 2019 Issue.

FREY, C. B., OSBORNE, M. A. (2013): The future of employment. How susceptible are jobs to computerisation? Oxford Martin School, Working paper 18, Oxford.

GARTNER, H; STÜBER, H. (2019): Arbeitsplatzverluste werden durch neue Arbeitsplätze immer wieder ausgeglichen. IAB Kurzbericht 13/2019. http://doku.iab.de/kurzber/2019/kb1319.pdf, last verified on August 8, 2019.

GOASDUFF, L. (2017): 2018 Will Mark the Beginning of AI Democratization. https://www.gartner.com/smarterwithgartner/2018-will-mark-the-beginning-of-ai-democratization/

GRATTON, L. (2019): Five Insights from Davos on the Future of Work. In: MIT Sloan Management Review, February 11, 2019. https://sloanreview.mit.edu/article/five-insights-from-davos-on-the-future-of-work/, last verified on September 29, 2019.

GRONAU, N.; ULLRICH, A.; VLADOVA, G. (2015): Prozessbezogene und visionäre Weiterbildungskonzepte im Kontext Industrie 4.0. In: Meier, H. (Hrsg.): Lernen und Lehren für die moderne Arbeitswelt, Berlin: GITO, p. 125–143.

GÜNTHER, J.(2017): Der Cyberboss – Algorithmen als Vorgesetzte. In: Human Ressources Manager, 2017. https://www.humanresourcesmanager.de/news/der-cyberboss-algorithmen-als-vorgesetzte.html, last verified on September 28, 2019.

GUSZCZA, J. (2018): Smarter together: Why artificial intelligence needs human-centered desing. Deloitte Review, issue 22. https://www2.deloitte.com/insights/us/en/deloitte-review/issue-22/artificial-intelligence-human-centric-design.html, last verified on September 29, 2019.

HACKER, W. (2016): Vernetzte Künstliche Intelligenz/Internet der Dinge am deregulierten Arbeitsmarkt. In: Psychologie des Alltagshandelns. Vol. 9/No. 2, November 2016, p. 4–21.

HACKER; W: (2018): Menschengerechtes Arbeiten in der digitalisierten Welt. Eine wissenschaftliche Handreichung. Zürich: Vdf Hochschulverlag an der ETH Zürich.

HOWARD, A. (2019): The Regulation of AI – Should Organizations Be Worried? – MITSloan Management Review Column July 29, 2019. https://sloanreview.mit.edu/article/the-regulation-of-ai-should-organizations-be-worried/, last verified on September 27, 2019.

KAWAMURA, S.; MACHIDA, K.; MATSUI, K., SAKAMOTO, D., ISHII, M. (2016): Utilization of Artificial Intelligence in Call Centers. In: NTT Technical Review Vol. 14 No. 5.

KUNZ, C. (2015): Next generation competencies for a digital world – Erfahrungen aus dem Siemens-Projekt "Industrie 4.0@SPE". In: Berufsbildung in Wissenschaft und Praxis (BWP) Heft 4/2015, p. 33–35.

MALONE, T. W. (2018): Superminds. The Suprising Power of People and Computers Thinking Together, London: Oneworld Publications.

McCARTHY, J.; MINSKY M. L.; ROCHESTER, N.; SHANNON, C. E. (1955): A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence. http://jmc.stanford.edu/articles/dartmouth/dartmouth.pdf, last verified on June 12, 2019.

MIT Technology Review (2019): How AI is changing knowledge work: MIT's Thomas Malone. Interview of Thomas Malone. January 24, 2019. https://www.technologyreview.com/s/612815/how-ai-is-changing-knowledge-work-mits-thomas-malone/, last verified on September 27, 2019.

OVIATT, S. (2006): Human-Centered Design Meets Cognitive Load Theory: Designing Interfaces that Help People Think.

Partnership on AI: AI, Labor, and Economy Case Studies. Compendium Synthesis. https://www.partnershiponai.org/compendium-synthesis/, last verified on June 12, 2019.

PEISSNER, M.; KÖTTER, F.; ZAISER, H. (2019): Künstliche Intelligenz – Anwendungsperspektiven für Arbeit und Qualifizierung. In: Berufsbildung in Wissenschaft und Praxis (BWP) 3/2019, p. 9–13.

PwC (Hrsg.) (2018): Auswirkungen der Nutzung von künstliche Intelligenz in Deutschland. https://www.pwc.de/de/business-analytics/sizing-the-price-final-juni-2018.pdf, last verified on June 6, 2019.

RANSBOTHAM, S.; KIRON, D. GERBERT, Ph.; REEVES, M. (2017): Reshaping Business with Artificial Intelligence. MIT Sloan Management Review, in collaboration with BCG. https://sloanreview.mit.edu/projects/reshaping-business-with-artificial-intelligence/, last verified on September 29, 2019.

SHOOK, E.; KNICKREHM, M. (2018): Reworking the Revolution. Accenture strategy, 2018. https://www.accenture.com/_acnmedia/pdf-69/accenture-reworking-the-revolution-jan-2018-pov.pdf, last verified on September 29, 2019.

STROHM, Oliver; ULICH, Eberhard (1997): Unternehmen arbeitspsychologisch bewerten. Ein Mehr-Ebenen-Ansatz unter besonderer Berücksichtigung von Mensch, Technik, Organisation. Zürich: Vdf Hochschulverlag AG an der ETH Zürich.

TITUS, A.; ACKERMAN, C.; CLUGAGE, J. (2019): Flipping the narrative toward a brighter future of work. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/human-capital/us-human-capital-flipping-the-narrative-toward-brighter-future-of-work.pdf, last verified on June 13, 2019.

VOGLER-LUDWIG, K. (2018): Beschäftigungseffekte der Digitalisierung – eine Klarstellung. In: IGZA (Institut für Geschichte und Zukunft der Arbeit): Konferenz Band: Roboter – Assistenz-Systeme – Künstliche Intelligenz, p. 51–62. http://igza.org/wp-content/uploads/2018/02/IGZA-Konferenz-Band_Robotik-und-KI.pdf, last verified on September 28, 2019.

WEF (WORLD ECONOMIC FORUM) (2018): The Future of Jobs Report 2018.
Internet: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf, last verified on June 14, 2019.

WILSON, H. J.; DAUGHERTY, P.R. (2019): Mensch und Maschine als Team. In: Harvard Business manager, Edition 3/2019.

WILSON, H. J.; DAUGHERTY, P. R.; MORINI-BIANZINO, N. (2017) The Jobs That Artificial Intelligence Will Create. In: MIT Sloan Management Review Summer 2017, p. 14–16. https://sloanreview.mit.edu/article/will-ai-create-as-many-jobs-as-it-eliminates/, last verified on June 13, 2019.

ZINKE, G. (2019): Veränderte berufsübergreifende Kompetenzen infolge des digitalen Wandels. In: Berufsbildung in Wissenschaft und Praxis (BWP) 3/2019, p. 39–43.

Biographies

Walter Ganz studied Industrial Sociology, Psychology and Political Science at the University of Freiburg (Germany). In his first careerstep he was working as an assistant researcher at the Max-Planck-Institute in Freiburg. After that he joined as a researcher at the ICT Research Center of Infratest in Munich.

In 1990 he joined the Fraunhofer Institute for Industrial Engineering (IAO) in Stuttgart as a research assistant. Meanwhile he is a director and member of the board of the Fraunhofer IAO Stuttgart, head of the Human Resource Management research department and head of the Service Engineering and Management research department. Beside his leadership performance he is taking part in a lot of supporting activities. For instance, assisting the German Federal Ministry of Education and Research (BMBF) regarding the development of research programs and activities in the field of future of work and innovation in services.

Dr. Anne-Sophie Tombeil studied Political Science and Rhethorics in Tübingen and Florence. She received her doctorate with a comparative thesis on regional development processes in Southern Europe.

Dr. Tombeil started her career at the Fraunhofer Institute for Industrial Engineering (IAO) with contributing to the establishment of Service Science as field of applied research. As assistant to the president of Fraunhofer Gesellschaft she created a large Initiative for Innovation in public private partnership with the federal government, industry and science. Her current work with Fraunhofer IAO focusses on digital transformation of work and networked value creation. Dr. Tombeil is married with three children.

Helmut Zaiser studied Political Science and British Cultural Studies at the University of Tübingen. There he worked as student assistant in comparative research projects on labour relations, labour market, and social policies.

At the Fraunhofer Institute for Industrial Engineering (IAO) he worked as student assistant and assistant researcher in national as well as international network projects on skills needs, Vocational Education and Training (VET), and future labour market scenarios. Since 2015 he has been working as researcher at the IAO in research projects on work, skills needs, and digitalization – keeping up an ongoing interest in R&D Governance, VET, and labour relations.

FUTURE WORK LAB 2.0: ARTIFICIAL INTELLIGENCE FOR MANUFACTURING WORK OF THE FUTURE

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Abstract

Our working world is in a state of upheaval. The Internet and mobile technologies are fundamentally changing the way we live and work. Industrie 4.0 and the Digital Transformation are relevant drivers for the development of our whole society. Even new digital technologies such as Artificial Intelligence and machine learning have a big footprint. The goal of the Future Work Lab 2.0 is to operate and develop a unique innovation laboratory for work, people and technology at the Stuttgart location. A Demonstrator World with more than 50 demonstrators showcasing manufacturing work of tomorrow makes new possibilities of digitalization and automation possibilities in the core areas of industrial work transparent. A Learning World serves to raise awareness, qualification and social dialog. An Ideas World provides a platform for national and international advanced research and academic discussion of changes in industrial work. The present paper describes the aims and the status of the German BMBF-funded project.

Key words
Digitalization, Industrie 4.0, Future Work Design, Innovation Lab, Artificial Intelligence

1 Introduction

Our working world is in a state of upheaval. The Internet and mobile technologies have begun to change our life and work fundamentally in recent years. Cyber-physical production systems, intelligent automation and crowd-working are driving change forward. Digitalization and the resulting intelligent networking of people, machines and objects reaches knowledge, production, service and all areas in between. Employees, companies and social partners already recognize the benefits of digitalized working and living environments in many areas. This is further fueling the development [1].

"The successful development and integration of digital technologies in industrial user industries is crucial for Germany's competitiveness, as ICTs are important drivers of innovative value chains and products in many industries" [2]. We need to find successful answers to new challenges: How can we make a real contribution to the opportunities of digitalization for the economy, administration, society and master the challenges together? How do we live, learn and work in a digital world? How can the demands of demographic change, concerning private life and digital working environments, be reconciled? The Future Work Lab project, funded by the German Federal Ministry of Education and Research (BMBF), presents concrete perspectives and implementation options for the successful shaping of future industrial work and makes them available in an open laboratory concept for companies, employees, works councils and the public.

2 Digitalization changes industrial work

The progressive development of information and communication technology (ICT) has made sure that in many parts of industry powerful and inexpensive embedded systems, sensors and actuators are available. Under the slogan "Industrie 4.0", developments are currently being discussed in terms of a manufacturing environment that consists of intelligent, self-controlling objects, which are temporarily networked to fulfill specific tasks. In this context, cyber-physical systems (CPS) and cyber-physical production systems (CPPS) are also mentioned [3, 4].

Cyber-physical systems (CPS) are systems that link the real to the virtual world in an Internet of Things, data and services. CPS capture data via sensors, process them with embedded software from controllers, and use the Internet and cloud computing to communicate via open, partial, global and ever-connected information networks. Application fields are characterized by automation, production logistics, robotics, medical care, energy distribution, etc. [5, 6, 7, 8].



Figure 1: Drivers of the transformation of industrial work

In the vision of fully networked Industrie 4.0, companies' orders are managed independently by whole value chains, which book their processing machines and their material and organize their delivery to the customer. Networking of these decentralized, intelligent systems is made possible thanks to the comprehensive and affordable availability of the technical infrastructure in the form of industrial (wireless) Internet connections. Logically, the systems are coupled by the consistent application of decentralized control principles such as multi-agency systems, which are based on the already long-propagated "Internet of Things". This allows the integration of the real and virtual worlds. Products, devices and objects with embedded software are growing together in distributed, function-integrated and recoupled systems in Industrie 4.0 [9]. In the context of industrial work, cyber-physical production systems can be characterized by intelligent assistants, which will provide employees with inaccessible information and analyses in the future. This allows a better mastery of complicated and complex workflows.

Offices and points-of-sales will also change their character in the future. On the one hand, the new technical possibilities mean that information and knowledge can be searched, generated and exchanged with a new quality of efficiency. This networking is growing steadily because it requires business processes and also because people and employees and their working conditions are pushing it ahead. On the other hand, this trend toward increasingly digital and ever more virtual coexistence and work must be supplemented by elements which guarantee our right to satisfy our human basic needs. These include human proximity, security, safety, good nutrition, exercise, health and the desire for physical and psychological well-being.

The digital networked world must therefore be balanced with things from the real, physical and haptic world. This will lead to a hybrid world of work and life in the future. It will therefore be important to create new offerings in the field of work design. Only in this way can the individual choose, decide and participate, use diversity, achieve diversity and ensure the necessary agility [10].

3 Designing industrial work of the future

Industrial work of the future is characterized by a new understanding. The growing spread of smart living and working environments is based on socio-technical networking. The classic success factors in technology, organization and personnel are experiencing a potential- and requirement-oriented expansion in times of digital transformation: human activities will in the future be almost completely supported by technology machines as well as software applications, thereby further optimizing individual and team work. The future industrial working world takes place in real and virtual spaces, which are characterized by system integration and user adaptivity. In the future, human beings will continue to be at the center of the studies in the field of labor science, and within this new, hyperflexible and mobile working world, there is still unprecedented support [11].

The main design fields influencing industrial work of the future are the shaping of the framework conditions with regard to flexibility and work-life balance, human-centric technology design and the interpretation of the interaction between workers and technology as the upcoming assistance systems (digital and physical) clearly show. In addition, the qualification and competence requirements for a successful design of future working situations are critical to success.

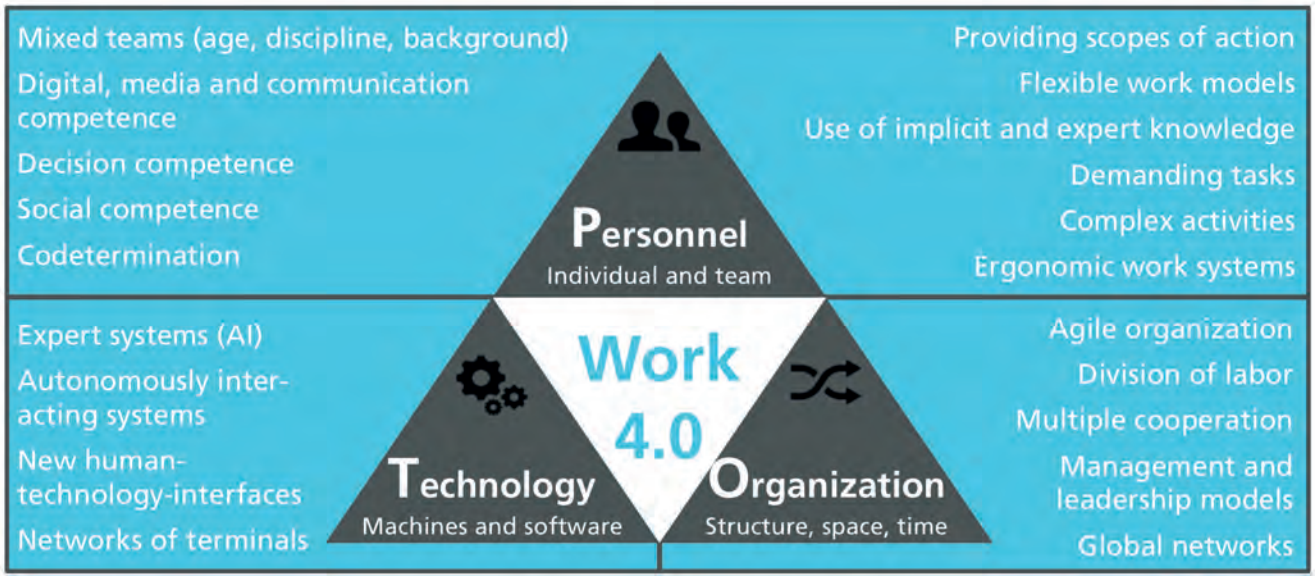


Figure 2: The traditional triangle of work T-O-P is expanding

4 Future Work Lab: Innovation laboratory for work, people and technology

In order to make these aspects of future work design visible, tangible and experiencible, the Future Work Lab provides and operates the largest German innovation laboratory for work, people and technology in Stuttgart. This lab is designed as a living and widely visible center of competence with three pillars.

To this end, demonstrators of the technical possibilities of digitalization and further automation in the core areas of industrial work are realized in the Demo World for current and future time horizons.

The Demo World shows operational requirements for the demonstration of industrial work in today's technological and organizational environment. This creates an important point of focus in industrialized and modern small and medium-sizes companies (lean production, lean systems, integrated production systems) within the Future Work Lab. Further demonstrators show operational applications for the digitalization and intelligent automation of industrial work in the time horizon until 2025. Different demonstrators address the poles of technology-centric automation and human-centered specialization, which by 2025 could be "standard" in the manufacturing industry. This refers to the two scenarios for the development of an Industrie 4.0, the automation and the specialization scenario [12] currently discussed in the context of the digital transformation of science and companies.

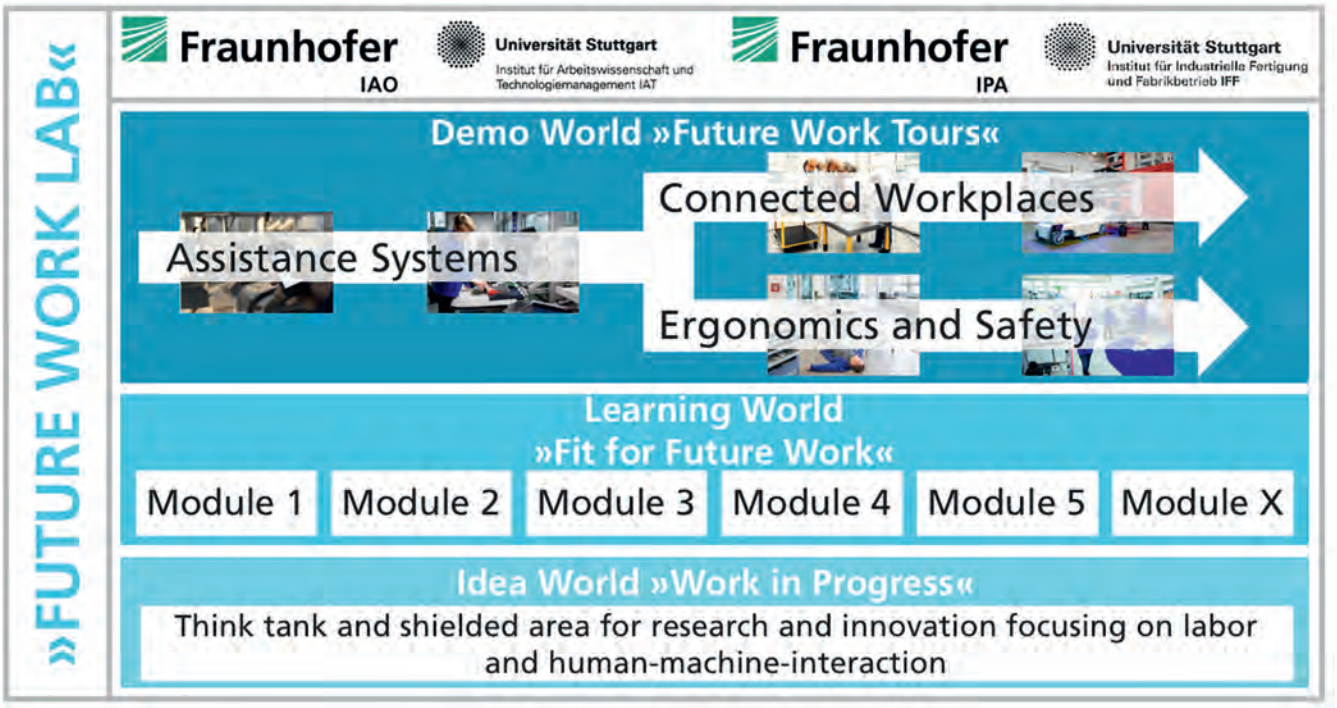


Figure 3: Structure of the FUTURE WORK LAB

The two scenarios stress a field of tension in which the work of the future can be shaped by the operational requirements. In this context, a "digitally strengthened shop floor" emerges. In the Future Work Lab, not only elements of the two extreme scenarios (automation and specialization scenarios) are mapped, but the resulting design space and possible realizations are shown transparently. On the one hand, the interaction of human workers with machines is at the forefront of all aspects of operational value creation (e. g. planning, production operation, maintenance). On the other hand, new forms of automation in the form of physical assistance systems (e. g. human-robot cooperation) are tangible. Current challenges with regard to the future world of work are the application of new technologies in the field of "Artificial Intelligence" with regard to the teaching of machines by humans, "big data" for statistical machine learning and autonomous optimization of machines. Abstract and complex technologies such as these are made tangible in the Future Work Lab in the sense of utility potentials and also by showing the limits of the new applications.

In 2019, the Demo World shows demos in different subject areas. There are demos in the context of networked production systems and intelligent machines. New visualization technologies such as VR and AR play an important role for planning and development activities. A main topic for the Lab are digital assistance systems, because these are often the interface to humans. Ergonomics and work safety are also important to the Demo World, as are, of course, new approaches to employee qualification on the shopfloor. The Demo World is highly attractive to all stakeholders. During the first two years after the opening of the Lab in 2017, more than 12,000 interested people visited the Lab [13].



Figure 4: Demo World – Projection Table as an innovative information system in production



Figure 5: Demo World – Molecular Workplace meets new generations' requirements towards empowerment and work design

In addition to this demo center, the sensitization, qualification, value proposition and the social dialog of future-oriented working systems are carried out in a Learning World focusing on social interest groups. The third pillar provides a platform for technology-oriented research and academic discussion of the changes in industrial work within an Ideas Center. The Future Work Lab makes the design of future-oriented working concepts transparent for companies, employees, trade unions and all other stakeholders. The laboratory integrates the path from the demonstration of concrete Industrie 4.0 applications through the development of competencies to the integration of the current state of work research, thereby enabling holistic development steps in the area of new work, people and technology.

To this end, the Future Work Lab offers an attractive qualification and seminar program, which can be used by companies, associations, trade unions and employees. In addition to the interested target group, the Lab is also made open for in-house exhibitions, lectures at congresses and events. The academically-oriented center of ideas develops new research contents. These allow the creation of future research perspectives on new projects and programs.



Figure 6: Learning World – sensibilization, qualification and consultancy for companies and unions

5 Example use case "assistance system for flexible manufacturing work"

The challenges that are currently affecting companies are various. They include demographic change, diversity, globalization, flexibility requirements in order to serve individual customer requirements and delivery dates [14].

Cognitive assistance systems offer the possibility of integrating digitalization into the company and master upcoming challenges successfully. The advantage is that the investments and the changes made by the assistance systems can be designed to be particularly variable, unlike, for example, comprehensive full automation. The development challenge is to find the right assistance system for the specific company and task [15].

The assistance systems in the production environment are differentiated according to physical and cognitive assistance systems. Physical assistance systems assist people with demanding physical activities. They compensate for physically declining abilities and the prevention of physical overuse [16]. Often, collaborative robots are used [17]. Cognitive assistance systems offer the possibilities of a closer cooperation between human and machine, with the aim of unifying the outstanding abilities of humans with the special characteristics of machines as the "best of two worlds" [16]. An assistance system records the actions of users and reprocesses information back to them. Employees process this information and uses it to solve their tasks. The system requires a communication interface (front-end) [18]. This consists of an input system for data acquisition from the operator side and an output system for information transfer [3]. It also means that the human being is supported by the technical systems, which in the ideal case corresponds exactly to their abilities and needs as well as the requirements of the work context [16]. The cognitive assistance systems do not support (or replace) the employee directly in terms of physical execution.

One example of an assistance system in the FUTURE WORK LAB's Demo World is the KapaflexCy use case which is outlined as follows: Fixed working hours from 7 a.m. till 4 p.m. are obsolete – even at the shop floor. Future labor teams coordinate themselves upon their work assignments via smartphones. On their own responsibility, at short notice, and highly flexible. Thus operations are closely follow demand – which is strongly driven by customer orders. To create customer-specific products, it is necessary to constantly increase dynamism, versatility and customer orientation. This requires maximum flexibility – both in terms of the technical equipment and the staff involved. Lean manufacturing close to the customer requires flexible control of the workforce that is as near to real time as possible. In practice, this usually still happens manually today: Team leads and shift managers coordinate employees' presence and absence times. To do this, they communicate daily with their staff, HR business partners, other team leads and temporary employment businesses – usually verbally, rarely and with sufficient advance notice by e-mail. Much easier and faster is the usage of methods and technologies from social media. The vertical cascade of instructions "from above" – which is still common today – is being replaced by horizontal decisions in and between working groups [19].

This becomes possible through the consistent use of mobile devices and through the pervasion of manufacturing with cyber-physical systems. Cyber-physical systems provide information in real time about the production environment, learn typical demand situations and the capacity profiles to match, and combine these with communication functions for the employees. Based on flexibility needs, communication patterns and capacity control process for production, a CPS tool (Kapaflexcy App) was developed that provides employees with a platform for coordinating capacity. This tool enables employees to take control of adjusting their capacity to the requirements.



Figure 7: Kapaflexcy Assistance System @ Future Work Lab – coordination of flexible work assignments in production

This new, self-organized capacity management shortens the response time for companies when the order situation is unpredictable and the markets are volatile, avoids unproductive times, and reduces the amount of work required for managing capacity. Employees experience transparent workforce planning and coordinate their shift times among themselves. They manage to balance their work, family and leisure time better, which in turn increases their motivation. The use case demonstrates new forms of capacity flexibility by using real-time CPS data, mobile devices, and Web 2.0 technologies in an application-related way.

6 Future outlook

With the "Future Project National Project Industrie 4.0", the digital transformation is accelerating above all for the manufacturing industry, which is of great importance for Germany's competitiveness [20]. For manufacturing work 4.0, networked production systems, intelligent machines, Artificial Intelligence and new visualization technologies such as VR and AR as well as digital assistance systems are playing an increasingly important role.

Today, digital transformation is already an integral part of the operational activities of many manufacturing companies. It can be seen that in recent years companies have increasingly moved in the direction of implementing individual 4.0 projects. In 2014, 39 percent of the respondents to the German Industrie 4.0 Index said that they were still in the observation and analysis phase, while only 14 percent were already in the implementation phase. In 2018, on the other hand, 43 percent of companies were already in the implementation phase while only just under one in four companies was still analyzing and observing [21].

Despite all this, German companies are lagging behind in the scope, speed and networking of the implementation of digital solutions in production. According to a survey by Bitkom, in 2018 it is above all SMEs that see themselves as laggards in the digital transformation [22]. Only among companies with more than 2000 employees their own management assume that they are more likely to be pioneers than laggards. However, the immense share of small and medium-sized enterprises is indispensable for Germany's economic power. In the future, precisely these companies will need more tangible and practical access to digital technologies and their operational use. In addition, a new wave of digital technologies (e. g. Artificial Intelligence, machine learning) is rolling towards German companies. Current surveys show that companies are particularly interested in questions concerning the use of these new technologies that are either directly related to Artificial Intelligence or are prerequisites and opportunities for networked work organization 4.0.

In order to take up the infrastructure successfully built up and put into operation in the first phase of the Future Work Lab project and to take up the external momentum, the Future Work Lab 2.0 project aims to expand and further develop the Future Work Lab as a lively and widely visible laboratory for the future, especially for SMEs. The expansion and extension of the research project will focus in particular on the overarching issues of the effects of technology on future work, human-centered work and technology design, and learning 4.0. New solutions, methods and procedures are developed for the stakeholder groups of management, employees, works councils, industry 4.0 project managers, associations, students and the interested public. The latest technologies such as AI and machine learning, networked work organization and Industrie 4.0, big data, intelligent robotics, autonomous systems, mobiles and wearables will serve as the basis for the research work which will take place from 2019 to 2022.

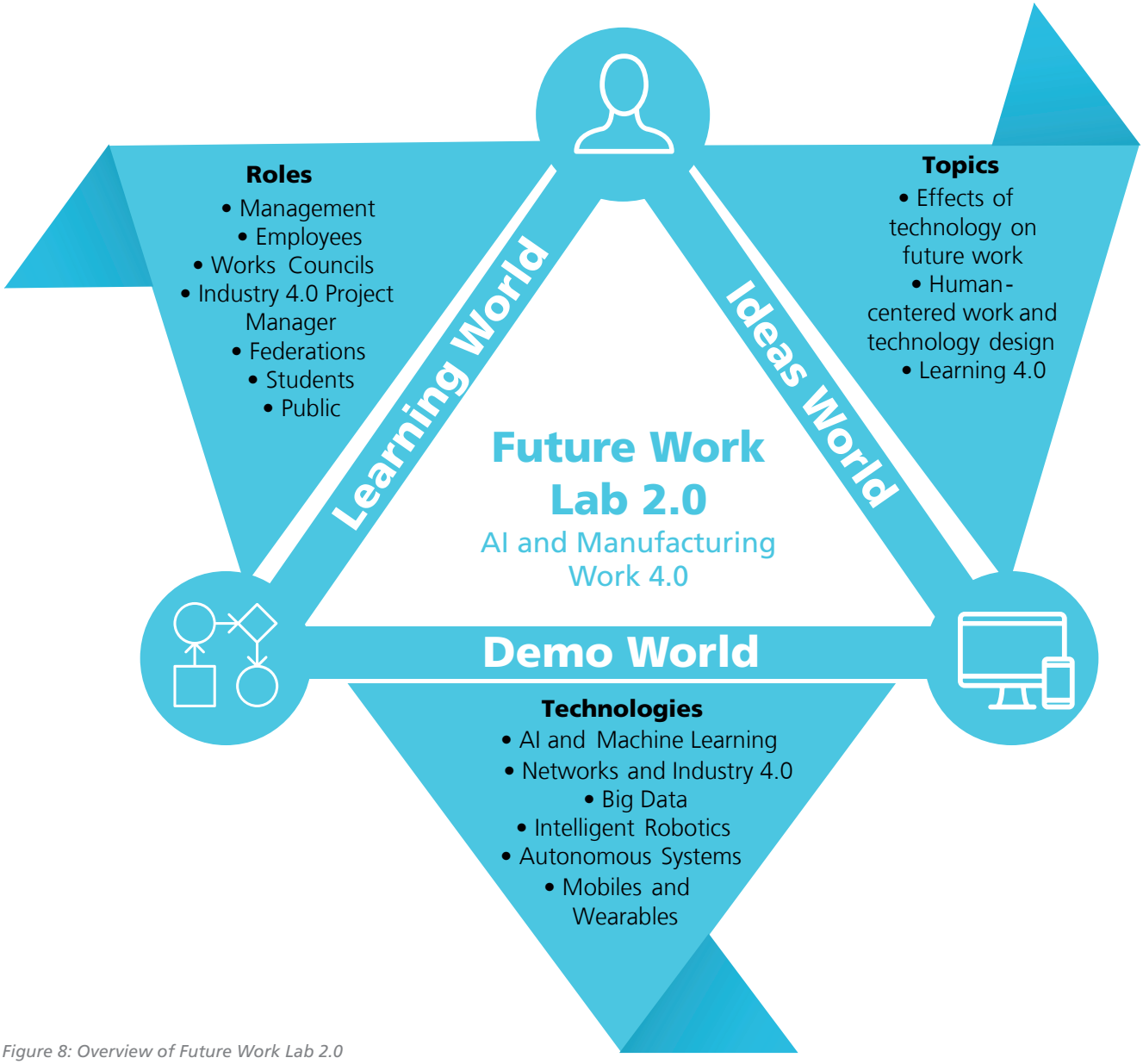


Figure 8: Overview of Future Work Lab 2.0

7 Acknowledgments

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References

[1] IG Metall: Digitalisierung der Industriearbeit – Veränderungen der Arbeit und Handlungsfelder der IG Metall. Frankfurt 2015.

[2 Bundesministerium für Bildung und Forschung (BMBF): Die neue Hightech-Strategie. Berlin 2014, https://www.bmbf.de/pub/HTS_Broschure_barrierefrei.pdf

[3] Ingenics/Fraunhofer IAO 2014: Industrie 4.0 – Eine Revolution der Arbeitsgestaltung. Wie Automatisierung und Digitalisierung unsere Produktion verändern werden. Ulm

[4] Spath, Dieter; [et. Al.]: Produktionsarbeit der Zukunft – Industrie 4.0, FhG IAO 2014, http://www.fraunhofer.de/content/dam/zv/de/forschungsthemen/ Wissenschaftsjahr/ 2014-die-digitale-gesellschaft/Produktionsarbeit-der-Zukunft_Industrie-4.0.pdf

[5] acatech (Hrsg.): Cyber-Physical Systems. Innovationsmotor für Mobilität, Gesundheit, Energie und Produkti-on. Acatech Position 2011. http://www.acatech.de/de/publikationen/stellungnahmen/ acatech/detail/ artikel/cyber-physical-systems-innovationsmotor-fuer-mobilitaet-gesundheit-energie-und-produktion.html

[6] VDI/VDE GMA: Glossar Cyber-Physical Systems: Chancen und Nutzen aus Sicht der Automation, http://www.iosb.fraunhofer.de/servlet/is/48960/ Begriffsdefinitionen%20des%20VDI%20GMA%20FA7%2021.pdf?command=downloadContent&filename=Begriffsdefinitionen%20des%20VDI%20GMA%20FA7%2021.pdf

[7] Broy, M. (Hrsg.): Cyber-Physical Systems. Innovation durch Software-intensive eingebettete Systeme. Heidelberg: Springer, 2010.

[8] Fischer, Innovation im Mittelstand am Beispiel der Senkung von Mobilitätskosten durch "Schwarmintelligenz". In: H. Broy, M. (Hrsg.): Cyber-Physical Systems. Innovation durch Software-intensive eingebettete Systeme. Heidelberg: Springer, 2010, S. 38–58.

[9] Bauernhansl, T.; ten Hompel; M. Vogel-Heuser: Industrie 4.0 in Produktion, Automatisierung und Logistik. Berlin

[10] Spath, D. (Hrsg.); Bauer, W. (et.al): Arbeitswelten 4.0: wie wir morgen arbeiten und leben. Stuttgart 2012.

[11] Bauer, W.: Working Smarter – Menschen. Räume. Technologien, Zukunftsforum Fraunhofer IAO. Stuttgart 2015.

[12] Spath, D.; Dworschak, B.; Zaiser, H.; Kremer, D.: Kompetenzentwicklung in der Industrie 4.0. In: Meier, H. (Ed.): Lehren und Lernen für die moderne Arbeitswelt. GIT0 Verlag, Berlin, 2015, pp. 113-124.

[13] https://futureworklab.de

[14] S. Adenauer, Leistungsfähigkeit im Betrieb: Kompendium für den Betriebspraktiker zur Bewältigung des demografischen Wandels, pp. 9–18.

[15] J. Merazzi, A. Friedel, Einteilung und Bewertung von Montageassistenzsystemen, in: ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb, pp. 413 – 416.

[16] Deutschland. Bundesministerium für Arbeit und Sozialordnung (Ed.), Forschungsbericht / Bundesminister für Arbeit und Sozialordnung, Referat L P 3, Bonn Bundesministerium, 2018.

[17] P. Hold, F. Ranz, W. Sihn, Konzeption eines MTM-basierten Bewertungsmodells für digitalen Assistenzbedarf in der cyber-physischen Montage, in: C. Schlick (Ed.), Megatrend Digitalisierung - Potenziale der Arbeits- und Betriebsorganisation, GITO, Berlin, 2016, pp. 295–322.

[18] T. Stahl, M. Völter, S. Efftinge, A. Haase (Eds.), Modellgetriebene Softwareentwicklung: Techniken, Engineering, Management, 1st ed., dpunkt.verlag, s.l., 2012.

[19] www.kapaflexcy.de

[20] https://www.bmbf.de/de/zukunftsprojekt-industrie- 4-0-848.html

[21] Staufen AG: Deutscher Industrie 4.0 Index 2018, Staufen AG, 2019

[22] Bitkom: Digitalisierung der Wirtschaft, 2018.

Biographies

Dr. Moritz Hämmerle completed his studies at the University of Stuttgart, Germany, majoring in Technology Management, Factory Operation and Labor Science. Immediately afterwards, he began his professional career as a research associate at the Institute of Human Factors and Technology Management IAT at the University of Stuttgart. In 2012, he switched to the partner Fraunhofer Institute for Industrial Engineering IAO, and in 2015 obtained his doctorate with summa cum laude at the University of Stuttgart. Following a stint as head of the Production Management team at Fraunhofer IAO, in 2018 Dr. Hämmerle took on responsibility as institute director for the new Cognitive Engineering and Production research unit.

His work focuses on the areas of Industrie 4.0, the future of production, Future Work Lab, personnel flexibility in production, reorganization of manufacturing enterprises, evaluation and design of production and work systems, and human-robot collaboration. Dr. Moritz Hämmerle has many years of experience in consulting and research projects for enterprises, associations and ministries and has published in excess of 25 scientific and technical papers, which in the course of his career have earned him various honors and best paper awards.

Bastian Pokorni is a researcher at the Fraunhofer Institute for Industrial Engineering IAO in Stuttgart, where he heads the department for Connected Production Systems. His work focuses on the human-centered design of digitalization and Artificial Intelligence in the production environment and its influence on human factors and productivity. In the field of Artificial Intelligence, he conducts research in the field of human-ai interaction, cooperation and collaboration, technology acceptance and the explainability of self-learning systems. Bastian Pokorni is responsible for several national and international consulting projects in the field of digital transformation, preparing the ground for the next steps toward productivity, flexibility and agility. In 2013, he developed the cross-industry innovation cluster "Innovationsnetzwerk Produktionsarbeit 4.0" with 15 companies to develop solutions and methods in an open innovation model.

ARTIFICIAL INTELLIGENCE IN EDUCATION AND WORK

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Birkbeck Knowledge Lab

Abstract

Increasing volumes of high-value data that can be generated by today's digital technologies are enabling the design and application of AI techniques that have the potential to enhance our understanding, creativity and work practices. However, for this to happen, we must design appropriate educational programmes, collaboratively between educationalists, practitioners and employers, so that individuals and organisations are able to be continually re- and up-skilled so that they can contribute to and benefit from data- and AI-driven opportunities. Birkbeck College is uniquely placed to participate in such collaborations through its long-standing mission to provide degrees to students from diverse backgrounds, most of whom are working while studying. Birkbeck's Department of Computer Science and Information Systems leads the college's participation in the UK-wide Institute of Coding, involving over 100 universities and employers with the aim of addressing the digital skills gap among computer science graduates. The Department also hosts the Birkbeck Knowledge Lab, which conducts interdisciplinary research into how computational techniques and models can be used enhance users' engagement with learning and knowledge creation processes. This article presents these three synergetic strands of activity, and draws conclusions about future integrative directions of research, teaching and practice.

Key words
Digital Skills, Lifelong Learning, Interactive Intelligent Systems, Knowledge Creation, Data Science, Artificial Intelligence in Education

1 Introduction

Birkbeck College is part of the University of London. It is a vibrant centre of research and teaching, and London's only specialist provider of higher education degrees through evening study. Birkbeck was founded in 1823 by Dr George Birkbeck and his supporters as the "London Mechanics' Institute", which was dedicated to the education of working people. In 1920, Birkbeck College officially became part of the University of London. Its mission continues to be a dual one of conducting excellent research across the arts, sciences and social sciences; and providing higher education through flexible courses designed to meet the needs of learners from diverse social and educational backgrounds.

Today's rapid innovations in digital technologies are transforming the possibilities and realities for learning, knowing, working and communicating. The creation, discovery and sharing of knowledge is undergoing a radical shift through the global-scale generation of information on the Internet, and the increasing prevalence of mobile, embedded and wearable technologies. At the Birkbeck Knowledge Lab (www.klab.bbk.ac.uk/), we conduct research into how computational techniques and models can be used to enhance users' engagement with learning and knowledge creation processes. The lab is centered in the Department of Computer Science & Information Systems at Birkbeck, which is one of the oldest academic computing departments world-wide (see www.dcs.bbk.ac.uk/about/our-history/) and is now part of Birkbeck's School of Business, Economics and Informatics (www.bbk.ac.uk/business/).

Research at the Birkbeck Knowledge Lab (BKL) draws on multi- and interdisciplinary perspectives and methodologies from across the Sciences, Social Sciences and Arts to investigate how digital technologies and digital information are transforming our learning, working and cultural lives. We work with educational experts and psychologists to under-

stand how people learn, and how we can design software that enhances students' learning as well as tools to support teachers in their multiple roles. We seek to understand how individuals and communities are empowered through digital technologies, how they represent and co-create knowledge, and how digital technologies can help them enhance their practice. A key research strand linking many of our activities is Artificial Intelligence – AI – and some of our work in this area is discussed here.

Section 2 describes research into the use of AI techniques to support learning and teaching, including support for lifelong learning. It gives an overview of work at the BKL on the design and development of intelligent components for interactive learning environments. Intelligent components allow learning environments to seamlessly combine explicit knowledge representation with learning and adaptation capabilities. At the same time they can handle uncertainty, which is inherent in human-machine interaction, in order to personalise the user experience. Using examples from various BKL projects, we illustrate a synergistic approach that combines data-driven design, AI and pedagogy theory to develop intelligent components for learner modelling, learning design and planning of lifelong learning.

Section 3 discusses research at the BKL on applying AI to assist the work of humanities scholars. This includes the use of machine learning techniques for automated text annotation of digital archives, exploring 3D content stored in digital archives through a holographic search interface using voice recognition, and application of knowledge representation and reasoning techniques to develop specialist knowledge bases to support humanities research.

Section 4 presents ongoing work in our department in delivering data science degree courses targeting the digital skills needs of those working in business and industry. We discuss Birkbeck's contribution to the newly established Institute of Coding (https://instituteofcoding.org/), a government initiative led by over 100 universities and employers with the aim of addressing the digital skills gap among computer science graduates. One of the goals of the Institute of Coding is to make the UK a leading hub for AI applications and practice, which aligns with much of the research and teaching expertise in our department. Section 5 gives our concluding remarks.

2 Designing interactive intelligent systems for learning and teaching

Research on interactive intelligent educational software at the BKL has led to the design and implementation of constructionist tools that provide personalisation, support and guidance to learners and teachers. Constructionist learning is founded on the principle of constructionism which argues for the pedagogical importance of building artefacts as a way of developing mental representations through construction, reflection, sharing and collaboration between the digital environment, the teacher, the learner and their peers (Papert & Harel, 1991). A key computational challenge in the design of tools that foster constructionist learning is to provide intelligent support that guides users towards productive interaction with the tool without constraining its creative potential.

BKL research has progressed along two major directions: intelligence-based tools to aid students and teachers in assimilating knowledge of a domain through iterative construction of an artefact; and intelligence-based learning analytics to assist teachers. We follow an interdisciplinary research methodology in which pedagogical theory informs the initial design of algorithms and tools; these are then iteratively evolved and enhanced through successive cycles of user-centred evaluation; concurrently, pedagogical theory and practice are transformed through the provision of our tools to education experts and practitioners (Cocea & Magoulas, 2015). Our approach to designing intelligent support for the learner goes beyond

standard approaches to user modelling in that it models users' learning as manifested by the artefacts they are constructing, so there is not a well-defined mapping between sequences of users' actions and explicit acquisition of knowledge; instead, there is an iterative process of negotiation and co-construction of knowledge, rendering the design of intelligent support for users much more challenging (Noss et al., 2012). Several of our techniques for generating feedback for the user are based on similarity matching, e. g. to compare a learning design that the user is constructing against similar existing ones (Charlton et al., 2012; Charlton & Magoulas, 2010), to compare students' construction activities against known patterns of productive and unproductive interaction (Cocea & Magoulas, 2017), and on the synergy of clustering and knowledge engineering methods for group formation in collaborative learning activities (Cocea & Magoulas, 2012; Gutierrez-Santos et al., 2017).

The research in one of these projects, the LDSE project, was motivated by the need to support lecturers and teachers in capturing their pedagogic ideas, testing them out and re-working them, building on what others have done before and sharing their results with their community. We developed the Learning Designer system (Charlton et al., 2012; Laurillard

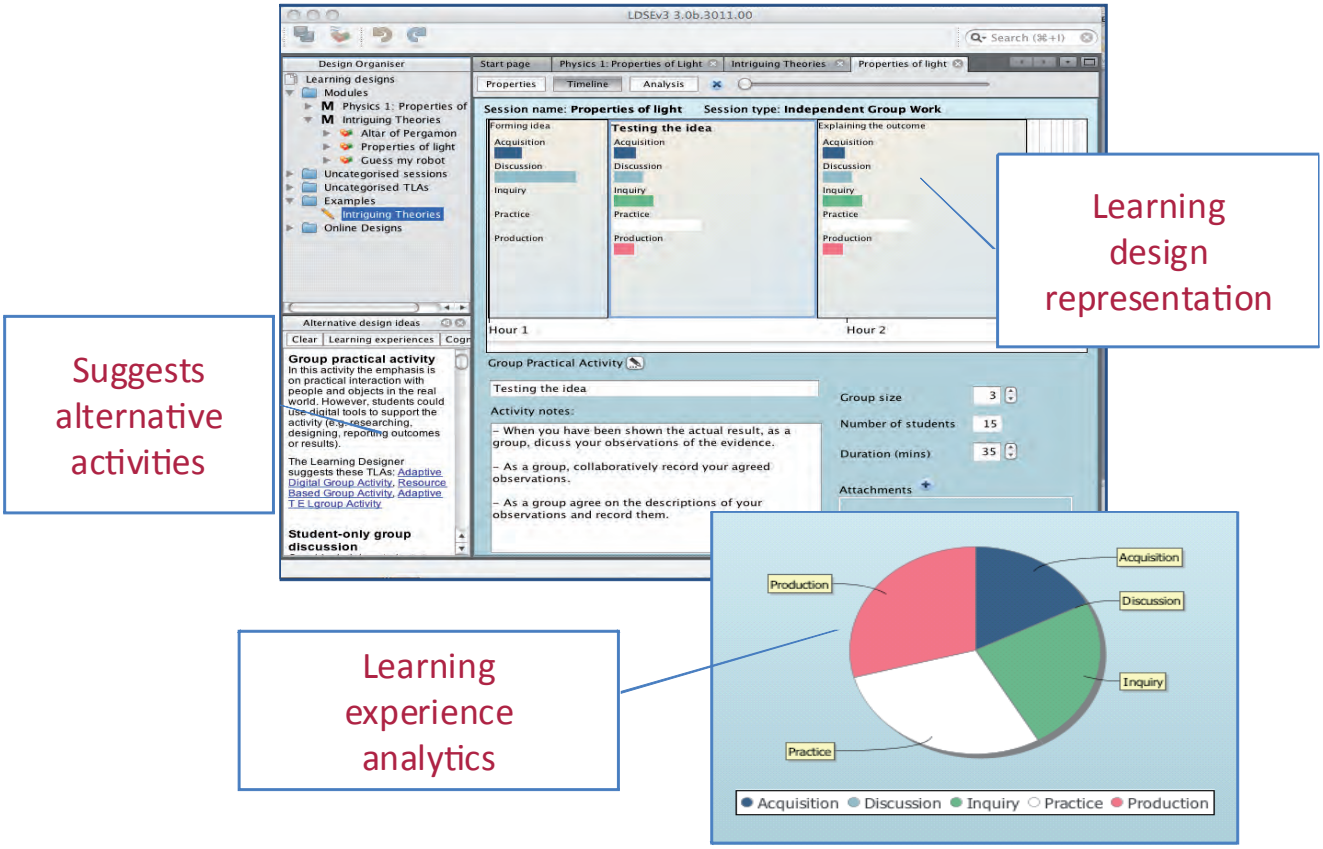


Figure 1. Prototype of the Learning Designer containing a manipulatable timeline representation of a pedagogical pattern for a lesson. The LDSE system evaluates the resulting learning experience and displays the result as pie-charts. The system also recommends relevant teaching and learning activities.

et al., 2013) that helps users to assimilate knowledge of the domain of learning design through construction, reflection, collaboration and sharing of learning design artefacts. These take the form of "pedagogic patterns" – a temporal sequence of teaching and learning activities addressing a specified learning outcome – which users can adapt to their own context. At the heart of the Learning Designer is an ontology that models core concepts of learning theory and practice with respect to which each learning design is annotated (both by the user and by the system). The system searches for existing learning designs similar to the one being worked on by the user in order to generate personalised feedback according to the user's context and the stated learning goals of their design. The system also generates analytics based on the learning design properties and annotations in order to support teachers in viewing their designs from different perspectives. A screenshot of the system is shown in Figure 1.

In another project, MiGen, the research focused on the learning and teaching of algebra, which is notoriously difficult for children to learn. We designed a constructionist environment for use in the classroom, called eXpresser (see Figure 2), that transforms the learning of algebraic concepts. Instead of working with symbols and equations, students use eXpresser to construct 2D tiling patterns and, at the same time, algebraic rules about properties of their patterns. MiGen's main intelligent component, the eGeneraliser, gathers information about students' construction activities and uses this to make inferences about students' progress in the learning task and in knowledge assimilation. This inferred information is used to generate personalised feedback for individual students during their construction in order to foster productive interaction with eXpresser. A key computational challenge is to provide real-time feedback to students without destroying the exploratory and creative potential of their interaction, and this is a major contribution of the research (Noss et al., 2012).

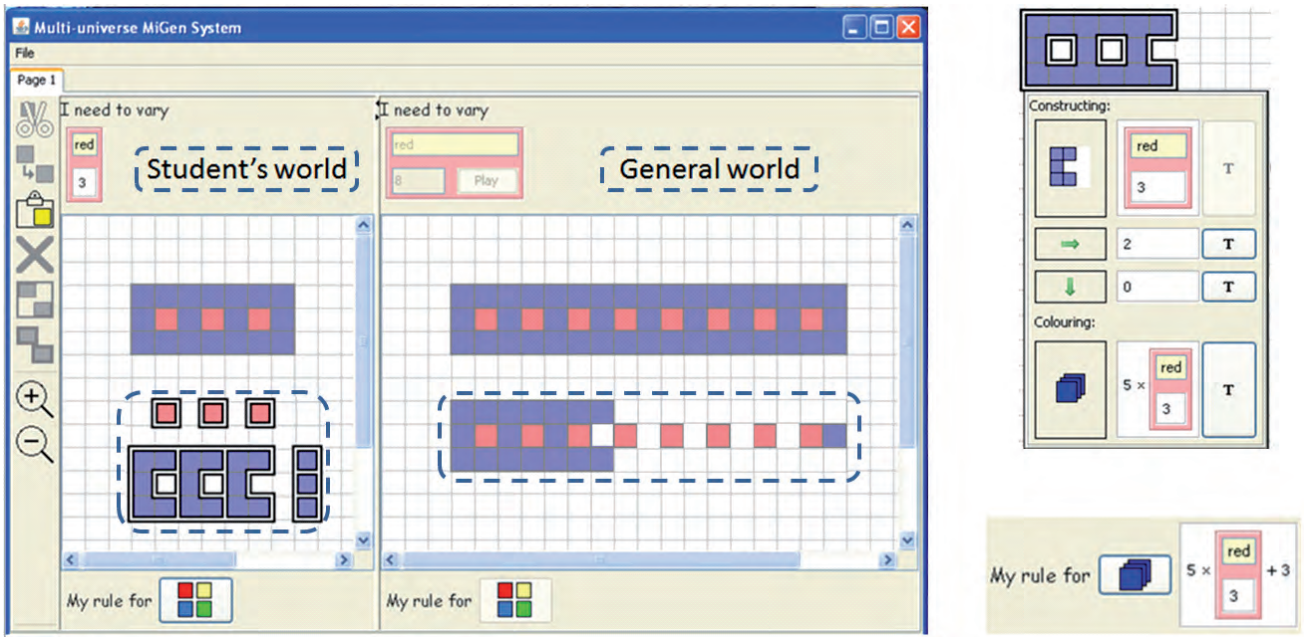


Figure 2. Prototype of the eXpresser: left – the toolbar, the student's world and the general world; top right – the property list of a pattern; bottom right – the corresponding rule. The text and constructions within the dashed lines are added for clarity; they are not part of the interface.

We also co-designed with teachers and teacher educators a suite of *Teacher Assistance Tools* to enhance the teacher's awareness of students' engagement and progress on the learning task, and to inform the teacher's own guidance to students (Gutierrez-Santos et al., 2012; Mavrikis et al., 2016; Gutierrez-Santos et al., 2016). These tools give teachers an at-a-glance overview of which students are productively engaged with the task, and who may be in difficulty and in need of the teacher's help. Teachers can also see detailed views of students' ongoing construction activities, achievement of learning goals, and occurrence of key indicators detected or inferred by the eGeneraliser. We envisage such tools also being useful beyond classroom-based learning, e. g. in distance and mobile learning settings, so as to monitor and support the progress of cohorts of online learners on open-ended learning tasks.

Turning to the context of professional development, the MyPlan project (Van Labeke et al., 2008, 2009) aimed to develop a system that supports learners' decision making when planning new learning experiences and lifelong learning. The learner iteratively constructs a public entity, a lifelong learning plan, whilst the system iteratively constructs personalised advice, guidance and information. Working in this way, MyPlan supports a more holistic approach to lifelong learners' work and learning that is based on learners constructing personal pathways, and sharing them with their peers. The system (see Figure 3) is used as a means to encourage students' reflection on their progress towards achieving specific goals, and is able to identify learning opportunities that may not otherwise have been considered. Its operation is supported by intelligent components that guide learners' focus on the development of their own knowledge structures about how

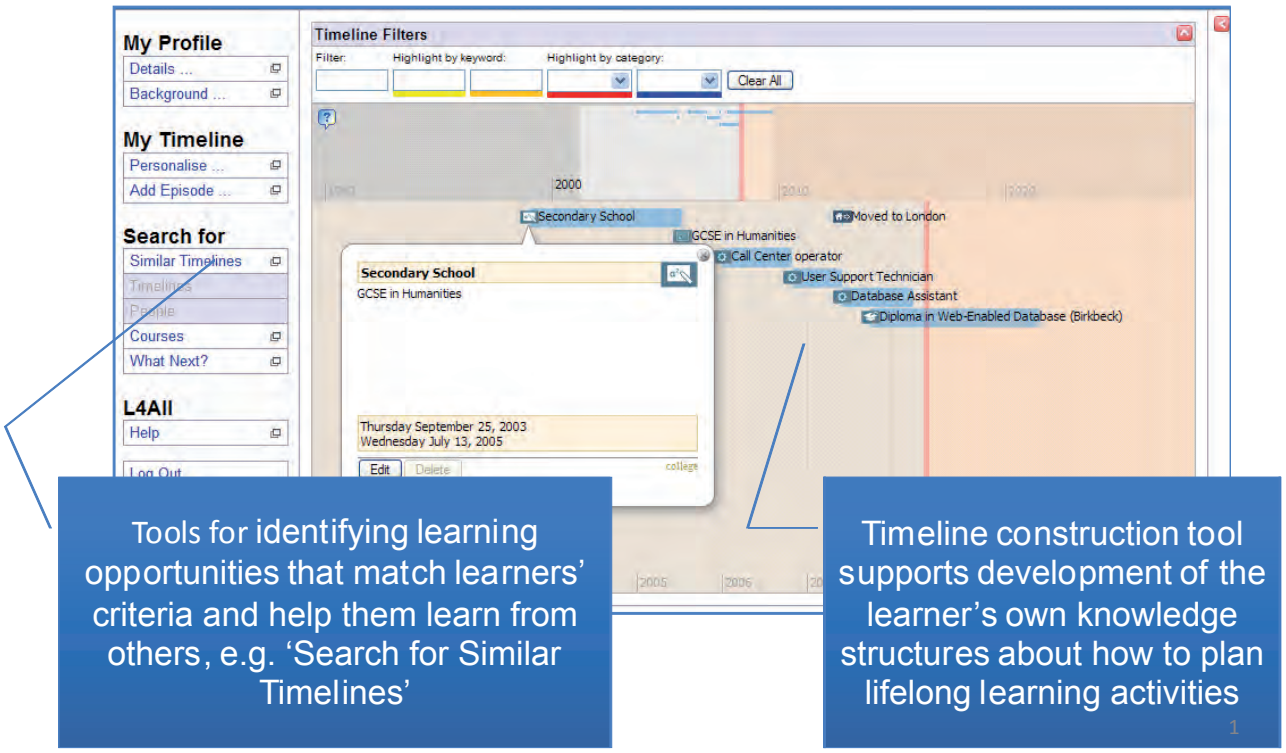


Figure 3: Prototype of the MyPlan system showing the timeline construction tool and the panel with tools for inspecting the learner model, searching other people's timelines and learning opportunities

to plan lifelong learning activities, helping learners' minds to move beyond the notion of learning as a collection of isolated knowledge events. The intelligent components use an information-rich open learner model and employ various similarity metrics and matching algorithms to underpin the operation of tools that facilitate identifying learning opportunities, which match learners' criteria, and similarities to learning pathways of other learners who have followed successful career paths.

Ongoing work is developing further the concept of constructing personalised learning paths for lifelong learners, supporting contemporary pedagogical approaches for learning across the learning continuum, from Pedagogy through Andragogy to Heutagogy (PAH continuum), where lifelong learners progress in maturity and autonomy (Karoudis & Magoulas, 2016). We follow a five-step approach to design a system that enables learners to integrate personal information held about them in different places with formal, informal and social training offerings in order to enhance their prospects for education, employment and personal development (see Figure 4). This allows exchanging distributed information held in different regions or countries but at the same time guarantees the quality (provenance and accuracy) of the exchanged learner data. A shared database – a distributed ledger – stores assets across multiple sites, geographies and institutions. It stores learning experiences in the form of Experience API (xAPI) statements (see xapi.com/overview/), which can be used to build individual learner models. The Experience API offers a means of tracking and recording learning experiences and learner activities between a client, called the learning record provider (LRP), and a server, called the learning record store (LRS). Our approach considers learner models and their parts as assets belonging to learners, and thus the release of such information to third parties needs to be regulated by smart contracts. It builds on the xAPI notion of a personal data locker (PDL), where learner data from an LRP is initially stored on the respective PDL of each learner, which regulates the subsequent release to third-party LRSs and applications. This allows constructing pathways of future learning opportunities as well as representing past episodes of work and learning, which could provide a holistic view of learners' experience of life and greater continuity between their learning and work experiences. The advantages of distributed ledger technology combined with those of the Experience API have the potential to offer adaptive learning technologies a common data layer for creating better learner models in terms of interoperability, portability, security, privacy and trust (Karoudis & Magoulas, 2018).



Figure 4: Five-step approach for constructing learning pathways across the cumulative learning continuum for digital learning ecosystems.

3 AI to support the research of humanities scholars

Another major research activity at the BKL focuses on developing search and text mining tools that can operate over digital archives containing digital text, images and 3D models. We develop tools to support researchers in locating source material for their research, and also provide analytic tools for them to explore the content of these sources. We aim for our tools to be language-agnostic, using techniques from information retrieval, machine learning and text mining. Our *Samtla* system (Search And Mining Tools for Labelling Archives – www.samtla.com) provides an infrastructure for developing tools for searching, browsing, comparing and labelling both modern and historic texts stored in digital archives and other document collections (Harris et al., 2018). The framework is composed of a character-based search engine which uses Statistical Language Models (Zhai, 2008) to rank search results, calculate similarities between texts, and in combination with machine learning approaches to provide a platform for developing conversational AI interfaces. We have pursued several strands of research from this initial infrastructure, including facilities for researchers to interrogate and compare primary source material. For instance, the *SamtlaAPI* provides a platform for the automatic labelling of text data with named entities and sentiments (Mudinas et al., 2018), which can be tailored to the genre of the text with the help of a small set of training examples provided by users. We use machine learning approaches to predict the appropriate semantic label for a word in the text, which can be used as the data for further research, or tool development e. g. faceted browsing.

Traditionally, researchers have interacted with *Samtla* through a web interface hosted in the browser. Although this interface may be of use to the general public, it is not the most engaging or interactive experience when deployed over collections comprising 3D renditions of cultural heritage artefacts. To this end, we have developed a new physical interface in the form of a holographic projector combined with a retrieval-based chatbot developed to respond to user queries relating to 3D renditions of cultural heritage artefacts (Harris et al., 2019). A chatbot is a computer application typically presented as a simple text messenger service, which has the ability to recognise natural language text input by a user and to respond along similar lines to a human participating in the conversation (Abdul-Kader and Woods, 2015). Chatbots are typically designed to focus on a narrow domain, such as providing information about one's bank balance, booking flight tickets, and resolving simple customer support queries. Holographic projectors work on the principle of *Pepper's Ghost* (Tiro et al., 2015), an illusion technique used at the theatre, concerts and on television, which involves projecting an image onto a transparent surface, such as a glass sheet, at a 45 degree angle. From the perspective of the viewer standing in front of the glass surface, the image appears face on, but the source of the projection is hidden, giving the illusion of a three dimensional object occupying the same physical space. Users interact with the projector through voice commands and 3D gestures, which provides a more intuitive interface for people to interact with 3D representations of physical objects.

When a user issues a request for information to our holographic projector, the recorded audio is converted to text using speech recognition tools and submitted as queries to the *Samtla* search engine. A text-to-speech tool reads outs the descriptions of the objects returned in the search results, from their metadata, to tell the story behind the objects. Users can also interact with the objects using hand gestures captured by a 3D gesture tracking sensor. The 3D objects can also be observed from four different angles by walking around the projector, which has the added benefit of providing multiple viewing positions simultaneously.

Our holographic projector currently uses a collection of 3D scanned artefacts held by the *British Library* and the *British Museum*. We envision that it will have applications in exhibition spaces alongside physical artefacts, as well as in museums as a replacement for items removed for research, or temporarily on loan. We are currently exploring machine learning

approaches to improve the chatbot responses. We train a neural network model on collections of sentences representing informational requests, or intent of the user. An intent can be a greeting, or a request for a specific piece of information. For instance, "Show me all Egyptian statues in your collection" or "Do you have any Egyptian artefacts?". Once trained on intents, the neural network is used to generate the most likely response to a user's utterance. One of the advantages of the neural network approach is the ability to identify intents that are similar despite slight differences in vocabulary. Our immediate aims are to develop a series of chatbots modelled on historical figures, such as Jane Austen using textual and 3D resources related to her life and work curated through the *British Library*. The adoption of a chatbot would simplify the process of developing an interface to a domain-specific collection of source material on a theme, event, or individual. This also provides the potential to extend the application of the holographic projector to other areas, including Education.

Other work at the BKL is applying Knowledge Representation and Reasoning techniques to develop specialist knowledge bases to support the work of humanities scholars. This kind of interdisciplinary project presents a number of challenges, arising from disciplinary differences between project team members and the lack of a well-defined set of software requirements at the outset of the project. The project work typically proceeds in an iterative collaborative fashion, comprising successive cycles of requirements elicitation, research, design, implementation, and testing. Two knowledge bases we have designed are illustrated in Figure 6.

The "Weaving Communities of Practice" project (Brownlow et al., 2015) aimed to research the history and practice of Andean Weaving, with the objective of informing curatorial practice and cultural heritage policy. The research team gathered data on activities, instruments, peoples, places, and techniques involved in the production of Andean textiles, relating to over 700 textile samples. A major part of the project was the modelling and representation of the knowledge of

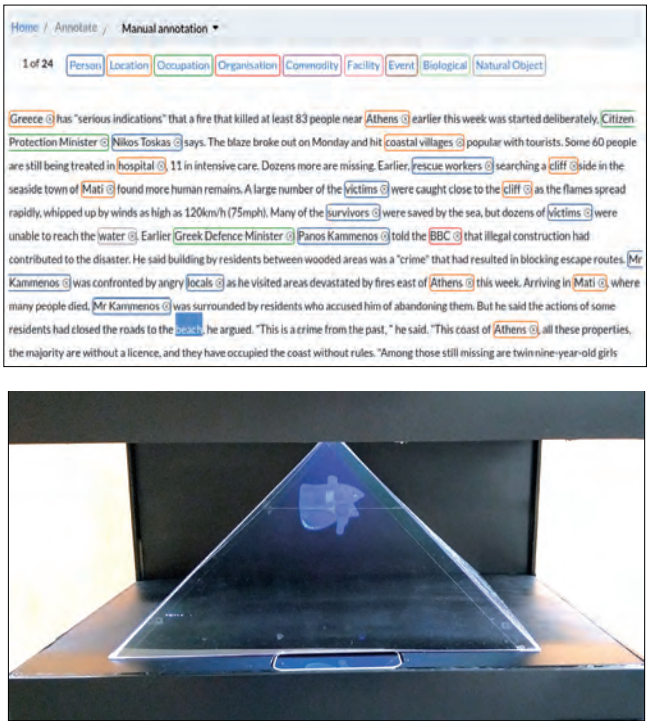


Figure 5: The SamtlAPI for the automatic labelling of documents with named entities and sentiments (top). The Samtla search and browsing holographic interface for exploring photogrammetry models of cultural heritage artefacts held at the British Library (bottom).

domain experts, and information about the textile objects themselves, within an online knowledge base (accessible at www.weavingcommunities.org/). The "Mapping Museums" project (Candlin et al., 2019) aims to provide the first evidence-based history of the development of the UK's independent museums sector and the links to wider cultural, social, and political concerns. The research team has so far gathered and integrated data on some 4000 UK museums (see www.mappingmuseums.org). A major part of the project is again the modelling and representation of knowledge relating to the museums sector within a knowledge base, combined with, in parallel, the design and development of a suite of browse, search and visualisation facilities over the knowledge base so as to support the research of the project's humanities scholars.

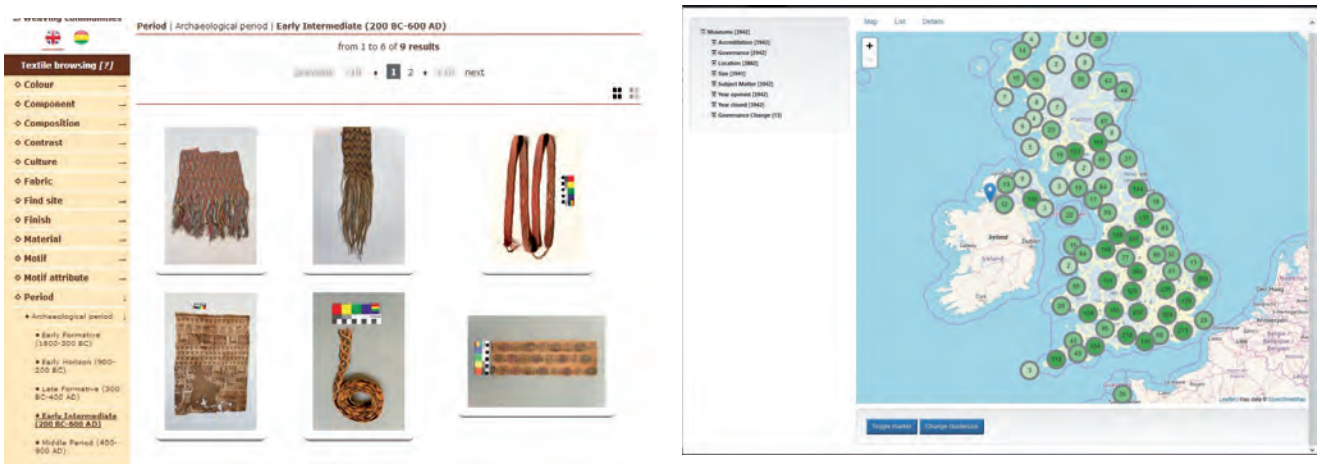


Figure 6: Weaving Communities of Practice Knowledge Base (left). Mapping Museums Knowledge Base (right).

4 Designing educational programmes in data science and AI

Over the last decade there has been a massive explosion in both the data generated and retained by companies, as well as by the general public. This is often referred to as "big data" and requires a certain set of skills to find patterns and gain insights for research or business, collectively known as "data science". Data science has applications in a wide range of areas, including business, industry, life sciences, social sciences, and the Arts. Data scientists analyse "big data" through statistical approaches, sometimes involving machine learning, to extract insights that can assist stakeholders in making more informed decisions. Data science has become one of Birkbeck's most popular subjects, which reflects the current demand in industry. Our Data Science courses are part of our contribution as a member of the Institute of Coding, a newly established national initiative led by universities and employers to address the digital skills gap among computer science graduates in areas such as AI, data analytics and cyber security.

In 2016, the UK Government commissioned a Review of Computer Science Degree Accreditation and Graduate Employability, led by Sir Nigel Shadbolt, to understand the employment situation among graduate computer scientists (Shadbolt, 2016). The report concluded with a number of recommendations, including:

- Establish which skills employers want and where graduates are working.
- Identify work experience opportunities for students, and review barriers for particular groups.
- Teach foundational knowledge of computer science.
- Include "work-ready" skills as a recognised and accredited part of degree programmes.
- Provide greater interaction opportunities between higher education providers, start-up companies, and small and medium-sized enterprises (SMEs).
- Flexible accreditation is valued by employers, students and higher education providers.

In response to the report, the UK Government proposed a national initiative to increase the employability of Comput-

er Science graduates, through a new partnership between government, universities, and industry – the Institute of Coding (IoC). The Institute's vision is to enhance the education and employability of every student to ensure that employers and individuals have access to the skills they need to thrive in the global digital economy. The IoC is backed by £40M from the UK Office for Students, with matched funding from the university and industry partners. The IoC has established five themes in which to focus partners' efforts and address the priorities highlighted in the Shadbolt report:

- Theme 1: University learners: Accreditation standards and verification, modular curriculum, industrially contextualised learning, mainstreaming data analytics.
- Theme 2: The digital workforce: Alternative delivery models, specialist and generalist provision, education training.
- Theme 3: Digitalising the professions: Digital Masters programmes, short taster courses, and postgraduate certificates.
- Theme 4: Widening participation: Creating a Pipeline, inclusive curricula, flexible delivery models, understanding barriers.
- Theme 5: Knowledge exchange hub: Observatory panel, conferences, events and media, sustainability, and educating the educators.

Birkbeck is contributing particularly to Themes 1, 3 and 4. We have developed and delivered new data science degrees targeting the digital skills needs of those working in business and industry (Theme 1). The modules offered cover a range of practical and theoretical topics including Big Data Analytics using the statistical software package R, Computer Systems, Data Science Techniques and Applications, Fundamentals of Computing, Principles of Programming, and Programming with Data. Data Science is taught at both level 6 (BSc) and level 7 (MSc) and has one of the most diverse cohorts across our programmes with 25 percent participation from female students. Our courses are research-led and students gain experience addressing real-world problems using industry datasets, which aid them in seeking employment at the end of their programme. As part of our contribution to Theme 3, we are working with the cultural heritage sector to develop short courses for those who wish to up-skill or acquire new skills in programming, data analytics and machine learning. Birkbeck is also committed to Theme 4, and is well placed to support those who are returning to employment, or who need to fit study around other commitments, such as work and family, through our flexible delivery model which delivers courses in the evenings well as during the day. We are also involved in outreach activities with schools, with the aim of increasing the number of women in computer science.

5 Concluding remarks

AI technologies are becoming increasingly prevalent in online spaces and can significantly enhance learning, research and work practices, bringing added-value to our societies and our economies. Their effective application is enabled by the availability of increasing volumes of high-value data being generated by today's digital systems. In order to make effective use of both data and AI, it is necessary to design educational programmes that address the technical and social aspects of this data-driven digital revolution so that organisations and individuals are appropriately skilled and empowered to contribute to and benefit from it. In the UK this need is being addressed by the activities of the new Institute of Coding described in Section 4. At Birkbeck we are not only engaging in data science and AI education within our undergraduate and postgraduate degrees, but also in the application of such techniques in interdisciplinary research conducted with experts from education, the arts, and the sciences; some of that work is described in Sections 2 and 3. Going forwards, we see increasing synergies and integration between research, teaching and practice in data science and AI, undertaken by partnerships involving universities, research centres, employers, schools, cultural heritage institutions and other stakeholders in the knowledge economy from across the space of public, private and voluntary organisations.

References

Abdul-Kader, S. A. & Woods, J. (2015). Survey on Chatbot Design Techniques in Speech Conversation Systems. International Journal of Advanced Computer Science and Applications (IJACSA), 6(7).

Candlin, F., Larkin, J., Ballatore. A. & Poulovassilis, A. (2019). The Missing Museums: Accreditation, surveys, and an alternative account of the UK sector. Cultural Trends (to appear).

Charlton P., Magoulas G.D. & Laurillard D. (2012). Enabling Creative Learning Design through Semantic Technologies. Technology, Pedagogy and Education Journal, 21(2), pp 231–253.

Charlton P. & Magoulas G.D. (2010). Autonomic Computing and Ontologies to Enable Context-aware Learning Design. Proceedings 22nd IEEE International Conference on Tools with Artificial Intelligence, pp. 286–291.

Cocea M. & Magoulas G. D. (2012): User behaviour-driven group formation through case-based reasoning and clustering. Expert Systems with Applications, 39(10), pp 8756–8768.

Cocea M. & Magoulas G.D. (2015). Participatory Learner Modelling Design: a Methodology for Iterative Learner Models Development. Information Sciences, 321, pp 48–70.

Cocea M. & Magoulas G.D. (2017). Design and evaluation of a case-based system for modelling exploratory learning behaviour of math generalisation. IEEE Transactions Learning Technologies, 10(4), pp 436–449.

Gutierrez-Santos, S., Geraniou, E., Pearce-Lazard, D. & Poulovassilis, A. (2012). Design of Teacher Assistance Tools in an Exploratory Learning Environment for Algebraic Generalization. IEEE Transactions in Learning Technologies, 5(4), pp 366–376.

Gutiérrez Santos, S., Capuzzi, S., Kahn, K., Karkalas, S. & Poulovassilis. A. (2016). Scalable Monitoring of Student Interaction Indicators in Exploratory Learning Environments. Proceedings 25th World-Wide-Web Conference (Companion Volume), pp 917–922.

Gutiérrez Santos, S., Mavrikis, M., Geraniou, E. & Poulovassilis. A. (2017). Similarity-Based Grouping to Support Teachers on Collaborative Activities in an Exploratory Mathematical Microworld. IEEE Transactions in Emerging Topics in Computing, 5(1), pp 56–68.

Harris, M., Levene, M., Zhang, D. & Levene, D. (2018). Finding Parallel Passages in Cultural Heritage Archives. Journal on Computing and Cultural Heritage, 11(3), pp 1–24.

Harris, M. & Levene, M. (2019). The Samtla holographic search and browsing interface for cultural heritage photogrammetry models. Collated abstracts of the 5th International Conference on Computational Social Science. July 2019.

Karoudis, K. & Magoulas, G.D. (2016). Ubiquitous Learning Architecture to Enable Learning Path Design across the Cumulative Learning Continuum. Informatics, 3 (4), 19; doi:10.3390/informatics3040019

Karoudis K. & Magoulas G.D. (2018). User Model Interoperability in Education: Sharing Learner Data Using the Experience API and Distributed Ledger Technology. In Responsible Analytics and Data Mining in Education, Badrul H. Khan, Joseph Rene Corbeil, Maria Elena Corbeil (eds.), Routledge.

Laurillard, D., Charlton, P., Craft, B., Dimakopoulos, D., Ljubojevic, D., Magoulas, G., Masterman, E., Pujadas, R., Whitley, E.A. & Whittlestone, K. (2013). A constructionist learning environment for teachers to model learning designs. Journal of Computer Assisted Learning, 29(1), pp 15–30.

Mavrikis, M., Gutiérrez Santos, S. & Poulovassilis, A. (2016). Design and evaluation of teacher assistance tools for exploratory learning environments. Proceedings 6th International Conference on Learning Analytics and Knowledge (LAK 2016), pp 168–172.

Mudinas, A., Zhang, D. & Levene, M. (2018). Bootstrap Domain-Specific Sentiment Classifiers from Unlabeled Corpora. Transactions of the Association for Computational Linguistics 6, pp 269–285.

Noss R., Poulovassilis A., Geraniou E., Gutierrez-Santos S., Hoyles C., Kahn K., Magoulas G.D. & Mavrikis M. (2012). The design of a system to support exploratory learning of algebraic generalisation. Computers and Education, 59(1), pp 63–81.

Papert, S. & Harel, I. (1991). Constructionism. Ablex Publishing.

Shadbolt, N. (2016). Computer science degree accreditation: An independent review of computer science degree accreditation and graduate employability. Department for Business, Innovation & Skills and Higher Education Funding Council for England. Available at: https://www.gov.uk/government/publications/computer-science-degree-accreditation-and-graduate-employability-shadbolt-review (retrieved 03/04/2019)

Tiro, D., Poturiović, A. & Buzadjija, N. (2015). The possibility of the hologram pyramid applying in the rapid prototyping, Proceedings 4th Mediterranean Conference on Embedded Computing (MECO), pp 25–30.

Van Labeke, N., Poulovassilis, A. & Magoulas, G.D. (2008). Using Similarity Metrics for Matching Lifelong Learners. Proceedings 9th Int. Conf. on Intelligent Tutoring Systems (ITS), pp 142–151.

Van Labeke, N., Magoulas, G.D. & Poulovassilis, A. (2009). Searching for "People Like Me" in a Lifelong Learning System. Proceedings 4th European Conference on Technology Enhanced Learning (EC-TEL), pp 106–111.

Zhai, C. (2008). Statistical Language Models for Information Retrieval - A Critical Review. Foundations and Trends in Information Retrieval. 2. 137–213.

Biographies

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Dr Martyn Harris is Manager of the Institute of Coding activities at Birkbeck and Research Fellow at the Birkbeck Knowledge Lab. His research interests are in linguistics, information retrieval, natural language processing, and machine learning. He completed his PhD in 2016 on the topic of search and text mining applied to multi-lingual and historic document collections stored in digital archives. Before that, his field of interest was in linguistics in which he completed an MRes in Applied Linguistics at Birkbeck, focusing on the development of corpus linguistic approaches for the decipherment of the Rongorongo Easter Island writing system (2010), and prior to that a BA in Japanese and Linguistics at the School of African and Oriental Studies, University of London (2006).

Mark Levene is Professor of Computer Science, Head of DCSIS, and the Institute of Coding Lead for Birkbeck. His main research interests include search engine technology, data mining, data science, natural language processing, and human dynamics/presence analytics. He has published his work widely in both journals and conferences and has written and co-edited books on relational databases, web dynamics, and most recently an Introduction to Search Engines and Web Navigation.

COLLABORATIONS BETWEEN HUMAN INTELLIGENCE AND ARTIFICIAL INTELLIGENCE: DIGITAL TRANSFORMATION IN TAIWAN

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Abstract

When Artificial Intelligence and robotic automation triggered the fifth wave of technology revolution in manufacturing sectors some time ago, the demand for digital transformation grew stronger. This paper illustrates this transformation by exploring recent studies of future human work evolution in new patterns. It also discusses the great potential for empowering human workers with human-machine collaboration by combining human intelligence (HI) with Artificial Intelligence (AI) (HI+AI), which sets out to transform work patterns instead of replacing future jobs outright. This paper begins with a review of studies on the glide path of HI+AI human-machine collaborative empowerment as well as the development and application of future intelligent technologies. It is then followed by an introduction to the concept of digital twins, one of the top ten strategic technologies since 2017. A detailed description of a project in which the introduction of a new conceptual framework of five different types of digital twins is given. Two use cases are provided detailing how this conceptual framework and digital twins solutions are integrated for selected industries, such as manufacturing and farming. Finally, proposed future use case studies are presented.

Key words

Artificial Intelligence, Digital Transformation, Digital Twins, Future of Work, Human Intelligence, Human-Machine Collaboration

1 Current trend of HI+AI human-machine empowerment

Research on the future work pattern of artificial intelligence

Rapid progress in science and technologies such as the Internet of Things (IoT), big data, robotics, and Artificial Intelligence (AI) gives rise to an inevitable transformation in human work patterns and the required skills for the job. Brown et al. (2018) pointed out in their research of future workforce that digital technology and Artificial Intelligence are changing the work environment of the future, and proposed four possible scenario predictions after the introduction of AI into the future work pattern with a view to the 2030 job market. Schwab (2017) also stated in his book, The fourth industrial revolution, that the era of "4IR" has arrived and that mankind has begun the transformation from the third industrial revolution in 1960, which made use of electronic and information technology (Computing) for automated production, to the Fourth Industrial Revolution, in which the digital transformation driven by the new technology integration (entity, digital data, and biology; cognification) will change everything. Developments and applications of AI as well as collaborations between humans and robots will lead to new partnerships (Jennings, 2018). Future human work patterns likely face the following transformations (Makridakis, 2017; Manyika & Sneader, 2018): (1) repetitive tasks will be gradually replaced by AI in which jobs will come with the required ability of HI+AI collaboration and cooperation; (2) the pattern of future work will shift from permanent placement to project-oriented HI+AI collaboration; (3) changes in workers' compensation will progressively shift from the present single fixed-pay model to a multi-source payment system due to the project-oriented nature and associated expertise requirements; (4) the competition of talent acquisitions will intensify with international acquisitions competing with regional

needs, which leads to increasing mobility of talent pools; and (5) the focus of commerce will gradually shift from B2C to C2B and the barrier between the production end and the client end will disappear, so that a new HI+AI service mode for achieving a customized bridge of balance between demand and supply can be realized.

Research on HI+AI human-machine collaborative task empowerment

In the work of Nowak et al (2018), strengths of AI lie in logic, digital information, goal setting and providing direction. Artificial Intelligence excels in a rational way, while mathematical and scientific derivation perform objective and rational analysis, leading to a perfect execution of instructions. Humans are good at intuition, analogous evaluation, creativity, sensibility, art and poetry. It was pointed out that man-machine inter-collaboration can be enabled by supplementing human wisdom with AI. The era of AI progress is not the era of robots, but the era of human-machine collaboration. Human intelligence (HI) provides innovative solutions, while Artificial Intelligence (AI) performs operations, where the future world will be shaped by both working together. However, at present, most of the research focuses only on replacing human workforce with machines. Few authors focus on the research of human-machine collaboration in which human capabilities are boosted by utilizing the machine. This leads to a need to systematize the best form of interactive and yet collaborative task empowerment between machines and humans.

Future intelligent technology development and application research

Driven by AI and the IoT technology, many new concepts and possibilities for intelligent services have found their way into the human world. Various Artificial-Intelligence-of-Things (AIoT) devices as well as software- and hardware-integrated solutions, such as drone delivery, unmanned taxis, self-service store, self-service bank, self-service hotel, voice-pay, face-scanning pay, intelligent dining tables, interactive advertising boards, intelligent shelves, emotional social robots, commercial navigation robots, delivery robots, warehouse-logistics robots, inspection robots, etc. are spreading all over the world (Russell, Moskowitz, & Raglin, 2017). At the beginning of 2017, Amazon rolled out a new intelligent unmanned store – "Amazon Go" that requires no service. The transformation of retail industry delivering the convenience of grab-and-go has brought about an industrial evolution which changes and impacts the social work pattern of the entire retail industry (Polacco & Backes, 2018).

2 Digital twins: One of the new emerging intelligent technologies

As AI-related technologies gradually matured in 2017, the know-how in developing innovative AI-based business models and the know-how in integrating machine learning into future work patterns resulted in significant competitive advantages for many technology companies. Among various intelligent technologies, "Digital Twin" has garnered new attention as it ascended from No.5 to No.4 in the list of Gartner Top 10 Strategic Technology Trends in 2019. It is listed at the top of the hype cycle for emerging technologies in 2018 (Fig. 1). According to Gartner, a strategic technology usually possesses significant disruptive potentials which shall set the stage for innovations over the next five years. Furthermore, it is estimated that there will be more than 20 billion networked sensors and systems by 2020. Thus digital twins could exist in billions of things. It is also predicted that in the next three to five years, digital twins of IoTs will be used by half of large industrial companies, resulting in a gain of 10 percent improvement in efficiency.

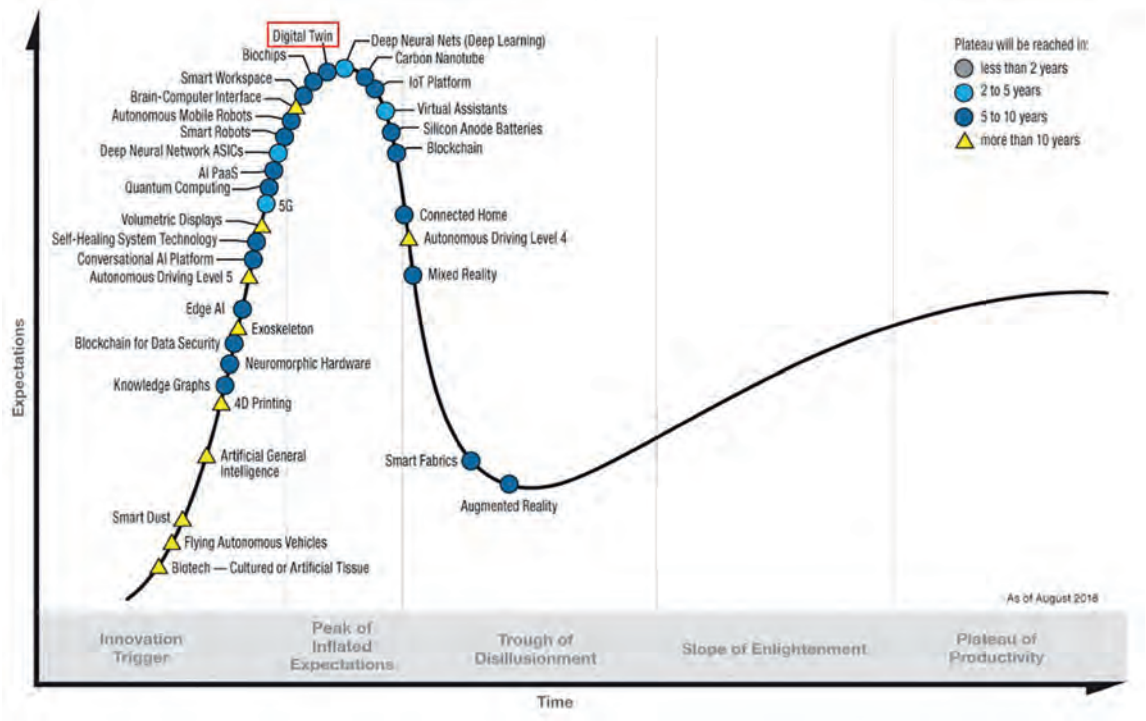


Figure 1: Digital Twin is listed in Gartner Hype Cycle for Emerging Technologies, 2018

Digital Twin is a dynamic representation in the digital world of a physical object which enables virtual models in the digital world to interpret, interact, and integrate the status of these physical objects, helped by continuous real-time data transmissions using sensors. Through the process of analyses, monitoring, control, simulation, prediction and recommendation, digital twins offer a powerful way to create and enhance economic values of the physical assets, processes and services. In our projects described below, the concept of digital twin was extended into a new conceptual framework encompassing Device Twin, Human Twin, Process Twin, Demand Twin and System Twin as illustrated in Figure 2.

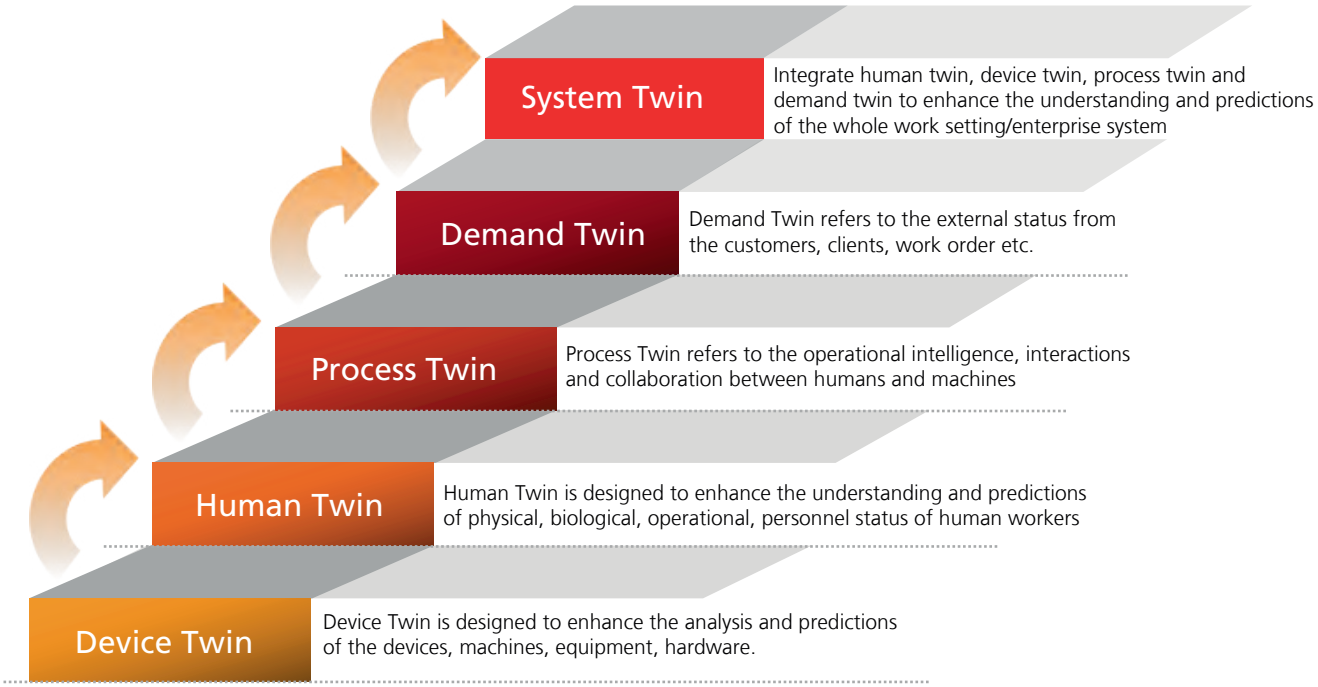


Figure 2: Our conceptual framework of digital twins

3 Use case in manufacturing: Digital twin-enabled intelligent mission center

The industrial personal computer (IPC) industry in Taiwan grew by 16.6 percent year-on-year to US$6.09 billion in 2017 and increased further to US$6.83 billion in 2018. The growth came mainly from a continuous demand for IoTs, primarily for smart factories, smart retail, smart transportation and intelligent robotics. Industrial PCs have been predominantly and widely used in the area of industrial applications, followed by embedded systems, and then by industrial automations. The IPC industry in Taiwan stands out particularly due to mass customization and rapid response to market. As the life cycle of electronic products becomes increasingly shorter, the IPC industry is confronted with extreme challenges in terms of monitoring, controlling and managing game plans to meet such a new demand from the market.

The sheer size of data communication from IoTs, the maturity of the wafer technology and the continuous improvement in software algorithms have advanced AI-related applications into a new era of smart automation and human-machine collaboration. Distributed AI (DAI) enables machines to continuously learn and to be optimized for efficient reading and testing. They are becoming more efficient, more accurate, and more flexible than conventional means. It is worth noting that DAI technology realizes digital twin benefits owing to its advantages in terms of autonomy and intelligence. Digital twin technology can also be implemented in IPC-based DAI hardware comprising CPUs, accelerators/specialized hardware, GPU/FPGAs and neuromorphic chips. Such DAI-based IoT hardware solutions use powerful industrial-grade electronic design to represent various types of digital twins to enable uninterrupted system operations under any type of environment. Their computing power provides high-speed calculations,

analyses, optimizations, and learning capabilities. Shop floor control systems are integrated into larger enterprise systems for governing various business processes and various aspects of business operations. IPCs are comprehensively deployed in the shop floor system to perform functions such as order management, inventory management, procurement, scheduling, material handling, quality inspection, robot control, machining and assembly, activity-based costing, energy management, facility maintenance and performance monitoring. The incorporation of IPCs helps firms to maintain a bird's-eye view of factory operations. Contemporary shop-floor control technology has shortcomings due to its complexity and inflexibility, while scalability and intelligence also present as two obstacles to be overcome. Digital twin technology will be a potential solution to these challenges because it facilitates interactions between the physical and the cyber world, as demanded by Industry 4.0, particularly for shop floor control systems. In light of this need, the Institute for Information Industry (III) and the National Taiwan University of Science and Technology (NTUST) collaborated with industry partners to develop the "Digital Twin-Enabled Intelligent Mission Center". In addition to traditional intelligent enterprise data collection, this intelligent mission center comes with functions of AI, machine learning and simulation, etc. The massive series of message transmissions calls for a backend system with a dynamic aggregation management system for its background operations, aggregating information from Human Twins, Device Twins, Process Twins and System Twins as illustrated in Figure 3.

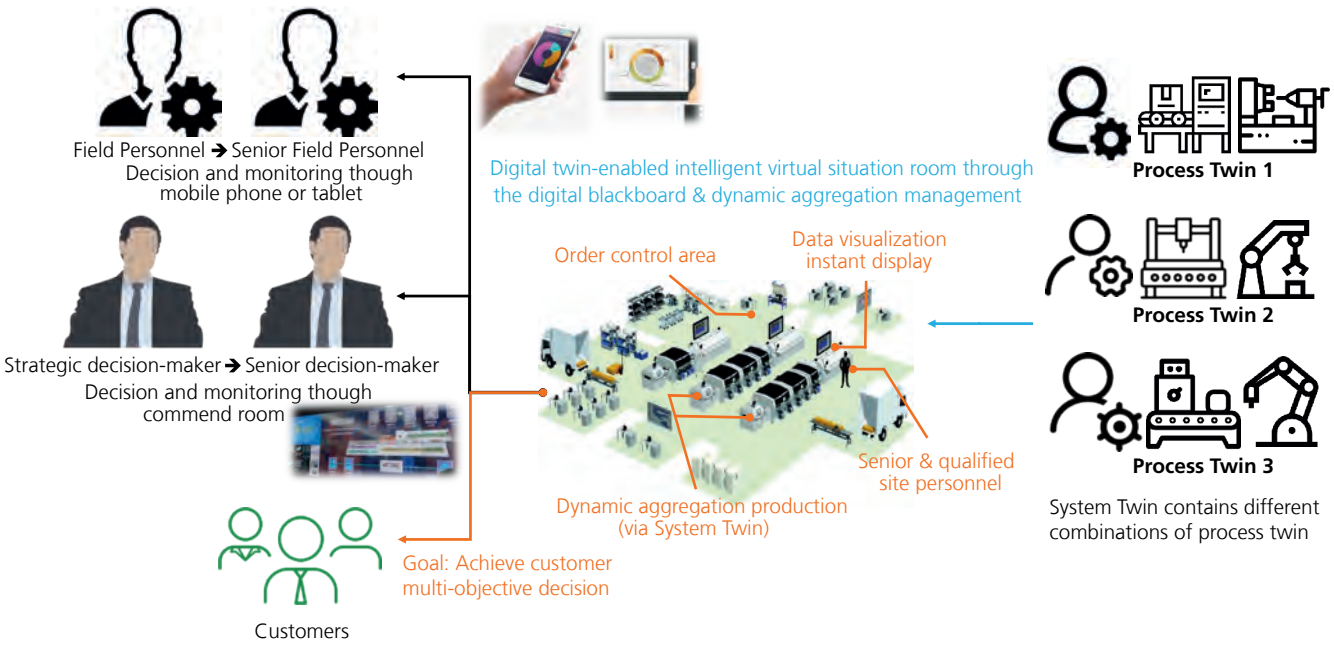


Figure 3: Digital Twin-Enabled Intelligent Mission Center by III & NTUST

For example, in the shop floor control scenario, human workers perform three crucial tasks: (1) training machines to perform tasks; (2) explaining the outcomes of those tasks, especially when the results are controversial; and (3) sustaining a responsible use of machines. Smart machines help humans expand their abilities in three ways – (1) by amplifing human cognitive strengths; (2) by interacting with customers and employees to re-optimize human workers for higher-level tasks; and (3) by embodying human skills to extend our physical capabilities. As a result of the human-machine collaboration, five aspects relelating to shop floor control requirements are improved and/or implemented: flexibility, speed, scale, decision making and personalization.

4 Use case in digital twin solutions for agriculture and aquaculture

In Taiwan's agriculture and aquaculture industry, production usually comes from local and regional farmers. The impact of an aging population and declining interest of younger generations in farming have rapidly changed the farming labor structure. There is an urgent need to sustain expert farming knowledge and to implement a workforce transformation. Therefore in order to digitally and systematically aggregate agriculture and aquaculture experience/knowledge of farmers and apply intelligent technologies to assist digital transformation, a comprehensive solution with a digital twin utilizing the concept of "AI collaborating with HI" to extract sensor data and to learn decision-making processes of experienced farmers in agriculture and aquaculture was implemented as shown in Figure 4.

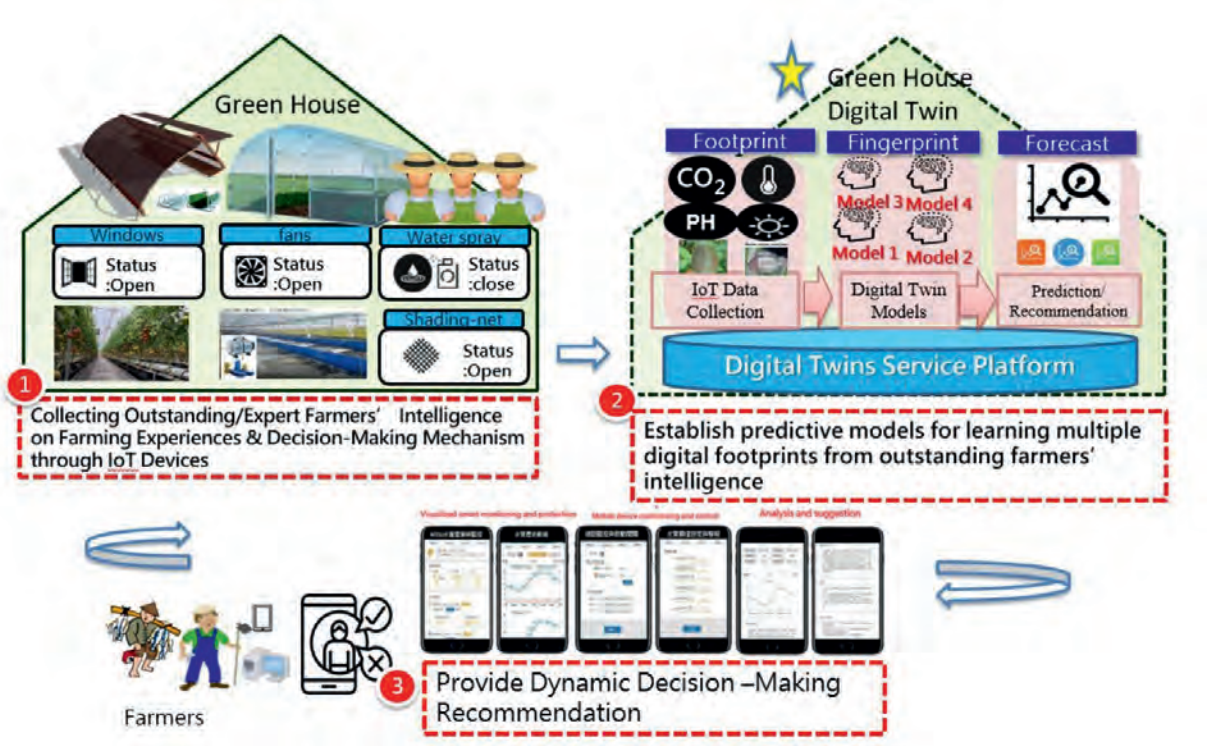


Figure 4: Digital Twin solutions for smart agriculture and aquaculture by III

The digital twin solution for smart farming consists of 3F functions: Footprint, Fingerprint and Forecast as illustrated in Figure 5.

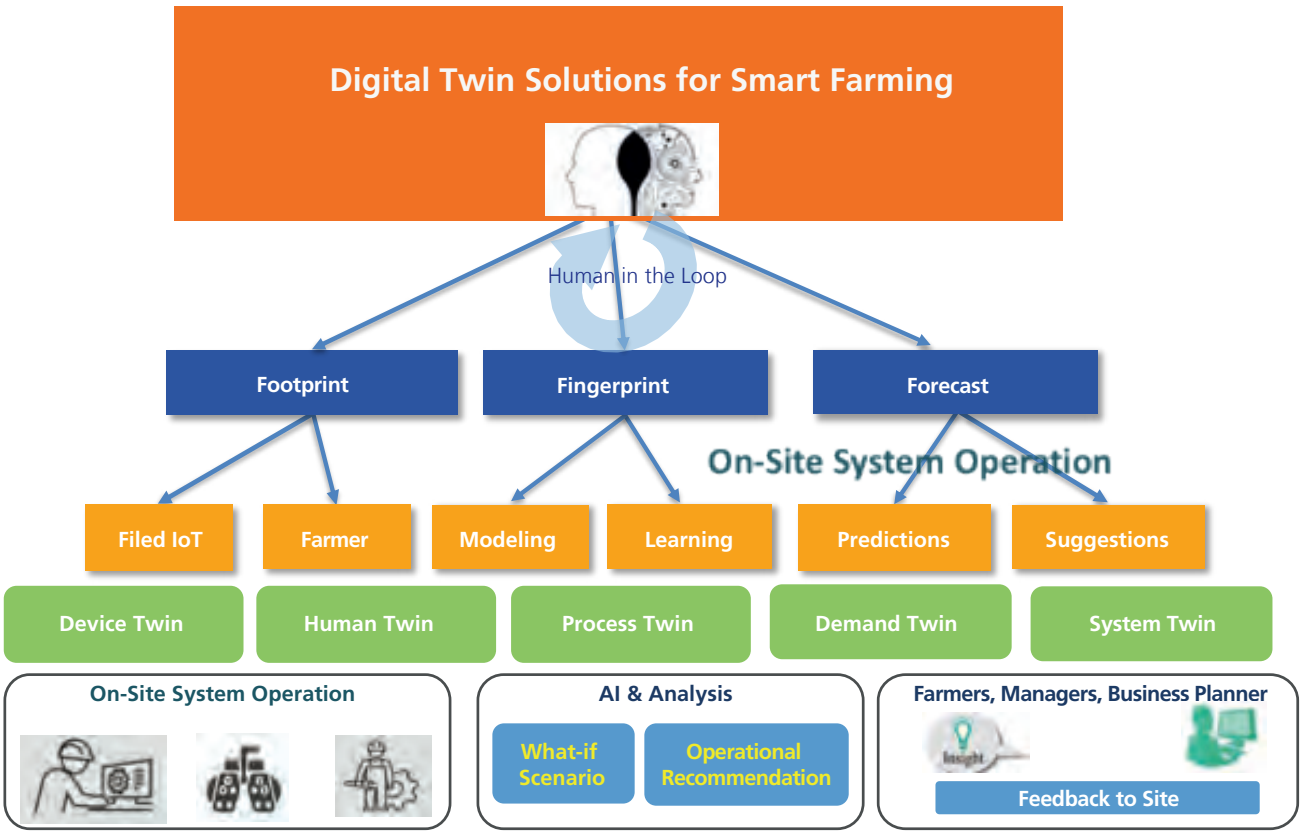


Figure 5: Digital twin solutions for smart farming

Firstly, "footprint" refers to data collection from sensors, machines, actuators and from the workers' operational behaviors/decisions. In the example of smart farming, the footprint refers to the IoT data from the greenhouse and the operational process data from expert farmers. Secondly, "fingerprint" refers to building what-if analyses and predictive models from the aforementioned footprints. In the case of farming, fingerprints include modeling and learning varying digital footprints from the greenhouse and farmers. Finally, "forecast" refers to adaptive decision-making logic by matching real time sensor data and other fingerprints as mentioned above. In the example of farming, forecast will provide on-site dynamic real-time operational suggestions for farm managers and workers based on expert farmers' fingerprint models.

5 Future research directions and suggestions

With the rapid development of information and communication technology (ICT), intelligent technologies will be applied in transportation, housing, retail, medicine and other fields in the future, touching all aspects of human life and how humans work. While it is important to develop AI in order to partially or completely eliminate labor costs, it is crucial to develop AI+HI human-machine collaboration models to cope with the ever-changing challenges of work in future and at the same time to meet the human challenge of how to design future work in a socially acceptable manner.

For example, in the shop floor control scenario, human workers continue to play a key role as the aforementioned 3F functions continue to remain deeply associated with humans. The present study places great emphasis on human-centric AI, digital twins and AIoT applications for digital transformation in empowering human workers for manufacturing, agriculture and aquaculture. Further use case studies will be needed in various other industries to focus on the collaboration framework and the application of HI+AI human-machine empowerment in order to deliver high values, innovative services and, in particular, socially sustainable business models.

6 Acknowledgements

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References

Brown, J., Gosling, T., Sethi, B., Sheppard, B., Stubbings, C., Sviokla, J., Fisher, L. (2018). Workforce of the Future: The Competing Forces Shaping 2030. Retrieved from USA: https://www.pwc.com/gx/en/services/peopleorganisation/publications/workforce-of-the-future.html.

Duan, F., Tan, J. T. C., Tong, J. G., Kato, R., & Arai, T. (2012). Application of the assembly skill transfer system in an actual cellular manufacturing system. IEEE transactions on automation science and engineering, 9(1), 31–41.

Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. International Journal of Production Economics, 210, 15–26.

Harayama, Y. (2016). Video Report: GDP of 600 Trillion yen: STI Policies for Society 5.0 Retrieved from https://fpcj.jp/en/worldnews-en/briefings-en/p=44658/

Jennings, N. (2018). Human-Artificial Intelligence Partnerships. Paper presented at the Proceedings of the 6th International Conference on Human-Agent Interaction, Southampton, United Kingdom.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. Nature, 521(7553), 436.

Makridakis, S. (2017). The forthcoming Artificial Intelligence (AI) revolution: Its impact on society and firms. Futures, 90, 46–60. doi:https://doi.org/10.1016/j.futures.2017.03.006

Manyika, J., & Sneader, K. (2018). AI, automation, and the future of work: Ten things to solve for. Retrieved from https://www.mckinsey.com/featured-insights/future-of-work/ai-automation-and-the-future-of-work-ten-things-to-solve-for

Nowak, A., Lukowicz, P., & Horodecki, P. (2018). Assessing Artificial Intelligence for humanity. IEEE Technology and Society Magazine, 26–34.

Polacco, A., & Backes, K. (2018). The amazon go concept: Implications, applications, and sustainability. Journal of Business & Management, 24(1).

Russell, S., Moskowitz, I. S., & Raglin, A. (2017). Human Information Interaction, Artificial Intelligence, and Errors. In W. F. Lawless, R. Mittu, D. Sofge, & S. Russell (Eds.), Autonomy and Artificial Intelligence: A Threat or Savior? (71–101). Cham: Springer International Publishing.

Schwab, K. (2017). The Fourth Industrial Revolution (1 ed.). London, United Kingdom: Penguin Books Ltd.

Topol, E. J. (2019). High-performance medicine: the convergence of human and Artificial Intelligence. Nature Medicine, 25(1), 44–56. doi:10.1038/s41591-018-0300-7

Vasconez, J. P., Kantor, G. A., & Cheein, F. A. A. (2019). Human – robot interaction in agriculture: A survey and current challenges. Biosystems Engineering, 179, 35–48.

Wang, P., Liu, H., Wang, L., & Gao, R. X. (2018). Deep learning-based human motion recognition for predictive context-aware human-robot collaboration. CIRP annals, 67(1), 17–20.

Yao, G., Lei, T., & Zhong, J. (2019). A review of Convolutional-Neural-Network-based action recognition. Pattern Recognition Letters, 118, 14–22.

Zhao, Z. Q., Zheng, P., Xu, S. T., & Wu, X. (2019). Object detection with deep learning: A review. IEEE transactions on neural networks and learning systems.

Biographies

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COLLABORATIONS BETWEEN HUMAN INTELLIGENCE AND ARTIFICIAL INTELLIGENCE: DIGITAL TRANSFORMATION IN TAIWAN

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3

SKILLS AND COMPETENCIES

MANAGING WORKFORCE DISRUPTION, UPSKILLING AND HYBRID TEAMS IN THE AI-DRIVEN FUTURE OF WORK

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Abstract

This paper posits that AI-driven changes in the future of work will create significant management challenges over the next decade. It focuses on three developments that will require re-thinking of today's workforce management strategies, namely:

- *Disruptive changes in the composition of the workforce in the majority of global organizations*
- *Dramatically accelerating need for upskilling, retraining, and multiskilling strategies as position requirements and workforce composition shift in tandem with the pace of AI adoption*
- *Emergence of hybrid teams in which full- and part-time employees work directly with robots and other types of AI-enabled contributors as well as with remote, freelance, and other categories of human workers*

The paper concludes with a brief discussion of innovative organizational approaches to these challenges and the need for top level executives and corporate directors to define their company's vision and values for managing the AI-driven future of work.

Key words
Managing AI Impacts, Upskilling, Workforce Disruption, Hybrid Teams, Human-Robotic Interfaces, Cross-Sector Collaboration, Robotic Process Automation (RPA)

The past fifty years provide ample evidence that widespread adoption of digital technology, like earlier analog technologies, drives the transformation of industries, enterprises, employment structures, and even the nature of work. This transformational impact on organizations and individual lives is expected to accelerate during the next decade. Adoption of AI-based technologies, for example, has given rise to predictions of industry disruption (Schwab, 2017), economic upheaval (Baldwin, 2019) and massive displacement of human employees by robots (West, 2018). Analysts differ about the longer-term impact of AI on the workforce and for society as a whole. The more optimistic predict that advanced AI, robotics and related technologies will, on balance, create even more jobs than they eliminate, freeing workers from repetitive tasks to focus on problem-solving (Potieven, 2018).

Among a plethora of predictions about the future of work and the digital technologies that will drive transformation, there are relatively few studies focused on the parallel and arguably inevitable disruption of the organizational structure and management practices of today's global enterprises. This paper posits that AI-driven changes in the future of work will create novel management challenges over the next decade. It focuses on three developments that will require significant rethinking of today's workforce management strategies. These are:

- Disruptive changes in the composition of the workforce in the majority of global organizations
- Dramatically accelerating need for upskilling, retraining, and multiskilling strategies as position requirements and workforce composition shift in tandem with the pace of AI adoption
- Emergence of a new form of hybrid teams in which full- and part-time employees work directly with robots and other types of AI-enabled contributors as well as with remote, freelance, and other categories of human workers

It may be argued that management best practices have long encompassed strategies for managing rapid technical and organizational change. Why are these best practices insufficient for the challenges presented by the AI-driven workforce disruption? One reason is that this disruption is happening simultaneously with global demographic shifts, with keen competition for digitally skilled talent, and escalating expectations among the most sought-after talent for engaging, purposeful work (Cronin and Dearing, 2019). A second reason is the strong interconnection between the emergence of new types of hybrid teams and an accelerated shift in the need for reskilling at multiple levels of the workforce. In combination, these developments require innovative strategies that must be applied across the organization. However, the majority of organizations have not yet developed a consistent strategy for managing the most salient impacts of the workforce and AI-driven changes that are already underway.

Organizations that do not effectively manage these factors will be seriously disadvantaged in motivating their remaining workforce and in attracting new talent, risking a downward spiral in productivity and competitiveness.

1 AI Impacts on the enterprise and the workforce

There is broad consensus that by 2030, business adoption of AI will transform hundreds of millions of today's jobs (Manyika, 2017). However, there is far less agreement about whether an AI-driven "fourth industrial revolution" will create enough new jobs by 2030 to replace those that are eliminated, as has happened in earlier waves of technology disruption (Schwab, 2018). Predictions of long-term impact are complicated by the fact that AI as a technical and business transformation driver is still in a very early stage of enterprise adoption.

Nonetheless, from chatbots for customer service to industrial robots doing smarter, more efficient heavy lifting in warehouses, to Robotic Process Automation (RPA) in financial, insurance, and legal services, AI implementation is accelerating. Forrester Research estimates that in 2019 over 10 percent of U.S. jobs will be eliminated due to RPA and AI adoption. As corporate decision-makers weigh the costs and benefits of implementing AI, the most predictable and measurable ROI from adoption comes from replacing human workers with intelligent software and hardware (Wiggers, 2018). AI's promise of increasing productivity while significantly reducing employee-related costs is compelling for managers who are evaluated based on the profitability and market valuation of their companies. AI adoption strategies in Asia are notably focused on the ROI of workforce replacement. A 2019 New York Times article cites a senior Foxconn executive as saying that Foxconn plans to replace 80 percent of its workers with robots within ten years. The same article quotes Richard Liu, JD.com founder stating, "I hope my company would be 100 percent automation someday." (Roose 2019).

A closer look at e-commerce and digital healthcare in the United States provides contrasting scenarios for the pace of adoption and the likely impact of AI on the U.S. workforce by 2030. As of 2018, global e-commerce giants such as Amazon were reported to be creating more new positions the jobs lost to closing of retail stores (Vandevelde, 2017). In total, e-commerce companies have added millions of entry and mid- level jobs in logistics, warehouses, delivery and customer service along with highly skilled technical positions. Looking ahead to 2030, however, today's e-commerce job gains at the entry level are threatened by increased reliance on robotics and AI, from machine-only warehouses to driverless delivery vehicles. In the next decade, the preponderance of new positions in e-commerce will require digital skills mastery.

Healthcare presents a somewhat more positive workforce growth scenario through 2030, with high demand for healthcare services at all skill levels to cope with a rapidly aging population. In the U.S., the replacement of health care aides and more highly trained medical clinicians with AI-enabled carebots and the application of AI to medical diagnosis and treat-

ment is still nascent. Ethical, social, and economic concerns are likely to slow carebot adoption in U.S. healthcare through 2030 and possibly beyond (Lin, 2017). In contrast, China and Japan have announced high priority government and private sector collaborations to accelerate the adoption of AI-based health care, especially for elders. (Hurst, 2018)

Current data shows that in parallel with AI-driven employment reductions, another major change in the workforce is well underway, especially among younger workers. According to a report by UpWork and the Freelancers Unions, about 57 million workers, or 36 percent of the U.S. workforce, were freelancers in 2018, with almost half of those under 35 describing themselves as freelancers (UpWork, 2018). By 2027 the U.S. freelance workforce is expected to number about 86.5 million U.S. freelancers, compared to only 83 million workers with traditional employment. Supporting the UpWork projections, a 2017 McKinsey study of the U.S. and European workforce reports that about 30 percent of workers currently earn part or most of their income through independent work. (Manyika, 2017)

In the short term, the rapid growth of a highly skilled global pool of freelance and contract workers has a positive impact on reducing the cost of talent acquisition. Companies that cut back on full time employees as part of implementing digital technologies can hire temp workers with skills as needed. As discussed in the next section, this approach is preferred by many companies with managers being less willing to invest in extensive retraining of current workers. However, reliance on temporary workers, especially when accompanied by elimination of permanent positions, has its own risks. Managers and directors must consider the impact of workforce reductions on public perceptions of corporate purpose and brand value. Corporations with a reputation for treating current employees badly will also be hard pressed to attract the highly skilled workforce and management talent essential to long-term growth and competitiveness.

2 Accelerating need for upskilling and retraining

RPA vendors and enterprise early adopters emphasize that AI adoption will also benefit current employees by freeing up human resources for higher level work. Optimistic predictions about using AI to create more skilled and rewarding positions imply that companies will make a major investment in retraining their current workforce to fill those positions. The World Economic Forum's (WEF) **The Future of Jobs Report 2018** discusses a growing "reskilling imperative," noting that "By 2022, no less than 54 % of all employees will require significant re- and upskilling." (Centre for the New Economy and Society 2018)

Strikingly, however, the companies surveyed for this WEF report do not regard retraining and upskilling as their leading strategy for addressing skills gaps created by AI and other digital technologies. By 2022, 84 percent of survey respondents plan to hire new permanent staff with skills relevant to the new technologies. More than 80 percent will seek also to automate some work tasks completely, avoiding the need to hire or to retrain. At 72 percent, strategies for retraining existing employees are almost equal to expecting existing employees to pick up skills on the job (65 percent), outsourcing to contractors (64 percent), and hiring new temporary staff with relevant skills (61 percent). Most troubling for lower-skilled employees, only 33 percent of respondents have any plans to prioritize at-risk employees for upskilling. Extrapolating these responses to the future job prospects of displaced workers makes optimistic job enhancement and corporate-led retraining scenarios seem unlikely.

If corporations are not stepping up to the reskilling imperative called out by the World Economic Forum, where will the momentum for retraining come from? Two alternative options are that individuals will take primary responsibility for retraining in hopes of obtaining a new position or promotion, and that expanded retraining programs will be provided by the public sector.

Increasingly, individual workers are assuming the risk and cost of upskilling in their pursuit of career advancement or at least job security. There are, however, significant disadvantages to relying on individual initiative in both personal and socioeconomic terms. In the U.S., the cost of higher education has already led to massive student debt, making further spending on retraining a challenge for most individuals. The current student loan burden (spread over 44 million U.S. borrowers) has reached the $1.5 trillion mark (Friedman, 2018). Despite this, there is strong demand for private sector training programs such as coding classes and boot camps that are focused on specific digital skills. In the UpWork report on Freelancing, 70 percent of freelance workers and 49 percent of traditional employees had completed some form of digital skills training in the past 6 months.

The disadvantage of putting the burden for retraining on individuals goes beyond the cost of repeated cycles of training and upskilling. Individuals selecting training programs do not have a clear window into the immediate or near-term skills being prioritized in corporate recruitment and hiring. This lack of connection between corporate skill demand and the skills offered in third-party training programs is especially stark when individuals undertake such training separately from any connection to relevant job prospects. Even when individuals do acquire high-demand skills, they may still face a challenge in convincing prospective employers to value their third-party training credentials.

According to the WEF Jobs Report 2018, those corporations that do plan to provide expanded retraining programs are most likely to rely on internal corporate resources and contracted training providers to address critical employee retraining and upskilling needs, noting that "across many regions, the least sought-after partners are local education institutions, government programmes, and labour unions (p. 22)."

In past cycles of technology adoption, in-house employee retraining programs were a viable option for large corporations. In-house programs allowed corporations to control the quality of training and to match its content directly to business needs. Over the next decade, however, the majority of corporate positions are expected to require some form of retraining and upskilling. In fact, adoption of ever-more advanced AI will transform the remaining positions in ways that require rapid upskilling and shorter and shorter intervals. In this future of work context, the traditional resource-intensive in-house training programs will not be enough to meet the "retraining imperative."

Developing innovative strategies for retraining and reskilling, and rethinking the viability of relying primarily on in-house training programs, is another key management challenge for companies with accelerating retraining needs driven by AI adoption. A starting point would be to adapt the AI tools already being used in hiring and recruitment to match current employees with the most relevant and productive upskilling opportunities. This could lead to cross sector collaboration with public and private sector educational partners to expand access to (AI) matching tools for workers seeking employment after obtaining new skills.

3 Emerging human-AI hybrid teams

Until recently, the term Hybrid Team typically referred to a mix of full-time, part-time, and temporary contract workers who might be working on-site or at remote locations. Best practices for managing such teams have emerged over a number of years. With AI, robotics and RPA adoption, hybrid team composition has stretched to include teams in which humans rely on the contributions of AI-enabled hardware and software robots to accomplish their work. Such teams present managers with new types of challenges, from motivating the human team members to optimizing human-AI interfaces, and defining accountability for performance.

Similar issues arose with the early introduction of robotic workers into manufacturing, for example in automotive assembly lines. Robotic arms could perform assembly steps much more efficiently than humans. But as the assembly line was optimized for robotic performance. the humans who were responsible for other manufacturing steps became less effective, in part because the system was no longer designed around human capabilities.

It is to be expected that in hybrid teams in which AI, robotics and humans share responsibility there will be similar issues at the interface between human and machine intelligence. Such challenges are unlikely to be resolved by additional use of AI, or even by improving workflow and interface design. Solutions must be based on a commitment to respect and motivate human team members over robotic and AI contributions. Building trust will be a fundamental requirement for managers responsible for these emerging hybrid teams. Rozanski, 2019)

4 Area for future research

This article presents a brief overview of selected management challenges involved in enterprise adoption of AI as a major component in the future of work. It is clear that addressing these challenges will require leadership from top level corporate leadership to define the company's vision and values for managing a hybrid workforce. To summarize, Figure 1 lists the intersecting AI Impacts on the enterprise and the workforce and example management challenges.

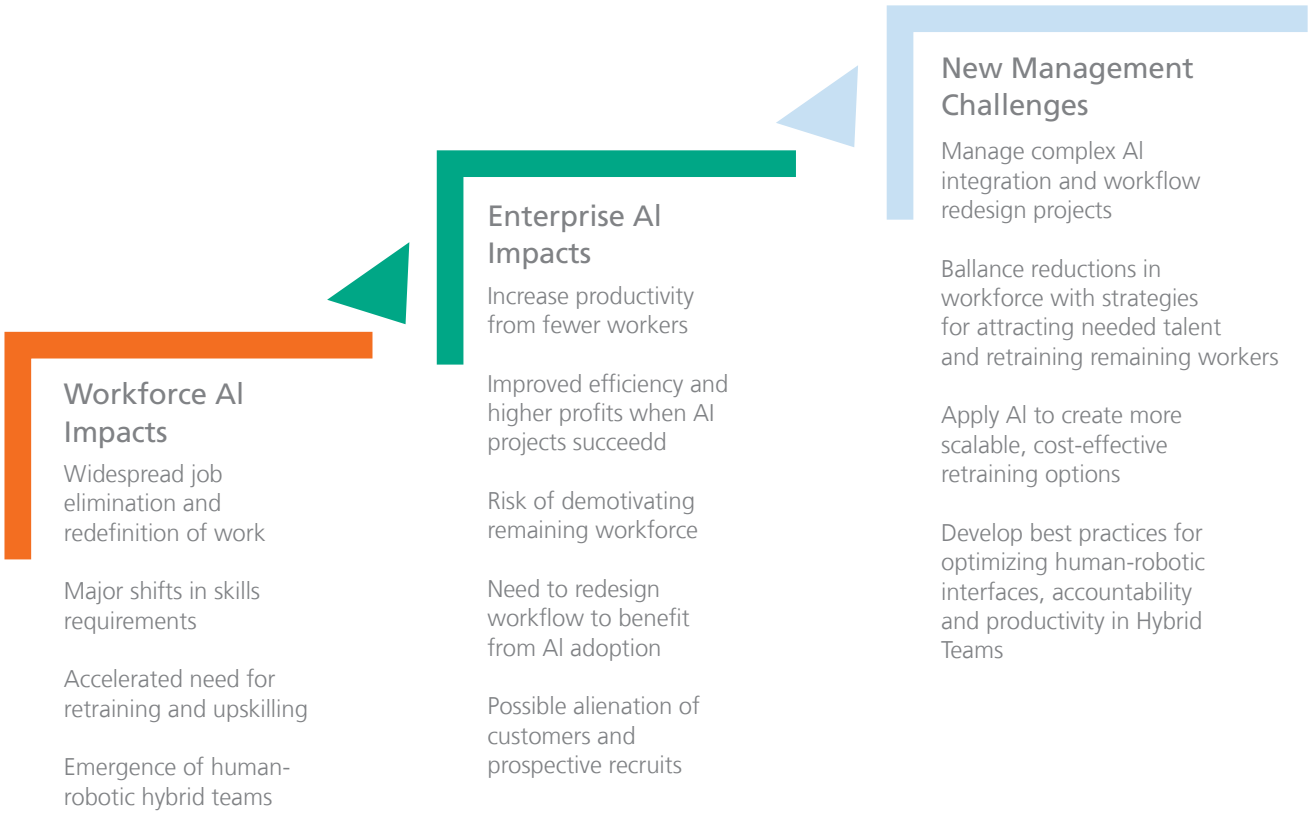


Figure 1: Management challenges from workforce and enterprise impacts of AI

These and related management challenges will be the focus of future research, including:

- Defining best practices for adapting AI to create more scalable and cost-effective upskilling and retraining options and building cross-sector digital training models to serve as on-ramps to employment as well as upskilling for current employees.
- Strategies for building trust and motivating human contributors in hybrid teams, including best practices for human-robotic collaboration
- Defining allocation of C-level responsibility for strategic and operational Future of Work decisions. Currently, this responsibility is diffused among various C-level positions with involvement by CEOs, CHROs/ Chief Learning Officers, COOs, CIOs and CFOs (McGee, 2018).

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References

Baldwin, Richard E. The Globotics Upheaval: Globalization, Robotics, and the Future of Work, Oxford 2019

Centre for the New Economy and Society, "The Future of Jobs Report 2018," World Economic Forum, 2018

Cronin, Mary J. and Tiziana C. Dearing, "Aligning HR and Corporate Responsibility Strategies to Enhance Employee Engagement," Boston College Center for Work & Family, 2019

Friedman, Zack, "Student Loan Debt Statistics In 2018: A $1.5 Trillion Crisis," Forbes, June 13, 2018 online at: https://www.forbes.com/sites/zackfriedman/2018/06/13/student-loan-debt-statistics-2018/#4b6b9c6d7310

Hurst, Daniel, "Japan lays groundwork for boom in robot carers," The Guardian, February 2018 online at: https://www.theguardian.com/world/2018/feb/06/japan-robots-will-care-for-80-of-elderly-by-2020

Lin, Patrick, et al. (editors) Robot Ethics 2.0: From Autonomous Cars to Artificial Intelligence, (Oxford University Press, 2017)

McGee, Ken, "Artificial Intelligence Is Closer to CIOs Than They May Think," Gartner Research, 2018

Manyika, James et al. "Jobs lost, jobs gained: What the future of work will mean for jobs, skills, and wages," McKinsey Global Institute, 2017 online at: https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages

Muhammed, A. "How AI Is Making An Entry Into The Freelance Economy," Forbes Jun 10, 2018 https://www.forbes.com/sites/abdullahimuhammed/2018/06/10/how-ai-is-making-an-entry-into-the-freelance-economy/#544ea8e46d0e

Poitevin, Helen et al. "Predicts 2019: AI and the Future of Work," Gartner Research, 2018

Roose, Kevin "The Hidden Automation Agenda of the Davos Elite," New York Times, January 25, 2019 online at: https://www.nytimes.com/2019/01/25/technology/automation-davos-world-economic-forum.html

Rozanski, Horacio "The AI Boom: Why Trust Will Play a Critical Role," Knowledge@Wharton May 09, 2019 online at: https://knowledge.wharton.upenn.edu/article/coming-ai-breakout-need-rules-road-now/?utm_source=kw_newsletter&utm_medium=email&utm_campaign=2019-05-09

Schwab, Klaus The Fourth Industrial Revolution, Crown Business, 2017

Upwork Global, "Freelancing in America 2018," online at: https://www.upwork.com/i/freelancing-in-america/2018/

Vandevelde, Mark "Amazon is creating more jobs than it destroys," Financial Times, July 29, 2017 online at: https://www.ft.com/content/cf98680c-738f-11e7-aca6-c6bd07d-f1a3c

West, Darrell M. The Future of Work: Robots, AI, and Automation, 2018

Wiggers, Kyle "Forrester: 10 % of U.S. jobs will be lost to automation in 2019," VentureBeat, November 6, 2018 online at: https://venturebeat.com/2018/11/06/forrester-10-of-u-s-jobs-will-be-lost-to-automation-in-2019/

Biography

Mary J. Cronin, Ph.D. is a Professor of Information Systems at the Carroll School of Management, Boston College where she teaches courses in Digital Commerce and Managing for Social Impact. Dr. Cronin's current research focuses on the impacts of AI on the future of work, in particular how workforce transformation, the accelerating demand for retraining and reskilling and the global competition for top talent are impacting organizations and managers.

Her books include Managing for Social Impact: Innovations in Responsible Enterprise (Springer, 2017); Top Down Innovation (Springer 2014); and Smart Products, Smarter Services (Cambridge University Press, 2010) Earlier books include Doing Business on the Internet, The Internet Strategy Handbook, and Unchained Value, along with many other technology, business and strategy publications

Dr. Cronin has more than 25 years of experience in managing and advising technology-intensive organizations as a consultant and board member. Recent consulting work includes assessment of corporate social impact, with a focus on aligning corporate social responsibility (CSR) with employee engagement, satisfaction, recruitment and retention (ESR); and managing generational transition in the workplace and its impact on team performance and productivity.

She currently serves on the IT Advisory Council at Brown University where she received her Ph.D. and as an editorial board member for Electronic Markets.

MANAGING WORKFORCE DISRUPTION, UPSKILLING, AND HYBRID TEAMS IN THE AI-DRIVEN FUTURE OF WORK

MAKING ONLINE EDUCATION WORK

INSIGHTS FROM MIT'S "SHAPING WORK FOR THE FUTURE"

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Abstract

In light of on-going debates about the added value of online education on the one hand, and the impact of technological change on the nature of work in the 21st century on the other hand, this paper provides insights into "Shaping Work of the Future", a popular massive open online course (MOOC) at the Massachusetts Institute of Technology. We elaborate on the overall course format, particularly promising instruction methods and innovative didactical tools, and argue that many of the potential draw-backs of computer- and web-assisted learning can indeed be overcome through a deliberate focus on student engagement and community-building. In the process, we introduce MIT's unique approach towards researching the nature and implications of technological change by focusing on the relationship between business, labor, government and education institutions, and by bringing together a wide range of researchers from across the Institute in an interdisciplinary Taskforce. We conclude with insights into how the next iterations of the online course seek to incorporate student feedback, while continuing to stress the engagement with emerging technologies needs to go hand in hand with a dialogue about broader social goals and values.

Key words
Digital Learning & Teaching, Future of Education, MOOCs, Social Implications of Technological Change

1 Introduction

The recent technological advancements that brought about terms such as "Industry 4.0" or the "digital economy" also created a rapidly growing need for individuals across all professions to acquire new skills. Employers and institutions of (higher) education have responded to this trend by increasingly relying on online resources. Just as many companies develop their own web-based training tools, also more and more universities are capturing lectures and creating videos that they make available online. Both trends are not uncontested. While supporters underline that online education provides a cheap, easy-to-scale and more flexibility-enhancing solution, skeptics raise doubts that the decreased amount of direct human interaction can ever be as effective as in-person instruction and individual mentorship, and the rather homogenous group of people who tend to enrol in these courses (Christensen 2013). To many, "blended learning", a combination of elements of face-to-face, class-room instruction and online learning, is the realistic and desirable compromise and, indeed, the "future of education".

While researchers across disciplines are in the process of testing and substantiating these claims through studies and surveys (see e. g. Bernard, et al. 2014, Wahl and Walenta 2017), this paper contributes to the debate with first-hand insights from designing, producing and co-teaching the course "Shaping Work of the Future" at the Massachusetts Institute of Technology (MIT). While we reflect mostly on the online version of the course offered in the Spring of 2019, focusing in particular on the elements we used to improve interaction and engagement among students, we also draw on the observations made with the blended-learning format of the course – a short, independent learning program, offered to Executive

MBA students at MIT's Sloan School of Management. We hope that our insights on the organization as well as strengths and limitations of the course may inform the thinking and approaches to online education and blended programs of fellow academics and practitioners.

Our second objective is to present the unique and innovative approach taken by MIT towards addressing the question of the highly relevant and widely discussed question of how technological change may affect the future of work. As detailed in the second part of the paper, it does so not only by identifying which technologies are causing what kind of change, in which industry and at what speed, but by situating these findings in a broader analysis of the relationship between business, labor, education institutions and government. In the MOOC this is evident in the way it draws on and adapts key elements of Jean-Jacques Rousseau's concept of a "social contract" to today's context. At MIT, more broadly, we see this comprehensive approach reflected in the composition and activities of the Taskforce on the Work of the Future, an intra-institutional effort to critically reflect on the role of technology and its impact.

To contextualize our observations and reflections, we begin with a brief overview of the online education space, focusing in particular on MIT's role as a key player in developing novel forms of teaching and learning. Thereafter, we elaborate on the objective, structure, contents and outcomes of the course "Shaping Work of the Future", focusing on the elements we used to create community and engagement among learners. Lastly, we identify areas that need to be addressed in the online education space and beyond to ensure that technological progress does not come at the expense of social inclusion, democracy and shared prosperity.

2 Mapping the status quo of online education and the role of MIT

"Online education", i. e. the wide range of computer- and web-assisted learning formats that include small and tailored lectures or seminar courses[1] is not a new phenomenon. Rather, it can be traced back to the end of the 20th century, when the Internet became more sophisticated and numerous organizations began experimenting with hosting classes online. The "breakthrough" of massive open online courses did not happen until 2011, however, when the course "Introduction to Artificial Intelligence", offered by two professors at Stanford University, saw an initial enrollment of more than 160,000 students from around the world. The innovation of MOOCs was to create a course that could be taken asynchronously and at scale, thus allowing for maximum flexibility of the student. A year later, Coursera and Udacity, two private companies, were founded which offered a standardized Learning Management System (LMS) platform that universities and educators could use to host MOOCs on their own. Harvard and MIT quickly followed this trend by co-founding the nonprofit edX in the same year. Able to reach large audiences at the same time and mostly free of charge or for a very low fee, MOOCs and online education overall were soon hailed for their ability to serve as a social "equalizer". This wave of enthusiasm decreased when participant demographics from various MOOC platforms revealed that the courses tended to attract a less diverse audience than anticipated, as the majority of learners already had a university degree (Liyanagunawardena 2015).

Yet, this finding hardly influenced the general trend towards more online education, and the number of organizations that make learning resources available to students or employees

1 These courses, also referred to as "SPOCs" or small private online courses, simulate an in-person class in that students gather in an (online) space at the same time to listen to a presentation or lecture, and complete their assignments on the platform under a shared deadline (Kaplan and Haenlein 2016).

continues to increase rapidly. With this has come a plethora of new business models, offerings and actors. Many new programs, for instance, are tailored towards the development of specific advanced skills in fields which they have a competitive advantage or are a known entity, and that are widely marketable to the labor force and industries. Companies are also requesting and underwriting tailored programs from top research universities, such as MIT, whose experience with using the Internet for learning dates back to 2001, when the OpenCourseWare project was created. The latter published all of the Institute's educational materials from its undergraduate and graduate courses on a free, open website under a Creative Commons license, thus making high quality education products such as syllabi, readings or problem sets freely available to non-MIT students and faculty. Importantly, this practice has also inspired 250 universities around the world to do the same and, thereby, promoted the idea of education as a global public good.[2]

Another key actor in this space is MITx, a core component of the Office of Open Learning, a body which operates under the mission to "share the best of MIT's teaching and learning with the world." Having published hundreds of MOOCs since its inception in 2012, MITx currently maintains about one hundred undergraduate and graduate courses from nine departments across all five schools of MIT on the site every year. In 2013, the "XSeries" created new certificates for the completion of sequences of related modules or courses on the edX platform. MIT thereby moved instruction and certification beyond the focus on individual courses which thus far had defined the MOOC landscape. This innovation enables students to progress through a curriculum pathway, and to demonstrate their commitment and ability to meet MIT standards without actually being on campus. To honor these efforts, MIT and 17 other universities[3] launched a new program in 2015, the "MicroMaster". The latter bestows a new credential on students who have both completed a full series of graduate level MOOC courses on edX and are able to pass a proctored competency exam of the material.[4]

Despite these indicators of success of MIT's online education programs, instructors have also expressed concern about the lack of one-on-one support and community building in comparison to traditional residential teaching. The introduction of the "bootcamp" model sought to address this shortcoming by bringing together students who had completed one of MIT's coordinated MOOCs in an intensive, week-long program that allowed participants to apply their newly acquired skills to solving real-world challenges. In combination with other programs, such as MIT ReACT, which offers MOOC-assisted in-person educational programs in computer coding and data analysis to participants in refugee camps, there is hence little evidence to suggest that the flexibility of online learning cannot go hand in hand with opportunities for community and relationship building. How this has been done in the context of the course "Shaping Work of the Future" will be shown in the next section.

3 "Shaping Work of the Future" – an MIT approach to studying technological innovation and its impact

On March 19, 2019, MITx launched the new course "Shaping Work of the Future" via the edX platform. Originally developed by Professor Thomas Kochan, co-director of the Institute for Work and Employment Research (IWER) at MIT's Sloan School of Management, and colleagues in 2014, the 2019 iteration of the course was characterized by substantially altered curriculum to provide more space to the role that different emerging technologies had in shaping work.

2 Today, MIT's OpenCourseWare website makes more than 2500 MIT courses available to teachers and learners everywhere.
3 In 2019 the number has risen to 28 universities.
4 The first degree of its kind, the MicroMasters in supply chain management (SCM) saw an enrollment of 127,000 students from 189 countries in at least one course, and more than 7000 verified ID certificates (MIT Office of Digital Learning 2015). The success of this measure has been indicated by the fact that in 2019, MIT offered no less than five MicroMasters programs via edX.

This shift was marked not only by the involvement of new faculty from a wide range of academic backgrounds, including of Dr. Elizabeth Reynolds, Executive Director of MIT's Taskforce on the Work of the Future as co-instructor, but also by the production of more than forty videos and the involvement of practitioners.[5] Featuring interviews with experts, case studies and mini-lectures, these productions covered a wide range of topics and questions over the course of eight weeks. Following a historical perspective and overview of work and employment policy in the United States and around the world in the 21st century, participants engaged with the roles of firms, employees and public policy over time, and the current status of the labor market. They learned about the types of jobs that have been emerging, changing and disappearing due to the proliferation of new technologies such as robotics and AI, and contemplated the implications of this development for different stakeholder groups and society as a whole. In light of this rather broad approach to the question of how work and workplaces are changing, the course team drew on the insights of a wide range of scholars, including leading technologists as well as social scientists and historians from across MIT's different departments. Moreover, and as indicated in the table below, "Shaping Work of the Future" also offered a wide range of external expertise, thus bringing together insights from years of research by MIT and the university's extensive network of collaborators.

Contributor (Name, Title & Affiliation)	Video Topic
David Autor, Ford Professor of Economics, MIT	Will Automation Take All of Our Jobs?
Dr. Elisabeth Reynolds, Executive Director of the MIT Taskforce on the Future of Work	The Geography of Work: Understanding Opportunity in Urban vs Rural Areas
Professor David Weil, Dean of the Heller School of Social Policy and Management, Brandeis University	The Fissured Workplace: Unpacking the Outsourcing of Jobs
Guy Ryder, ILO Director-General	The International Labor Organization and the Future of Work
Tom Kochan, George Maverick Bunker Professor of Management, MIT	Understanding the Social Contract of Work
David Mindell, CEO & Founder of Humatics, Professor of Aeronatics and Astronautics, MIT	Lessons from the Industrial Revolution for Industry 4.0
Panel: Professor Daron Acemoglu, Department of Economics, MIT; Diana Farrell, President & CEO, JPMorgan Chase Institute	Job Displacement in the 20th century
Christine Walley, Professor of Anthropology, MIT	Social Impacts of de-Industrialization in America
Professor Erik Brynjolfsson, Director of MIT's Initiative on the Digital Economy	Technology and the Future of Work
Julie Shah, Associate Professor of Aeronautics and Astronautics, MIT	Robot See, Robot Do: Using Robots in the Workplace
Vivienne Ming, Co-Founder of Socos	From AI to Augmented Intelligence
John Leonard, Professor of Mechanical and Ocean Engineering, MIT	Should the Goal be Driverless Cars?
Ryan Chin, CEO of Optimus Ride	Spotlight on Jobs of the Future: Autonomous Vehicle Safety Drivers
Professor Daniela Rus, Director of MIT CSAIL	Robots in Everyday Life
Kamau Gachigi, Founder and Executive Director of Gearbox	Emerging Tech Transforming Work in Kenya

Table 1: Contributors and contributions to "Shaping Work of the Future" (Part 1)

5 A group of consultants from Mercer / Oliver Wyman, for instance, led students through a case study of a bank looking to upgrade its IT functionality

Contributor (Name, Title & Affiliation)	Video Topic
Dr. Martin Krzywdzinski, Head of Research Group Globalization, Work and Production, Weizenbaum Institute for the Networked Society	Industry 4.0: Germany's Strategy for Technology Change
Al Fuller, CEO Integrated Packaging Corporation	View from the Inside: Manufacturing Companies Navigating Technological Change
William Bonvillian, Lecturer MIT	Developing an Advanced Manufacturing Ecosystem in the United States
Lee Dyer, Professor of Management, Cornell University	Careers and Competencies
Dr. Tony Wagner, Senior Research Fellow, Learning Institute	Workplace Survival Skills
Professor John Gabrieli, Director of the McGovern Institute for Brain Research, MIT	Science of Learning
Professor Sanjay Sarma, President of Open Learning, MIT	Digital Learning: Bringing Learning Science into Education
Dr. Inez von Weitershausen, Research Associate, MIT	Smart Models for Education Systems
Paul Osterman, Professor of Management, MIT	Community Colleges: More Important than Ever
Professor Joseph Aoun, President of Northeastern University	Rethinking Higher Education in an Age of Technological Change
Liz Shuler, Secretary-Treasurer of the AFL-CIO	Organized Labor in America
Duanyi Yang, PhD Candidate, MIT Sloan School of Management	Rebuilding Worker Voice: What do Workers Want Today?
Jenny Weissboud and Megan Larcom, PhD Candidates, MIT Sloan School of Management	Emerging Models of Worker Advocacy
Brian Lang, President of Unite Here Local 26	Growth in Worker Advocacy
David Rolf, President of Local 775	Success Stories from the Front Lines in Seattle
Nazma Akter, Labor Leader	Organizing Labor in Bangladesh
Kent Greenfield, Professor of Law, Boston College	The Changing Role of the Corporation
John Reed, Former Chairman of CitiBank	Careers and Competencies
Zeynep Ton, Professor of Management, MIT	Market Basket: A High Road Business Case Study
Scott Stern, Professor of Management, MIT	Entrepreneurship and Good Jobs
Jean Pitzo, CEO Ace Metal Crafts Company	How are small manufacturing companies dealing with change?
John van Reenen, Professor of Management, MIT	Good Management in Big Firms
Panel: Dr. Andrew McAfee, Co-Director, MIT Initiative on the Digital Economy; Professor Daron Acemoglu, Department of Economics, MIT; Diana Farrell, President & CEO, JPMorgan Chase Institute; Tina George, World Bank	Magic Wand Policy Solutions
Panel: Professor Thomas Kochan, Professor Erik Brynjolffson, Congressman Ro Khanna, California	Innovative Policy Ideas in Regulating Big Tech
Hans Timmer, Chief Economist, World Bank	Technological Change and Social Contracts around the World
Yasheng Huang, Professor of Management MIT	China: An Emerging Technological Leader

Table 1: Contributors and contributions to "Shaping Work of the Future" (Part 2)

To complement the lectures, interviews and panel discussion featured in the videos listed above, online discussion forums were created to facilitate peer-to-peer learning and further promote engagement.[6] Each week, students were invited to either share their personal experience relating to the course material, to work through a case study or problem together, or to interact with an outside expert on a topic related to the weekly material. While all participants were able to read each other's insights and recommendations, about one fifth – 1093 individuals – decided to regularly engage in the lively debates on each week's topic. While this number suggests room for further engagement, it is also remarkable as it meant that a group of individuals which by far exceeds the size of a classroom or lecture hall, decided to interact with each other on a frequent basis[7], independent of their diverse cultural and educational backgrounds. This may have had to do with the fact that participants' median age was 38 years[8] and that many of them were working professionals, motivated to learn how to effectively navigate their organizations – and their careers – through our current time of change and curious to learn about practices in other countries.

In an exit survey, a majority of students also indicated that part of why they considered these discussion forums to have been "very important" for their learning experience, motivation and the sense of community in the course was the fact that course instructors were "extremely accessible" to the learners Indeed, the instruction team regularly posted comments and suggestions for further resources to the forum, and set up a live session in week four, which enabled students to directly engage with them and other participants in a virtual meeting room. The insightful comments and high level of engagement of many of the more than 80 individuals who participated in this session, and their subsequent self-organization in a LinkedIn Group, clearly speak to the fact that through careful planning and organization it is possible to build community in an online course.

This insight was confirmed in the last session of the course, where instructors and participants met online to celebrate the joint achievement and to discuss the outcomes of the social contract exercise, the central piece of the course. In this exercise, students had, over the course of several weeks, developed their own ideas for action that business, labor, education providers and government could take to create a society that worked for all. Among the numerous proposals that were suggested, they then voted to select a list of five items per group that constituted concrete recommendations that could lead to a more inclusive and just society (see Table 2). A similar, albeit shortened, list was also created by the participants of the blended version of the course, who did not vote on, but rather negotiated the outcomes after having engaged with a smaller selection of the same materials.

6 Forthcoming research by Perdue and Sandland (2019) suggests that the larger the number of participants in a MOOC discussion forum, the higher the likelihood for individual completion.

7 During the eight-week period, more than 7000 comments, questions and critical statements were posted. On average, this amounted to each participant having left ten comments and each post being read 950 times.

8 While the age span ranged from 15 to 95, 45 percent of all participants were between 26 and 40 years old.

Education
1. Life-long learning needs to be made available and delivered to all workers through coordinated efforts of educational institutions, businesses, governments and unions.
2. Educators at all levels, from early childhood through college, should combine teaching of both technical literacy and the social skills the future workforce will need to work effectively with changing technologies.
3. Universities, high schools and community colleges should provide coop opportunities or apprenticeship training for students to get both a high-quality education and job skills.
4. Higher education institutions should provide more online and blended degrees and transferable credit-bearing offerings that are cheaper and easier to schedule for working or remote students, taking advantage of new technology platforms and VR. The government should help subsidize these programs.
5. Government should provide free access (or very reduced fees/subsidies) to higher education, particularly for displaced workers or people who cannot afford it.
Labor
1. Labor organizations should work in partnership with employers to represent the economic and job-related interest of the workforce and to foster improved operational and financial performance of their firms. They should work with management to bring technological solutions into the workplace in a way that enhances, not replaces human workers
2. Unions should work with employers and educational institutions to develop training programs for unemployed / technologically displaced workers to help them re-enter the workplace. They should also be working with companies to produce materials for lifelong learning and upskilling.
3. Government policy makers should reform labor policies to make it easier for workers to gain access to representation and collective bargaining and to provide opportunities to extend the coverage of collective bargaining to regional or sectoral levels.
4. Labor organizations should go beyond the procedures provided in the National Labor Relations Act for organizing and representing workers by using social media, AI apps and other modern tools of communication to provide all workers the opportunity and protection needed to speak up and improve conditions on the full range of issues of concern to today's workforce, and to organize in an agile, flexible and less formal way.
5. Labor organizations should work with educational institutions to teach young people about labor relations and provide continuous education to workers about how to exercise their voice at work. Labor organizations should rebrand their image and be more proactive and cooperative in reaching out to engage young workers, employers and other worker advocates
Business
1. Corporate leaders should prioritize long term benefits for stakeholders (as well as shareholders) and the environment. This should be cemented in changes to corporate governance regulations, and become a priority for investors.
2. Business leaders should be held accountable to create high quality jobs, favorable benefits, flexible work schedules and living wages. These should be extended to all employees regardless of race or gender.
3. Businesses should create an education fund for workers who are facing lay-offs, or who are employed and wish to advance their skills to meet new demands.
4. Business leaders should be proactive in providing employees opportunities to voice their ideas and concerns, and in fostering worker-management collaborative processes to improve workplace practices and performance.
5. Workers should be provided a voice in corporative governance and strategic decisions through representation on company boards, periodic meetings with executives or work councils.

Government
1. The government should provide incentives to companies implementing High Road strategies, including public procurement contracts, subsidies and tax breaks. Along with this, the government should send clear signals to companies not performing to these standards and refuse to do business with them.
2. The national minimum wage should be raised to a level that would support a living wage.
3. The government should provide basic portable benefits for all people, including healthcare and retirement.
4. Corporate federal tax policy should incentivize human labor over capital investment.
5. The government should update labor laws to provide easier access to different forms of worker voice and representation and expand labor laws to cover contractors and independent contractors.

Table 2: Results from Social Contract Exercise of 15.662x Shaping Work of the Future, Spring 2019

The underlying idea of this exercise was informed by the ideas of political theorist Jean-Jacques Rousseau, whose concern with the inequalities that characterized the society he lived in eventually led to the famous conception of a "contrat sociale" among the individuals of a society which should not be guided by personal preferences but by a general will that served the greater good (Rousseau 1761a). A proponent of the idea that power and sovereignty emerged from and lay with the people, he was also a great champion of education as apparent in the famous quote "Make the citizen good by training, and everything else will follow" (Rousseau 1761b).

The exercise was intended to raise participants' awareness of the need to think beyond their individual position in light of the uncertain outcomes that the technological innovations of our time may bring for society as a whole. Consequently, we hoped it also familiarized the participants with the unique approach taken by MIT's Taskforce on the Work of the Future. Launched in early 2018, the latter is an Institute-wide effort to "understand and shape the evolution of jobs during an age of innovation" (MIT News 2018) in a more comprehensive way than similar initiatives. Rather than focusing merely on the narrow question of how new technologies impact the work in the future, the Taskforce's explicit mission is to identify ways to "shape and catalyze technological innovation to complement and augment human potential" and provide insights into how "civic institutions (can) ensure that the gains from these emerging innovations contribute to equality of opportunity, social inclusion, and shared prosperity" (Taskforce on the Work of the Future 2019). Part of how this can be done becomes apparent in the statement with which Professor Kochan described the MOOC he designed: "We can influence how these things play out and manage them better. But we've got to understand what the choices are, and we've got to get people really energized and taking actions to shape these forces" (Relihan 2019).

4 The path forward

In the last part of the paper, we focus on what can be done to ensure that technological progress and broader social goals go hand in hand. In pursuit of inclusive participation, democratic rule and shared prosperity we see three pathways forwards and recommend that they be taken simultaneously.

First, stakeholders in the education space should stay open-minded towards and up to date with how different technologies may inform education in the future. Our experiences with designing and teaching the course "Shaping Work of the Future" and the overwhelmingly positive feedback we received from course participants[9] have shown that online tools can be highly engaging and foster students' learning in a way similar to classroom-teaching. To achieve this outcome, it is crucial, however, that instructors invest time and resources to foster engagement with and among participants. Doing so also requires extraordinarily high levels of presence and involvement as well as a commitment to constantly rethink and improve both materials as well as delivery methods. This may well be worth the investment, however, as studies have shown that greater engagement among students and instructors leads to higher retention and completion rates (Hone and El Said 2016). Taking these insights to heart, the instructor team of "Shaping Work of the Future" has made the following adjustments with view of the next iteration of the course.

The 2019 run of the course was "instructor-paced", meaning only students who enrolled before April 2019 were eligible to earn a certificate or complete the course. Offering the MOOC as a "self-paced' version in 2020 will enhance accessibility and flexibility – in particular for working professionals who can find it very challenging to meet fixed deadlines in an extra-curricular course. Moreover, we are considering a greater focus on the design and use of new technologies that pertain to climate change as this topic emerged regularly in the discussion groups. Ways of doing so could include covering the impact of technology on agriculture, and the geographic distribution of technological and productivity benefits. In a similar vein, we see will integrate participants' excellent knowledge of other places, practices and systems and enable MIT researchers to draw on existing connections and build new relations with partner institutions around the world. Lastly, we seek to further improve community-building and participants' engagement by building a "global alumni community". To support this objective, the instructors already put in place a live webchannel on open.mit.edu that can be used to continue the dialog and exchange materials. Elaborating on this effort may include integrating this year's participants into next year's learning experience in some kind of mentorship capacity.

In addition to these issues pertaining mostly to the instructional dimension, we see a second priority in the need to ensure that the knowledge underpinning the course and wider discussion about the future of work is constantly developed further and widely disseminated. In this regard, the research carried out by the faculty members of MIT's Taskforce on the Work of the Future will be of crucial relevance. Finally, efforts should be made to communicate relevant findings towards stakeholders in the public and private sphere. While engagement with policy- and decision-makers will be of crucial importance, additional channels of communication should be developed to raise awareness among those groups who will be particularly affected by the upcoming changes. This may include a closer cooperation with workers' representatives, and those parts of the population who have already lost their jobs due to structural and technology-induced changes.

9 Upon completion of the course, students filled in an evaluation survey. Many suggested that the experience had been "transforming", "eye-opening" and "enlightening" and criticism was mostly limited to the fact that the course was not self-paced. Moreover, we received numerous emails in which students expressed their gratitude towards the course team and MIT and laid out how they intend to use the knowledge they acquired in the future.

References

Allen, I. Elaine, and Jeff Seaman (2016), "Online Report Card: Tracking Online Education in the United States." Babson Survey Research Group.

Antonaci, Alessandra, et al. (2017), "Identifying game elements suitable for MOOCs." European Conference on Technology Enhanced Learning. Springer: Cham.

Bernard, Robert M. et al. (2014), A Meta-Analysis of Blended Learning and Technology Use in Higher Education: From the General to the Applied, Journal of Computing in Higher Education, 26.1, 87–122

Christensen, Gayle, et al. (2013), "The MOOC phenomenon: who takes massive open online courses and why?".

De Freitas, Sara Isabella, John Morgan, and David Gibson (2015). "Will MOOCs transform learning and teaching in higher education? Engagement and course retention in online learning provision." British Journal of Educational Technology, 46.3, 455–471.

Holmberg, Börje (1995), "The evolution of the character and practice of distance education." Open Learning: The Journal of Open, Distance and e-Learning 10.2, 47–53.

Hone, Kate S., and Ghada R. El Said (2016). "Exploring the factors affecting MOOC retention: A survey study." Computers & Education 98, 157–168.

Kaplan, Andreas M., and Michael Haenlein (2016). "Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster." Business Horizons 59.4, 441–450.

Korn, James H. (2007). "Attention during lectures: Beyond ten minutes." Teaching of Psychology 34.2, 85–89.

Lee, Y., Choi, J., & Kim, T. (2013). Discriminating factors between completers of and dropouts from online learning courses. British Journal of Educational Technology, 44.2.

Liyanagunawardena, Tharindu Rekha (2015), Massive Open Online Courses, Humanities, 4, 35–41.

MIT News (2018), MIT launches Task Force on the Work of the Future, available at: http://news.mit.edu/2018/mit-launches-task-force-on-work-of-future-0227

MIT Office of Digital Learning (2015), Thirteen universities adopt MicroMasters and launch 18 new programs via edX, available at: http://news.mit.edu/2016/thirteen-universities-adopt-micromasters-and-launch-18-new-programs-via-edx-0920

MIT Taskforce on the Work of the Future (2019), Homepage, available at: https://workofthefuture.mit.edu/

MIT (2019), The Work of the Future: Shaping Technology and Institutions, available at: https://workofthefuture.mit.edu/sites/default/files/2019-09/WorkoftheFuture_Report_Shaping_Technology_and_Institutions.pdf

MIT News (2019), MIT report examines how to make technology work for society, available at: http://news.mit.edu/2019/work-future-report-technology-jobs-society-0904

Perdue, Meghan and Jessica Sandland (forthcoming), "Looking at Posting Behavior in MOOCs Across Disciplines".

Relihan, Ted (2019), Designing a new social contract for the future of work, MIT Sloan School of Management, available at: https://mitsloan.mit.edu/ideas-made-to-matter/designing-a-new-social-contract-future-work

Rousseau, Jean-Jacques (1762a), The Social Contract, London: Penguin. (1953 edn.).

Rousseau, Jean-Jacques (1762b), Émile, London: Dent (1911 edn.).

Stich, Amy E., and Todd D. Reeves (2017), "Massive open online courses and underserved students in the United States." The Internet and Higher Education 32 (2017): 58–71.

Wahl, Ingrid and Christa Walenta (2017), Mehr Zeit und bessere Vereinbarkeit durch Blended-Learning? Befragungsergebnisse von Studierenden eines berufsbegleitenden Studiengangs, Öffnung von Hochschulen, 233–254.

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DOMINANT TECHNOLOGY AND ORGANIZATION: IMPACTS OF DIGITAL TECHNOLOGY ON SKILLS

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Abstract

This paper describes a new approach to investigating, unraveling and explaining the implications of digital technologies for skills. To do so, the paper develops an approach to assess technology in companies in a more precise way, building on three main arguments. Firstly, current approaches to the subject treat all (new and emerging) technologies as equal. A more specific approach to technology is needed. Secondly, instead of starting from the potential of digital technologies, the focus should be on how technology investment decisions of companies are actually taken. Companies do not automatically reason from the available technology potential, but rather build on their current technology and capital stock and competitive position (the potential of technology). Thirdly, the organizational context should be considered. The actual use of skills in companies is strongly related to the organizational context. This is identified as the dominant organizational context. Based on these three main arguments, a new framework for work and skills technology impact research is suggested. Subsequently, the framework is applied to two professions in Dutch industry.

Key words

Skill Development, Future of Manufacturing, Industry 4.0, Work Design, Digital Skills

1 Introduction

The increasing use of advanced digital technologies is transforming innovation and production activities (Alcacer et al. 2016). This also changes the requirements for skills within and between organizations, sectors and countries, and may even render existing skills redundant or outdated (Autor 2015; Autor et al. 2015; Silva/Lima 2017; Zysman/Kenney 2018). The new digital paradigms include a wide range of enabling technologies, such as the Internet of Things, additive production, big data, Artificial Intelligence, cloud computing and augmented and virtual reality (Rindfleisch et al. 2017). However, although substantial research is being conducted into the relationship between digital innovation and skills, especially also in relation to ICT-acceptance (e. g. Autor et al. 1998), the impact of new digital paradigms for innovation, production and skills needs to be further explored (Consoli et al. 2016).

The existing research on the impact of new (digital) technologies on labor and skills is mainly focused on the impact of (digital) technology on the number and type of jobs (e. g. Atkinson/Wu 2017; Frey/Osborne 2013; 2017; Van Roy et al. 2018). Yet, the predictions in these studies are rather mixed. Some studies predict that between 40 and 90 percent of jobs may be lost (Frey/Osborne 2017), while in other studies, these percentages are around 10 percent (Arntz et al. 2016). This often gives too static an interpretation of what professions are. Little or no account is taken of mitigating effects such as the job content changes because of technology. New technology creates new types of jobs and new technology can lead to more work if the demand for products increases (Arntz et al. 2016). In fact, the introduction of these types of technologies is also much slower than expected (Van Helmond et al. 2018). In practice, the range of tasks in professions appears to be much broader and more adaptable than expected – which means that professions continue to exist, even if many tasks are computerized (Atkinson/Wu 2017). In general, the

research has also mainly been approached from a macro and policy perspective (e. g. McKinsey 2018), and based on existing but limitative datasets (Frey/Osborne 2013; 2017). To the best of our knowledge, no new data or monitors have been developed to assess the impact of new technology.

Another important criticism of existing research is that technology has only been operationalized in a limited fashion (see for example Arntz et al. 2016; Frey/Osborne 2013; 2017; Kim et al. 2017). Frey and Osborne (2017), for example, only look at the possibilities of Artificial Intelligence (AI) and robots to overcome bottlenecks in professions. The most contentious point in their approach, however, is that computerization risk is measured by looking at the degree jobs contain certain skills: social, communicative, mathematical, problem solving and ICT skills. The degree that current jobs contain these skills predicts the degree that they will be computerized. It should be clear that predicting future skill needs with such an approach will lead to tautological reasoning. Graetz and Michaels (2015) and Acemoglu and Restrepo (2017a; 2017b; 2018) look at robot technology present in a region. Bessen et al. (2019) only focus on investments in technology. Brynjolfsson et al. (2014) also focus on a limited number of digital technologies, in particular AI, but do not empirically investigate this.

And finally, an important point of criticism is that the organizational context must be considered but is generally ignored in the analysis (Agnew et al. 1997). There is a lack of specific insights into how specific digital technologies are implemented and developed in organizations. In most research, this organizational dimension is a black box, as it is completely absent (including Frey/Osborne 2017; Kim et al. 2017; Arntz et al. 2016). However, these insights into the relationship between technology and organization are crucial to understanding and explaining the real impact of digital technologies on labor, organizations, tasks and skills.

Therefore, the understanding of the impact of digital technology needs further development. Technology must better be operationalized, and the organizational context and aspects of work, as well as technology investment factors, should be included in future research as well. This paper introduces two core concepts for research into the impact of digital technologies on work in companies and sectors that address the above issues and can bring the discussion further: the dominant technological context and the dominant organizational context. These concepts will be operationalized and the benefits of using these concepts in research will be shown. An example of changes in skill demand within and between jobs in the Dutch manufacturing industry shows the strength of this approach.

2 Dominant technology

To examine the impact of new digital technologies on skills and organizations it is important to determine what the dominant technologies will be for organizations. We believe three elements are important for this: first, specify the focus technologies; second, understand the heterogeneity of technology in organizations, i. e. vintage and investments in technology; third, the measurement of technology. These elements are explained below. The ideas are applied to the example of Dutch industry.

2.1 Five technology types

In the current research into digital technology, the implicit assumption is that it does not matter which manifestations technology takes. In the recent World Economic Forum report 2018 (WEF 2018), technology was conceived as the degree of adoption of nineteen specific technologies (from big data analytics to drones). The technology adoption rate is the percentage of companies that have implemented the technology. Bessen et al. (2019) see automation as the cost of automa-

tion. They make the distinction between automation costs and computer investments. However, they mainly gain insight into technology investments rather than the existing technological situation in a company. Also, the Internet of Things, additive manufacturing, big data, Artificial Intelligence, cloud computing, augmented and virtual reality, cobots, etc. are all assumed to have the same impact on the scope and quality of the work. In other examples of this approach, digital technology is sometimes measured using proxy variables, such as the percentage of robots in a country (Graetz/Michaels 2015) or calculated at the level of a region (Acemoglu/Restrepo 2017a, 2017b, 2018; Dauth et al. 2017). Some authors make more distinctions between types of technology. Acemoglu and Restropu (2017a, 2017b, 2018) distinguish between two types of capital: low-skilled automation and highly-skilled automation. They link these differences in automation to examples such as "industrial robots" and "AI". The Acemoglu and Restropu-model does not consider other types of technology.

From an organizational point of view, not all technologies are the same and they not only influence the complexity of tasks, but also the way in which organizations are managed. New technology thus influences various aspects of organizing that determine productivity. Bloom et al. (2014) have proposed another classification. They assert that ICT should not be viewed as a whole, but that information technology and communication technology in particular have different organizational consequences. Information technology (e. g. ERP, CAD/CAM) helps to strengthen the ability of middle managers to search for solutions, so that they can be expected to broaden their jobs and grow in autonomy and decentralization ("data access": Trantopoulos et al. 2017). Communication technology, on the other hand (e. g. email and communication networks), ensures that decision-making and coordination can take place more quickly. This allows middle managers to specialize more in what they are strong at and allows central managers to more quickly ensure alignment between middle managers. Communication technology therefore leads to task specialization and centralization of decisions. In fact, their distinction can also be used for the relationship between (all) management levels and the first-line workers. Communication technology affects the relationships from top to bottom in an organization; information technology allows for task enlargement at all levels. Ter Weel (2015) adds to this distinction that technologies can be aimed at automating tasks, or at increasing the capacities of employees (in line with information technology). We would like to add that innovations are also possible in management systems or organizational measures (Kuipers et al. 2018; Maenen 2018; Oeij et al. 2017). These different technologies can be more or less aligned in their implementation in organizational settings. Innovations in other dimensions of technology can be in line with impacts of information and communication technology.

With these distinctions, the complex technological developments can be reduced to the five categories information technology, communication technology, management systems, "hard" automation and human enhancement technology. These technologies have distinct predicted impacts on employment dimensions. Table 1 provides an overview of these five types of technology, with their process impact and expected labor impacts.

Type of technology	Process impact	Employment impact
Hard automation	Technology can automate human labor. This usually involves "hard automation" in which technology takes over the actions and tasks of employees completely. Examples are robots or automatic welding machines. Other examples in logistics are self-driving cars and trains, autonomous ships. It is important in hard automation that it does not always involve equipment. Sometimes it is possible to have customers do more work so that work can disappear. Think of supermarkets where cashiers become redundant when customers do self-scanning.	Disappearing tasks and occupations.
Human enhancement (supporting) technology	Technology can support employees in the execution of their tasks. This usually involves mechanical tools, but it can also involve automated tools such as exoskeletons (in construction and assembly) or digital tools such as vision picking (in logistics).	Enlargement of operator capabilities. Increased productivity.
Communication technology	This technology focuses on the communication processes between employees or between employees and managers. Communication with the outside world (e.g. customers, suppliers) can also be structured differently using this technology. Communication technology has contributed to the strong rise of global value chains. This technology fits in with the management processes in organizations. Communication technology does not always have to be mobile technology. A conveyor belt can also be seen as communication technology. Such a conveyor belt helps employees to specialize and centralizes decisions about the production process.	Strengthening of hierarchy, narrowing of tasks/specialization.
Information technology	This is a separate technological change that fits in with the way in which employees gain access to information. Data access technology is mentioned in the literature: information technology helps to speed up access to information.	Decentralization, broadening of tasks.
Management systems	With this technology, activities in organizations are to a large extent standardized and uniformed. Other technologies can play a role in such systems, but not necessarily. An example is the Lean Production system.	Quality improvement, productivity improvement, integration and specialization.

Table 1: Five technology types and their impact

2.2 The process of technology implementation: vintage and investments

In addition to the distinction between types of technology, the process aspect in technology needs to be considered. As was indicated, the potential of technology, the investment strategy and the available technology differ by nature. The process perspective helps us to understand the heterogeneity of the technology situation in organizations.

A starting point to understanding the technological situation in organizations is to find out what the current technology base of a company is. Porter (1985) saw technology as part of the core competence(s) of a company. The success of the application of new digital technologies depends on the current technological knowledge in the company. In the 1980s, a great deal of attention was given to the composition of the capital stock of companies. In calculations of total factor productivity, an estimate of the capital stock is needed. In this context, much research has been done into the calculation and composition of (company) capital. The reasoning is that the strength of a company depends on the extent to which the capital consists of new "vintages" of technology. Old vintages of capital must be replaced by new ones in order to cope with rising wages (Vergeer et al. 2015). During the 1980s, the importance of vintage effects of capital was long discussed by Dutch economists (Meijers 1994). The opinion was that the low wage policy followed by Dutch governments removed an incentive to invest in new technology, with the result that productivity fell due to outdated technology ("old vintages"). A criticism of this view is that vintage only "looks back", i. e. determines what existing technology is. However, recent investments in new technology can be an obstacle to investing in the most recent disruptive technologies. And new technologies may not always be the most efficient. "The results show that in some circumstances older vintages might appear on the efficiency frontier, unlike some newer vintages that are found to be inefficient, despite benefiting from the advancement of the technology." (Belu 2015).

There are few data sources available for the operationalization of "vintage". Calculating the impact of vintage is usually fairly complicated and the results only apply when all kinds of problematic assumptions are met. A recent German study, the IAB company panel survey (TNS Infratest 2014), measures vintage in a qualitative way: companies indicate to what extent their technology is "out of date" or "state of the art". What is important about the vintage discussion is that new technology needs time to be implemented. It can take time before a new technology has a positive influence on production/service provision (Nilutpal et al. 2009).

Secondly, it is also about the investments that companies make. What do companies want to change in their current capital? If the market offers a lot of "potential" of new technology, what exactly is the potential selected? If we take the results of Table 1 into account, can we then gauge what is being invested in? Traditionally, investments in "hard technology" are considered in order to show the capital investments of a country. For example, EU-KLEMS data[1] indicates how much was invested in tangible assets in the last year. Much is known about these investments at an aggregated level. Acemoglu and Restrepo (2018) focus precisely on these investments. Two questions are important here. The first question is what exactly is it that you want to know about this tech_nology. The EU-KLEMS study is mainly concerned with estimating the differences in the distance to the technological frontier. This frontier is a measure of technological advantage, and traditionally the country that generates the highest Total Factor Productivity with a technology is seen as the frontier. The EU-KLEMS data provides information on the differences in technology. The changes in investments indicate how countries want to make up for their shortfall (or lead) (CBS 2018, S. 106).

But it is not just about "hard technology". Various studies, sponsored by the OECD, have clarified that companies also invest money in less "hard" technologies to increase their

1 www.euklems.net/

productivity (Corrado et al. 2012; OECD 2015). This concerns "knowledge-based capital (KBC)" that consists of investments in ICT, R&D, management training, organizational capital, etc. (Gomez/Vargaz 2012; OECD 2013a). According to research by Corrado et al. (2012), investments in KBC contribute about 7 percent to 8 percent to the annual growth in labor productivity, which is slightly more than the contribution of investments in "hard capital". However, the research on KBC is progressing slowly. The main reason is that only register data is considered, only what is available about investments in companies. In the KBC, investments in management quality and company-related R&D account for the largest share (Elbourne/Grabska 2016; Andrews/Westmore 2014). For management quality, several measures are used. In Saia et al. (2015), this quality is related to PIAAC scores. Andrews and Westmore (2014) look at the extent to which professionals are supported for management positions. Earlier KBC studies looked at the size of the management consultancy sector. The importance of KBC is that it is seen as an important factor in promoting the diffusion of new technology (Elbourne/Grabska 2016).

The research into "intangibles" is also relevant to this paper because it provides us with insight into the scale of ICT investments. The main objective of the research by the EU-KLEMS network is to establish why all investments in technology and ICT do not yet lead to a productivity leap in economies (Byrne/Corrado 2016). Byrne and Corrado identify several reasons why the expected productivity leap is not visible, such as the fact that ICT costs are falling very sharply. More work is needed here because it remains difficult to determine the impact of ICT investments on growth. Various elements of ICT appear to be difficult to grasp in growth statistics. For many aspects of the investments, it will actually be necessary to look at the company level to determine what companies pay attention to technology and capital stock development (see Bessen et al. 2019).

2.3 The potential of technology

Most analyses of technology are about the potential of technology, what technology can do and how that potential will have consequences for work. Most consultants focus on this potential (WEF 2018; McKinsey 2018). In addition to the fact that no coherence is seen/differentiation is made between all these technologies, there is also no weighing of which technology will have the most impact. The OECD (2015) has proposed the "technology burst" imagery to determine differences in the potential of new technology. A "burst" exists when the number of patents in a technology field increases sharply at a given moment. In that case you can expect that new applications will flood the markets in the short term. Patents may not be the best indicator of the potential of technology. It is important to bear in mind that only half of the patents are used for a variety of reasons (CBS 2018). Despite this complication, a patent does give some indication of the development of the knowledge intensity of a sector and specialization of knowledge.

To illustrate this, we indicate what this "technology burst" reasoning yields if we use the distinction of five types of technology in the manufacturing industry. Using the Espacenet patent database, we made an inventory of patents related to the five technology-types. Espacenet is a tool of the European Patent Office (EPO) and gives free access to more than 100 million patents from all over the world. For the purpose of our analysis, specific technology categories were investigated, the date on which the first patent could be found, and the percentage of new patents for each category in the past five years. Figure 1 presents an overview of this analysis.

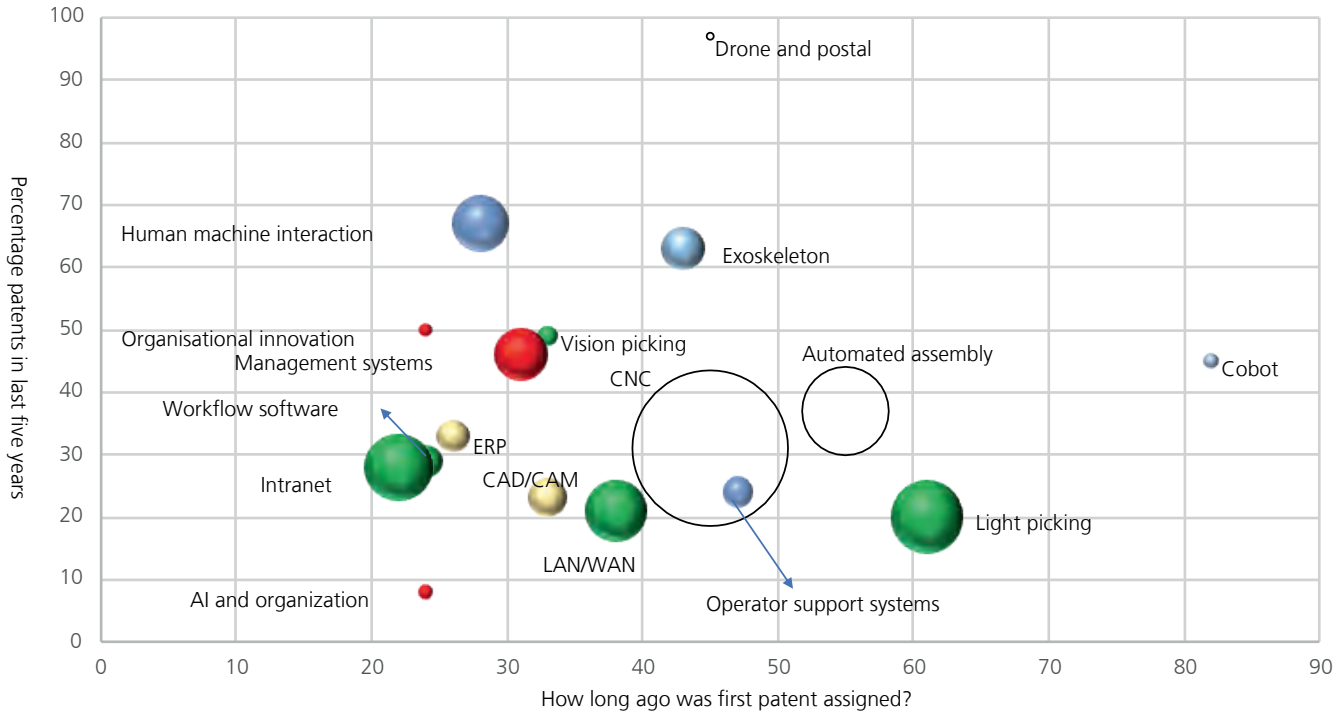


Figure 1: Overview of history of patent category, size of number of patents (size of bulb) and importance of number of patents in the past five years (Espacenet, download 10-8-2018) | Black circle: technology that automates human labor ("hard technology") | Blue circle: technology to support employees | Green circle: communication technology or technology that allows control from above | Orange/yellow circle: information technology that gives employees more access to information | Red circle: management systems or organizational innovation

2.4 Measuring dominant technology

How can these ideas relating to type of technology, vintage, investments and potential of technology be integrated to assess the technology situation in an organization sector or country? This is where the concept of "dominant technology" becomes useful. It is appropriate to distinguish between type of technology and phase in the investment process, but how can one weigh the dominant technological position of a company? There are no approaches to this in the literature. We propose to develop a composite index to determine which technology is dominant. Figure 2 clarifies what we have in mind.

The figure shows three phases in which a technology for a company, sector or country is situated: the actual use, the investment phase and the development or potential phase. The size of the bulb in the figure indicates how the technology in a phase relates to other technologies: the larger the bulb, the greater the importance of a technology in that phase. The colors of the bulbs indicate the growth of the technology in a specific time context: dark green indicates strong growth in a technology, light green limited growth, and orange a decline in growth. The figures in the bulbs mean the following:

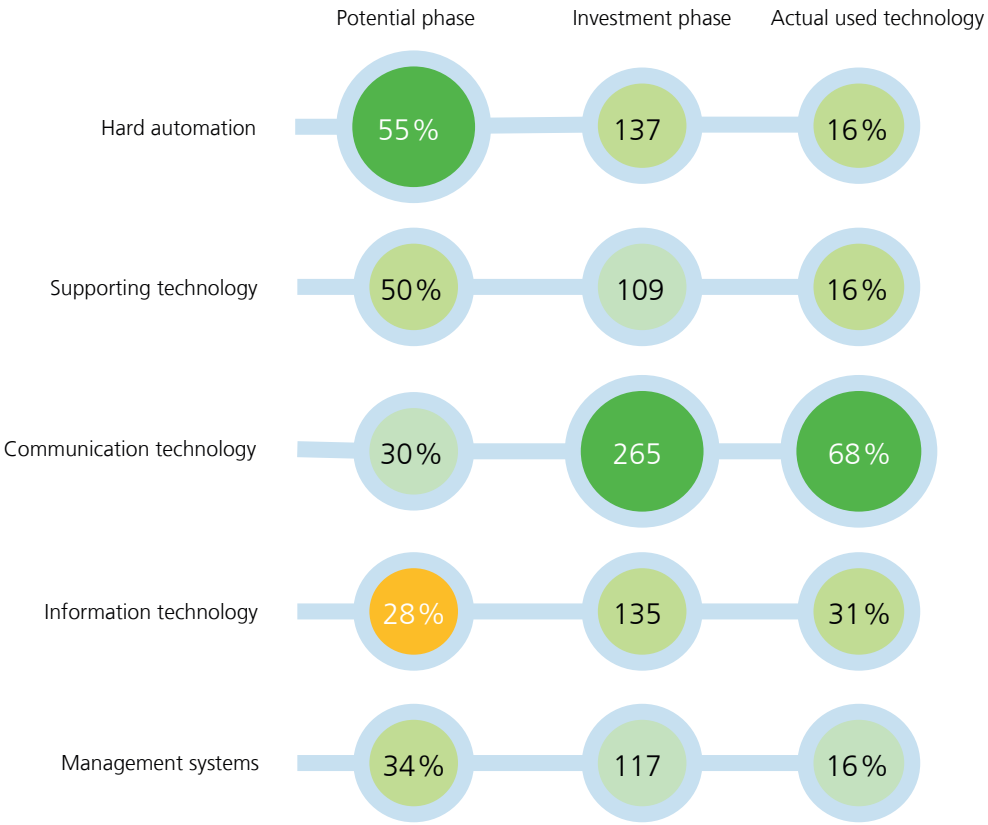


Figure 2: Visualization of dominant technology in the Dutch manufacturing industry

- Actual technology use ("reality") is the percentage of companies that have implemented a specific technology.
- Investments ("strategy") are an index figure (with an index = 100 for a comparable reference year) showing the growth compared to a reference year.
- Development ("potential") is the percentage of patents that have been approved in the past five years compared to the total number of patents in a technology.

Dominance is then determined as the technology that comes out strongest in the comparison between the three phases.

The assumption is that the current reality must first be weighed, then the investments and only then the potential phase. In order to determine which technology will have the most influence on skills and work, we need to look not only at each phase, but also at all phases at the same time. This means that many combinations are possible, i. e. in the "vintage", for example, communication technology can be dominant, and in the investment phase attention shifts to information technology. In the longer term, it may be that the development in hard technology will weigh most heavily. Figure 3 shows three possible alternative technology situations.

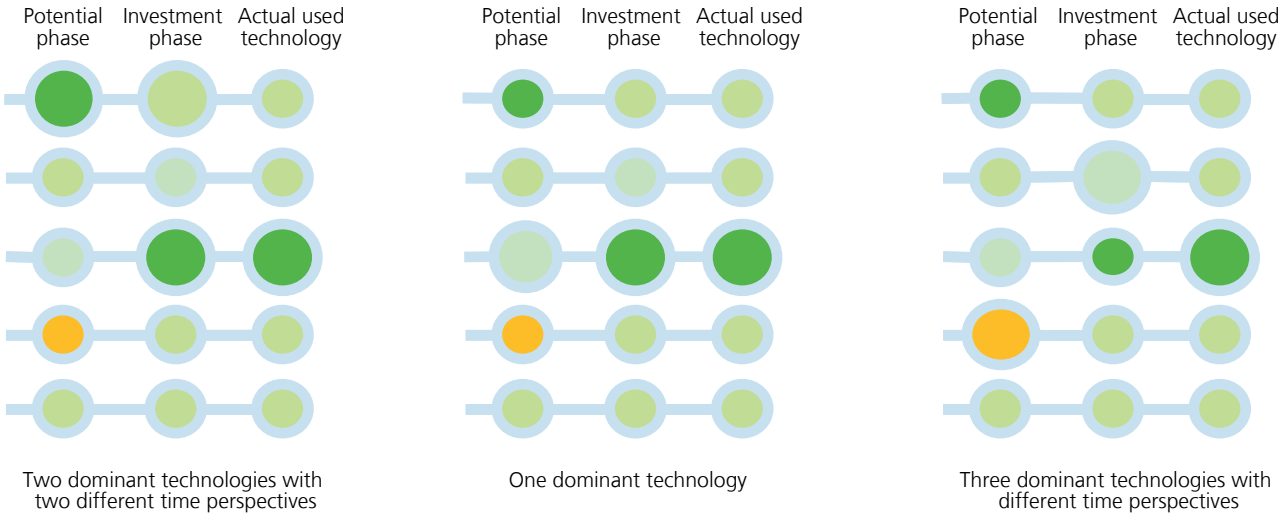


Figure 3: Examples of three alternative technology situations

In the first figure in Figure 3, two technologies are dominant, but in different phases: hard automation is a future given while currently communication technology dominates the installed base of technology and the investments. The second figure only shows one dominant technology: communication technology. Figure three shows a very dispersed picture: information technology promises a lot of changes in the future, supporting technologies are most important in the investment phase, and communication technology dominates the installed base. The dominant technology situations may therefore sometimes be very clear, sometimes more heterogeneous.

This perspective means that the supply of technology itself is not enough to grasp what will happen in companies. First it is important to examine what technology is present in the companies and then in which technologies investments are made. Only then is it useful to look at the supply of new technology.

2.4 Dominant technology in the Dutch manufacturing industry

To illustrate the power of this approach, an example of the dominant technology in the Dutch manufacturing industry was developed. In order to determine the dominant technology, a combination of several information sources was used (see for full information: Dhondt/Kraan 2019). For the existing technology, an analysis was made of the Dutch Statistics data on ICT (Statline data on ICT use by companies) and the Netherlands Employers Surveys (Van Emmerik et al. 2017). To calculate the investments in knowledge-based capital in Dutch industry, some of the necessary data is available. The EU-KLEMS data indicates how much was invested in tangible and intangible assets in the past years. However, the intangible assets are not complete, as described by Corrado et al. (2012) and the OECD (2015). Costs incurred for HRM, e. g. organizational investments, are not included in the figures for EU-KLEMS. Corrado et al. limit themselves to R&D and software investments. In the Dutch manufacturing industry, the

ratio between tangibles and intangibles has shifted in favor of intangibles in the short term. In recent years, companies have again started to invest more in "hard technology", but intangible investments appear to have received even more attention in the manufacturing industry in the past few years. If one looks at at the whole of the Dutch industry, the same increase can be seen in intangibles, thanks to the fact that hard investments still weigh more heavily.

Figure 2 shows the outcome of our analysis for the dominant technology in Dutch manufacturing. The development in a technology is reflected in the series of three bubbles. The numbers in the bubbles represent the proportions between the bubbles at one particular moment:

- Potential: to assess the potential of technologies we use the percentage of patents in the last five years of total patents in a technology category in a given industry (for example 55 percent = 55 percent of patents for hard automation have been issued in the last five years);
- Strategy: the investment index for 2011–2015 has been calculated, which reflects the growth in investment in a technology (2011=100) (for example, investments in hard technology have increased by 37 percent during this period);
- Reality: the percentage of companies that have applied a technology from that category (e. g. 16 percent of companies have robots).

The size of a bubble indicates in which development perspective (potential, strategy, reality) a technology has the most weight. The largest bubble in a phase carries the greatest weight. The colors represent the situation in 2011–2017: dark green shows that there is strong growth in a technology; light green indicates that growth is limited; orange indicates that there is decline. In the Dutch manufacturing industry, this means that communication technology can be expected to have the most important influence now and in the short term. This means that network technology, e-mail systems and mobile technology will have the strongest impact on organizational processes and occupations. This technology strengthens the communication flows in the companies and, according to Bloom et al. (2014), should result in a stronger centralization of decisions towards top management and a narrowing of occupations on the shop floor. In the longer term, "hard automation" in Dutch industry seems to be bringing about major changes.

3 Dominant organizational context

3.1 Distinct organizational concepts

A second major determinant when looking at the impact of technologies on jobs and skills is the organizational context in companies and organizations. There is a general lack of insights into how specific digital technologies are implemented and developed in organizations. With management systems as the 5th technology type, we already introduced at the dominant technology level an aspect of how work is organized. However, we need to clearly distinguish management systems from organizational concepts, even though in practice there may be overlap between the two. Management systems are defined here as rules on how to work and the information systems that contain those rules. This means that these systems mainly include parts of the control system in an organization. Organizational concepts are broader and include the control, but also the views on how the work should be carried out, i. e. the division of labor. Organizational systems that are aimed at visualizing all aspects of the work are aimed at control. TQM, lean production and other concepts try to operationalize quality and performance of production systems. Other concepts such as workplace innovation (see Oeij et al. 2017) or employee-driven innovation (Aasen et al. 2013) are aimed at maximizing employee involvement in order to optimize innovation.

3.2 Measuring organizational concepts at different levels

The way in which technology is shaped within companies is also related to the organizational form. This presents a chicken-egg problem. According to economists (Bloom et al. 2014; Ter Weel et al. 2010) organizational form is seen as an effect of the technology, whereas organizational sociologists indicate that the choice for the technology is an effect of targeted choices (Child 1972; Kuipers et al. 2018; Maenen 2018). Changes in the organizational concept are regarded as an innovation instrument for companies. In the previous section, it has been indicated how companies have in recent years invested more in their organizational capital than in hard technology (see also OECD 2013a). The question is how the organizational concept itself can be operationalized. Different perspectives are discussed here. When looking at the organizational level, control and production processes should be considered. Control processes concern differences in the relationship between controlling, preparatory (planning) and supporting (maintenance) tasks. Decisions in these tasks can be centralized or concentrated. Centralization is about decisions in the execution of tasks in production or services, i. e. the distinction between managing and operational tasks. Concentration refers to bringing together preparatory and supporting tasks in production or service provision, i. e. creating complete or incomplete functions (job enrichment or the reverse) (Huys 2001). Companies can have all kinds of considerations to centralize or concentrate decisions. As the example of the Netherlands illustrates, in recent years companies appear to have increasingly centralized their control systems, supported (or driven) by communication technology (Borghans and Ter Weel 2006).

The introduction of this paper indicated that insight can be gained into the organization of work at the individual level of a worker. The task analysis advocated in the British Skill Survey (Felstaed et al. 2007), the PIAAC (OECD 2013b) and recently in the Netherlands Skill Survey (Oudejans 2012; Kleruj 2017) provides overviews of tasks related to preparation, support and management within organizations. Occupations without such tasks seem to indicate a focus on operational tasks. Occupations that do contain such tasks operate in contexts in which employees themselves must control their environment and the content of the work. Lorenz and Valeyre (2005) used the European Working Conditions Survey (Eurofound) to successfully distinguish, at the country level, the application of four organizational concepts: learning organizations, lean organizations, Taylorized organizations and simple organizational forms. The "learning" model is characterized by a high degree of autonomy and task complexity, learning and problem solving and a low degree of individual responsibility for quality management. The "lean" model is characterized by the presence of teamwork and job rotation, the variables for quality management and the various factors that limit the pace of work. Job autonomy is relatively low and strict quantitative production standards are used to control employees' efforts. The "Taylorist" model shows minimal learning dynamics, low complexity, low autonomy and an overrepresentation of the variables that measure the limitations of work pace. The "simple" model groups simple forms of work organization, where the methods are for the most part informal and uncoded. Advances in research into the impacts of technology will also have to take dominant organizational concepts into account in the research design.

3.3 Dominant organizational context in the Dutch manufacturing industry

What is then the current situation in the Dutch manufacturing industry? Dhondt et al. (2019) investigated seven major occupational jobs using the Netherlands Skill Survey (Ter Weel/Kok 2013). As explained above, the degree to which organizational tasks are included in a job explains the degree of labor division in an occupation[2]. From the study, 33 percent of middle managers operate in highly Taylorized work organizations. For packaging personnel, this percentage rises to 52 percent. The

2 For more information on operationalization, see Dhondt et al. 2019. A further elaboration of the results of the Netherlands Skill Survey is taken up in a follow-up article to this publication.

organizational concept used in a company is an important explanation of differences in occupational profiles. It is striking that in most occupational positions in Dutch manufacturing, the degree of Taylorization plays an important role. The reported percentages have not changed in both groups in past years, but the expectation is that Taylorization in both occupations will increase. One explanation is that the dominant communication technology logic plays a role, because this technology ensures a stronger centralization of regulating tasks in organizations. Occupations will tend to specialize.

4 Predicting impact of dominant technology and organization on skills

4.1 Future impacts

The analyses in sections 2.4 and 3.3 indicate that communication technology and Taylorization will be the dominant technology and organization in the coming years. If this context remains dominant in Dutch manufacturing, then further specialization at the occupational level and centralization of decision-making (with less autonomy for individuals) are the consequence. To illustrate this, results of the analysis of job profiles for middle managers and packaging jobs in the Dutch manufacturing industry are shown here. Both occupations are common in the manufacturing industry.

This paper focuses on improving the discussion about the relationship between new technology and work. The core debate is about the relationship between technology and skills. Other dimensions (quality of work, wages, etc.) are equally important, but receive less attention in the debate. Acemoglu and Restrepo (2018) and Bessen et al. (2019) for example focus exclusively on skills development. Frey and Osborne (2013) are interested in the size of employment in a job. Most of these studies assume a direct link between technology and labor aspects. Yet as indicated earlier, the organizational context must also be considered as a co-determinant of what kind of skills are needed. The skill debate revolves around two topics: the requested qualifications of individual workers and the issue of skills polarization at the workplace. The focus here is what impacts we can expect for the future of skills in the Dutch manufacturing industry, given the dominant technology and organization.

For estimating short-term impacts (three to five years), extrapolating trends still seems to be the most appropriate method. Other methods such as econometric estimations (Frey/Osborne 2017) or Markov Chain analysis (Kim et al. 2017) are only fruitful for long-term forecasts. The extrapolation method involves assessing the development in a dimension of work and then estimating how the dominant technology and organization will influence the development in that dimension. Trend information in itself is insufficient. It is important to estimate which factors will have more weight on the trend than others. That is why it is important to consider "expert judgement" in order to weigh the development in the trend. If possible, the information should be enriched with calculated information (e. g. extrapolation of time series). The full prediction requires (a) the current trend development in an occupational dimension and (b) the trend extrapolation for that dimension to the short-term future. Other extrapolations are possible but make calculations unnecessarily complex. The advantage of the presented approach is that any deviation from the trend should be made explicit. We only speak of a trend if there is a statistically significant change (or continuity) in a dimension. This approach is illustrated below.

4.2 Impact on skills within jobs

The following two figures below show the differences in required qualifications in two occupations in the Dutch manufacturing industry – for middle managers and packaging jobs – considering different organizational contexts. Organizational context is operationalized at the individual level as described above.

Figures 4 and 5 show that both middle managers and packaging workers in a "full job function" are asked for significantly more social, communicative, STEM and ICT competenci-

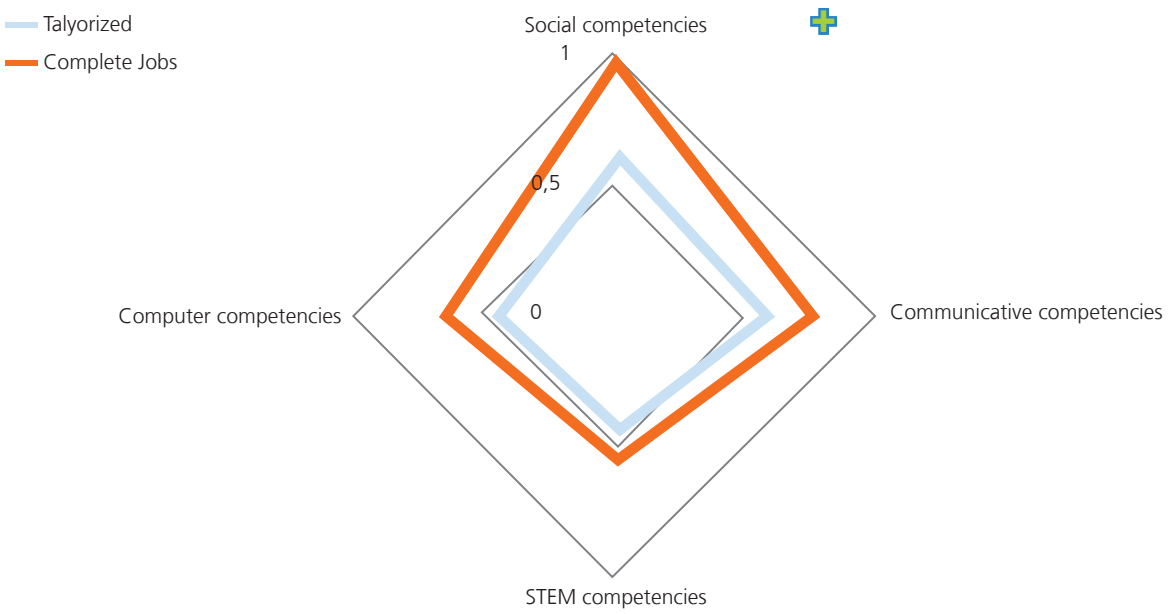


Figure 4: Middle managers: Overview of social, communication, STEM and computer competencies present. Comparison between available competencies according to Tayloristic or complete working context. Differences have been tested for significance (+: p<0.05).

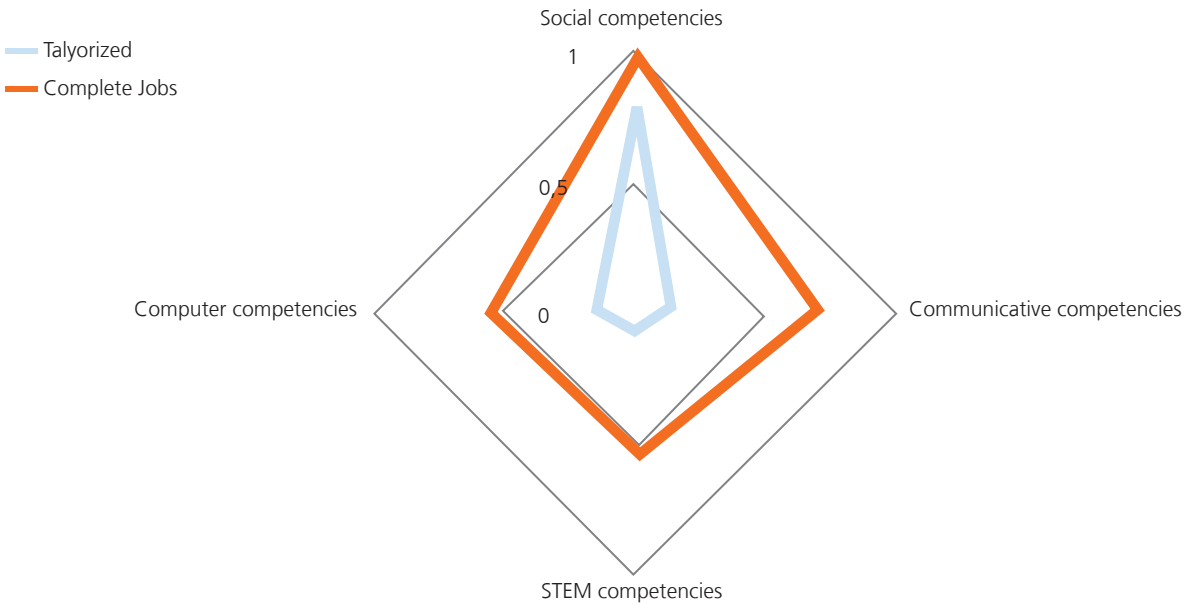


Figure 5: Packaging jobs: Overview of social, communication, STEM and computer competencies present. Comparison between available competencies according to Tayloristic or complete working context. Differences have been tested for significance (+: p<0.05).

es than in a "Taylorized function". If we know that the future degree of Taylorization in the function will increase, then it is clear that in the long term, fewer social competencies will be required for middle managers and fewer requirements will be set for packaging workers at all skill demands. Tayloristic concepts always lead to less reliance on these skills than in organizational concepts with more complete occupations, regardless of the technology used. Probably the type of technology can help strengthen the choice for an organizational context and in that way influence certain impacts.

4.3 Impact on skills distribution between jobs

The second discussion is about polarization of skills at the workplace. Impacts of dominant technology and organization may not be visible within an occupation, but in the relationships between occupations. Therefore, at least a sector view of occupations is required. The changing relationships between jobs can be described as polarization. When looking at skills, the access to and the development of skills may be very different between job categories. To illustrate the polarization effects, we look at the skill distance of the middle managers from the packers. To measure the distance, the level of higher skilled employees in a job is taken as an indicator: the percentage with a bachelor or master's degree. In packaging jobs, this percentage is 7 percent. In the period 2014–17, however, this percentage has significantly risen. In the middle manager jobs, there are 2.4 times more highly educated persons. The expectation is that the dominant technology and organization will not increase this skill polarization. The explanation is that the number of people with a bachelor degree or academic diploma among middle managers has hit a limit: a higher percentage of high-skilled managers seems improbable. If the degree of Taylorization increases, this will further reduce the skills required in both positions: figures 4 and 5 show that more Taylorized positions make less use of the social, communicative, STEM and computer skills. The polarization (i. e. the skill distance) may therefore decrease even more.

5 Conclusion and discussion

This paper proposes an alternative approach to analyzing the impact of digital technology on work in companies and sectors. In the literature, predictions about employment impacts are quite disperse. The main reason why predictions are still unreliable stems from the way in which technology, organization and aspects of work are currently conceptualized. The example of the Dutch manufacturing industry shows that one can arrive at predictions that differ substantially from those by Frey and Osborne (2013). The example of the skill changes within and between jobs was used to illustrate the importance of a new approach to understanding technological and organizational change. The estimations for the Dutch manufacturing industry show that the skill requirements for jobs are very high in non-Taylorized environments, and quite low in Taylorized working environments. The expectation is that dominant technology, the stress on more communication technology, will lead to more Taylorized jobs, reducing the needs for the so-called 21st Century skills. A second result is that there are polarized skill differences between job categories. These differences seem to become less in the future, because of the Taylorization. This is not itself a positive development for jobs, because the overall requirements are lower. Certain jobs will profit more of these changes than the ones covered in this paper.

New to this approach and monitoring system is the conceptualization of technology itself. In contrast to other approaches, a more "contained" approach to technology has been chosen in line with and following the process impact of technology: the impact is different when we talk about the potential of technology, the technology investment strategy and the current technology stock. Five technologies have been mapped and described. The concept allows us to formulate theoretically substantiated conclusions about possible impact. Based on these conclusions, professions in sectors were examined. The model provides a broad impact framework, broader than currently used in the analysis of technological development.

This paper has limited itself to skill differences within jobs and between jobs. In Dhondt et al. (2019), more work dimensions are used, also looking at the extent of employment in occupations, development in the quality of work, consequences for polarization in sectors, and perception of work dimensions. The model allows us to make predictions for the impact of technology on labor.

The task we have set ourselves is ambitious. More work is needed to elaborate and further operationalize the concepts developed in this paper. Most work will be needed on the three technology horizons proposed in this paper. For the research strategy, a combined data collection approach at the company and employee levels will be required. The bottom-line of the paper is that the work on the future of technology and its impact is only starting. Better methods need to be developed. This paper provides the first steps.

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References

Aasen, T.M., Moller, K., Eriksson, A.F., 2013. Nordiske strategier for medarbeiderdrevet innovasjon – 2013. In: Alasoini, T., Amundsen, O., Høyrup, S., Kallevig, A., Philips, A., Reksten, P.M., Sundin, E. (Eds). Nordic Council of Ministers, 62, Copenhagen.

Acemoglu, D., Restropo, P., 2017a. Robots and Jobs: Evidence from US Labor Markets. NBER Working Paper No. 23285, NBER, Cambridge.

Acemoglu, D., Restropo, P., 2017b. The Race Between Man and Machine: Implications of Technology for Growth, Factor Shares and Employment. NBER Working Paper No. 22252, NBER, Cambridge.

Acemoglu, D., Restropo, P., 2018. Low-Skill and High-Skill Automation. Special Issue of Journal of Human Capital.

Agnew, A., Forrester, P., Hassard, J., Procter, S., 1997. Deskilling and reskilling within the labour process: The case of computer integrated manufacturing. International Journal of Production Economics 52(3), 317–324.

Alcacer, J., Cantwell J., Piscitello, L., 2016. Internationalization in the information age: A new era for places, firms, and international business networks? Journal of International Business Studies 47(5), 499–512.

Andrews, D., Westmore, B., 2014. Managerial Capital and Business R&D as Enablers of Productivity Convergence. OECD Economics Department Working Papers, No. 1137, OECD Publishing, Paris.

Arntz, M., Gregory, T., Zierahn, U., 2016. The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. OECD Social, Employment and Migration Working Papers, No. 189, OECD Publishing, Paris.

Atkinson, R.D., Wu, J., 2017. False Alarmism: Technological Disruption and the U.S. Labor Market, 1850–2015. Information Technology & Innovation Foundation ITIF. http://dx.doi.org/10.2139/ssrn.3066052.

Autor, D.H., 2015. Why Are There Still So Many Jobs? The History and Future of Workplace Automation. Journal of Economic Perspectives 29(3), 3–30.

Autor, D.H., Katz, L.F., Krueger, A.B., 1998. Computing Inequality: Have Computers Changed the Labor Market? Quarterly Journal of Economics, CXIII, 1169–1214.

Autor, D.H., Dorn, D., Hanson, G.H., 2015. Untangling Trade and Technology: Evidence from Local Labor Markets. Economic Journal 125(584), 621–646.

Belu, C., 2015. Are distance measures effective at measuring efficiency? DEA meets the vintage model Journal of Productivity Analysis 43(3), 237–248.

Bessen, J., Goos, M., Salomons, A., Van den Berge, W., 2019. Automatic Reaction – What Happens to Workers at Firms that Automate? Discussion Paper, CPB Netherlands Bureau for Economic Policy Analysis, Den Haag.

Bloom, N., Garicano, L., Sadun, R., Reenen, J. van, 2014. The distinct effects of information technology and communication technology on firm organization. Management Science 60(12), 2859–2885.

Borghans, L., Ter Weel, B., 2006. The Division of Labour, Worker Organisation, and Technological Change. The Economic Journal 116(509), 45–72.

Brynjolffson, E., McAfee, A., 2014. The Second Machine Age – Work, Progress, and Prosperity in a Time of Brilliant Technologies. Work, Progress, and Prosperity in a Time of Brilliant Technologies. Norton, New York.

Byrne, D., Corrado, C., 2016. ICT Prices and ICT Services: What do they tell us about Productivity and Technology? Economics Program Working Paper Series (Revised July 2016), The Conference Board, New York.

CBS, 2018. Internationaliseringsmonitor. Statistics Netherlands (CBS), Voorburg.

Child, J., 1972. Organizational structure, environment and performance: the role of strategic choice. Sociology 6(1), 1–22.

Consoli, D., Vona F., Rentocchini F., 2016. That Was Then, This Is Now: Skills and Routinization in the 2000s. Industrial and Corporate Change 25(5), 847–866.

Corrado, C., Haskel, J., Jona-Lasinio, C., Iommi, M., 2012. Intangible Capital and Growth. in Advanced Economies: Measurement Methods and Comparative Results. Discussion Paper No. 6733, IZA, Bonn.

Dauth, W., Findeisen, S., Südekum, J., Wößner, N., 2017. German Robots – The Impact of Industrial Robots on Workers. Technical report. Nuremberg: Institute for Employment Research.

Dhondt, S., Kraan, K.O., 2019. Gids monitoren technologisering en arbeidsmarkt. TNO, Leiden.

Dhondt, S., Kraan, K.O., Preenen, P.T.Y., 2019. Rapport Monitor Technologisering en Arbeidsmarkt. Report R678910 for Institute GAK. TNO, Leiden.

Elbourne, A., Grabska, K., 2016. Evidence on Dutch macroeconomic and sectoral produc¬tivity performance: some stylised facts. Background document, CPB Netherlands Bureau for Economic Policy Analysis, Den Haag.

Felstead, A., Gallie, D., Green, F., Zhou, Y., 2007. Skills At Work, 1986 to 2006. University of Oxford, SKOPE, Oxford.
Frey, C.B., Osborne, M.A., 2013. The future of employment: how susceptible are jobs to computerization? Oxford Martin Programme on Technology and Employment Oxford, University of Oxford, Oxford.

Frey, C.B., Osborne, M.A., 2017. The future of employment: How susceptible are jobs to computerisation? Technological Forecasting and Social Change 114, issue C, 254–280

Gómez, J., Vargas, P., 2012. Intangible resources and technology adoption in manufacturing firms. Research Policy, 41(9), 1607–1619.

Graetz, G., Michaels, G., 2015. Robots at Work. CEP Discussion Paper No 1335, Centre for Economic Performance, London School of Economics and Political Science, London.

Huys, R., 2001. Uit de band? De structuur van arbeidsverdeling in de Belgische autoassemblagebedrijven. Acco, Leuven.

Kim, Y.J., Kim, K., Lee, S., 2017. The rise of technological unemployment and its implications on the future macroeconomic landscape. Futures 87, 1–9.

Kleruj, N., 2017. Nederlandse Skill Survey (NSS) 2017. Vragenlijst afgenomen in het LISS panel. Centerdata, Tilburg.

Kuipers, H., Van Amelsvoort, P., Kramer, E.-H., 2018. Het Nieuwe Organiseren: alternatie¬ven voor de bureaucratie. (3rd. Ed.) Acco, Leuven.

Lorenz, E., Valeyre, A., 2005. Organisational innovation, human resource management and labour market structure: a comparison of the EU-15. The Journal of Industrial Relations 47(4), 424–442.

Maenen, S., 2018. Van Babel tot Ontwerp. Concepten en methoden voor organisatieontwikkeling. Pelckmans Pro, Kalmthout.

McKinsey, 2018. Skill shift. Automation and the future of the workforce. Discussion Paper, McKinsey Global Institute, Brussels.

Meijers, H.H.M., 1994. On the diffusion of technologies in a vintage framework : theoretical considerations and empirical results. Maastricht: Datawyse / Universitaire Pers Maastricht.

Nilutpal, D., Falaris, E.M., Mulligan, J.G., 2009. Vintage Effects and the Diffusion of Time-Saving Technological Innovations. The B.E. Journal of Economic Analysis & Policy 9(1), 1–37.

OECD, 2013a. Supporting Investment in Knowledge Capital, Investment and Innovation. OECD Publishing, Paris.

OECD, 2013b. Technical Report of the Survey of Adult Skills (PIAAC). OECD Publishing, Paris.

OECD, 2015. OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society. OECD Publishing, Paris.

Oeij, P.R.A., Rus, D., Pot, F.D. (Eds), 2017. Workplace Innovation: Theory, Research and Practice. Springer, Cham (Switzerland).

Oudejans, M., 2012. Value and effectiveness of work tasks. Vragenlijst afgenomen in het LISS panel. Centerdata, Tilburg.
Porter, M., 1985. Competitive advantage. Free Press, Boston, MA.

Rindfleisch, A., O'Hern, M., Sachdev, V., 2017. The Digital Revolution, 3D Printing, and Innovation as Data. Journal of Product Innovation Management 34(5), 681–690.

Saia, A., Andrews, D., Albrizio, S., 2015. Public Policy and Spillovers From the Global Productivity Frontier: Industry Level Evidence. Working Paper No. 1238, OECD Economics Department, Paris.

Silva, H. C., Lima, F. 2017. Technology, employment and skills: A look into job duration. Research Policy, 46(8), 1519–1530.

Ter Weel, B., & Kok, S. 2013. De Nederlandse arbeidsmarkt in taken: Eerste bevindingen uit de Nederlandse skills survey [The Dutch labour market in tasks: Preliminary findings from the Netherlands skills survey]. Den Hague, The Netherlands: Netherlands Bureau for Economic Policy Analysis.

Ter Weel, B., 2015. De match tussen mens en machine. Beleid en Maatschappij 42(2),156–170.

Ter Weel, B., Van der Horst, A., Gelauff, G., 2010. The Netherlands of 2040: Thinking Ahead in the Netherlands. CPB Netherlands Bureau for Economic Policy Analysis, Den Haag.

TNS Infratest, 2014. The IAB Establishment Panel. Employment Trends. Employer Survey, Munich.

Trantopoulos, K., Krogh, G. von, Wallin, M.W., Woerther, M., 2017. External knowledge and information technology: implications for process innovation performance. MIS Quarterly 41(1), 287–300.

Van Emmerik, M.L., Vroome, E.M.M. de, Kraan, K.O., Bossche, S.N.J. van den, 2017. Werkgevers Enquête Arbeid 2016; Methodologie en Beschrijvende Resultaten. TNO, Leiden.

Van Helmond, C., Kok, R., Ligthart, P., Vaessen, P., 2018. Veel ruimte voor meer digitali¬sering Nederlandse maakbedrijven. ESB 23(4), 2–3.

Van Roy, V., Vértesy, D., Vivarelli, M., 2018. Technology and employment: Mass unemployment or job creation? Empirical evidence from European patenting firms. Research Policy, 47(9), 1762–1776.

Vergeer, R., Kraan, K.O., Dhondt, S., Kleinknecht, A., 2015. Flexible labour and a firm's labour productivity growth: The importance of the innovation regime. European Journal of Economics and Economic Policies 12 (3), 300–317.

WEF, 2018. The Future of Jobs. Report 2018; Insight Report, World Economic Forum, Centre for the New Economy and Society, Cologny/Geneva.

Zysman, J., Kenney, M., 2018. The Next Phase in the Digital Revolution: Abundant Computing, Platforms, Growth, and Employment. Communications of the Association of Computing Machinery 61(2), 54–63.

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TECHNOLOGY, AUTOMATION AND SKILLS DEMAND FOR THE FUTURE OF WORK

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Abstract

Recent years have seen a surge of future of work studies, spurned by claims that close to a half of jobs in advanced economies may be replaced by Artificial Intelligence technologies. Although the impact of current technologies may differ from the past, what is certain is that automation and digitalisation will continue to affect jobs, skills and wages via complex, interrelated, channels. This paper reviews the available evidence on the impact of technology and automation on jobs and skills. Drawing on data from the Cedefop European skills and jobs survey (ESJS), it highlights how technological change and automation may displace some lower-skilled workers while rendering the skills of the higher-skilled obsolete. About 14 percent of EU jobs are at high risk of substitution by machine learning algorithms, while about 5 percent of EU adult workers are affected by skills-displacing technology that can facilitate job loss. But technological change is primarily a source of job-task transformation and skill development, higher earnings and job satisfaction. Keeping up with a future world of work characterised by more high-tech jobs, and bridging the ongoing digital skills divide, will require modernisation of EU vocational education and training systems.

Key words
Technology, Automation, Artificial Intelligence, Skills, Digital Skill Gaps

1 Introduction

Recent years have seen a surge of new research studies on the future world of work. Much of this literature was spurned by claims that close to a half of jobs in advanced economies may be replaced or automated by machine learning technologies (Frey and Osborne, 2013, 2017), or that we are faced with the "rise of the robots" (Ford, 2014) and we are at a critical turning point where disparate digital technologies are now combining to cause an exponential leap in innovation (Brynjolfsson and McAfee, 2014). Such rhetoric has bred fear that people will either get displaced in their jobs or not be able to find decent work in the new digital age. It is hence perhaps not a surprise that a 2017 Eurobarometer survey revealed that 72 percent of EU citizens fear that robots and AI may "steal people's jobs" (European Commission, 2017).

With so much innovation and change taking place around us – "algos", big data, Artificial Intelligence, Internet of Things, advanced robotics, semi-autonomous cars, 3D printing, smart devices, quantum computing – it is hard not to blame new technology for the high rates of underemployment and social ills affecting European and other advanced Western societies. But history tends to highlight the potential fallacy of doing so. The same way that one of the most celebrated economists of all times – John Maynard Keynes – who eloquently predicted in 1930 that a "new disease" of technological unemployment will afflict societies due to the gains in productivity outpacing or replacing the need for human labour, proved to be too dismal.[2]

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2 "Today we are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely technological unemployment. This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour" (Keynes, 1930).

2 Technology and labour market outcomes

2.1 This time is different

Since the time of Keynes' writings, his grandchildren, as those of many others, have enjoyed sustained growth in employment and prosperity over the long term. Many hence reject fears of robots and machines breeding a jobless future; they argue that technological "alarmism" has featured in all previous industrial revolutions (Autor, 2015), so why should it be different this time round? Although any prediction about the future cannot be definite, there are several reasons however why current technological progress may differ from the past. With the advent of new digital technologies, innovation cycles have become faster. Big data, cloud computing, 3D printing and the platform economy are changing product markets, business models and work and, consequently, skill needs in all sectors. Firms can now engage in rapid product prototyping and marketing, leveraging the power of data analytics and Artificial Intelligence, especially machine and deep learning, processes. Organisations may be less dependent on a core workforce as they can harness the power of the crowd (Brynjolsfsson and McAfee, 2014) and of online (platform) labour (Kassi and Lehdonvirta, 2018). The digital world also allows for fast upscaling of "digital innovators" in winner-take-all markets (Autor et al., 2017).

In the past, new technologies would tend to manifest in cheaper and better products that would spill into higher demand by consumers and hence more jobs. However, in recent decades the link between higher productivity and labour income share has been severed in most EU countries (Karabarbounis and Neiman, 2014). This implies that this time round technological progress may exacerbate wealth inequalities.

And the demographic crunch constitutes a significant threat for the ability of societies to adapt to the changing skill demands of future labour markets, given the greater difficulty for people to upskill and change jobs mid-career. Cedefop's research based on the European skills forecasting model (Cedefop, 2018b) shows that the key factor behind future job openings is not employment growth – it is the ageing of the European workforce. Retirements will constitute the major reason why employers will be searching for available workforce to fill their vacant posts; out of more than 150 million work opportunities between years 2016– 2030, less than 1 of 10 will be created because of a new job opening (Figure 1).

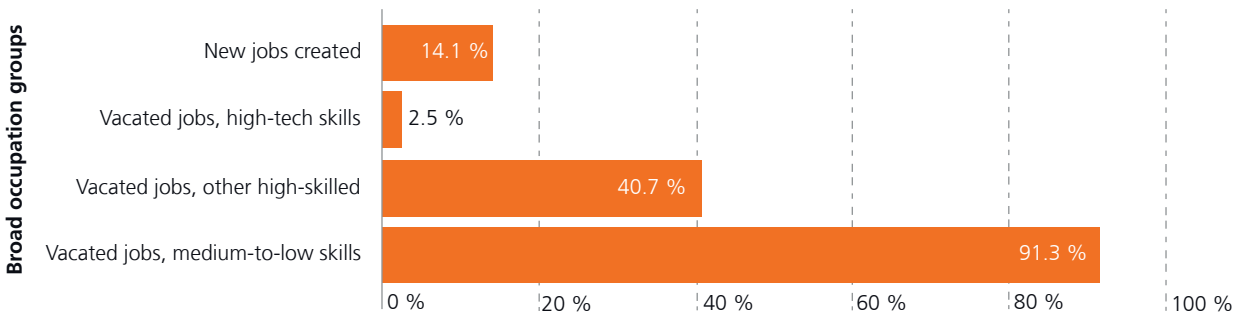


Figure 1: Openings for new and vacant jobs in Europe (2016–2030) – Source: Cedefop Skills Forecast, authors' own calculations

Crucially, although past technological breakthroughs would tend to replace low-skilled, routine, work, one of the distinguishing features of today's computer algorithms is that many high-skilled tasks, including in the health, legal, finance and education industries, may now be performed faster and more efficiently by machines than humans. In particular, AI – which harnesses the capacity of computers and machines to make predictions using large amounts of data and take action in complex, unstructured environments – has the ability to facilitate better decision-making in a wide range of industries, including public administration, education, health care, transport and manufacturing inter alia (Agrawal et al., 2019).

2.2 Measuring the impact of technology and automation

Despite these differences with previous industrial transformations, it is reasonable to expect that automation and digitalisation will continue to impact on jobs, skill needs and wages via complex, interrelated, channels, as has been the case in the past. Measuring the full equilibrium impact of technological progress, including inter- and intra- industrial and occupational spillovers and externalities spurred by the advent of new technologies, is a highly challenging endeavour. The literature has identified several main conduits through which technological change is expected to affect economic growth, productivity and labour market outcomes, described below (Acemoglu and Restrepo, 2019a):

- *Productivity effect*: Technological progress usually fosters higher productivity growth and innovation, given that output (new products or services) can be produced more efficiently for given factor inputs – in this regard, product innovation tends to be job-creating while, inversely, process innovation may be labour-saving (Vivarelli, 2015);
- *Substitution effect*: Usually evident with factor-augmenting technological improvements, which affect labour's share in total employment/wage bill without any changes in the task content of production;
- *Displacement effect*: Typical when automation substitutes machines for people, especially when relative factor prices make capital investments more profitable for firms than using labour, in tasks that humans previously had a comparative advantage in performing them;
- *Reinstament effect*: automation and new technologies will affect the extent to which the task content of workers' jobs changes, raising labour's share and productivity as newly generated tasks exploit the comparative advantage of human input;
- *Equilibrium effects*: New technologies often have unintended side-effects across industries and market compensation mechanisms may ensue: falling input prices may stimulate product demand in non-automating industries; falling wages in one sector may stimulate greater labour supply in another; sectoral reallocations and changing share of value added across sectors may ensue, following automation in one sector, depending on demand elasticities and input-output linkages (Goos, 2018).

Although fully quantifying the above interlinked channels is difficult, most evidence to date has pointed to a positive (or neutral) net employment balance associated with technological innovation (especially R&D and product innovation) (Vivarelli, 2014). However, recent findings on the impact of robot exposure on employment are mixed; while U.S. research (Acemoglu and Restrepo, 2019b) has found a significant negative effect of robot adoption on employment and wages, evidence from Germany (Dauth et al., 2017) and other advanced economies (Graetz and Michaels, 2018) has pointed to positive job creation spillovers across industries. The latter studies, however, have still noted important distributional consequences for wages and work hours among people of different skill and age levels, such as lower-skilled and new labour market entrants in manufacturing industries seeing their wages squeezed due to increasing mechanisation of their job tasks.

More recently, several empirical analyses have widened the scope of analysis beyond the impact of robot adoption on job outcomes, given that robotics is a form of automating technology that predominantly affects only the manufacturing sector in Europe (85 percent concentration), and in particular about half of that penetration affects only the automotive industry (European Commission, 2018a). Interest has hence widened towards the examination of the heterogeneous effects of different types of *new digital technologies* on individual-level employment and wage-dynamics. Fossen and Sorgner (2019), in particular, find in the U.S. job market a significant impact of high computerisation risk on individuals' labour market transitions and deceleration in wage growth, although advances in AI are likely to improve an individual's job stability and wage growth.

Perhaps more concerning for whether ongoing technological advancements will continue to have relatively muted negative effects on employment in the future is the fact that innovation capacity and productivity in recent years seems to have run out of steam – reminiscent of the Solow productivity paradox (Brynjolfsson et al., 2019; Gordon, 2000, 2016). Many economists still recall Nobel laureate Robert Solow's aphorism that "we can see the computer age everywhere but the productivity statistics" (Solow, 1987). In a similar spirit, it has been argued that recent commercial digital innovations tend to rely on "so-so technologies", namely, technologies associated with small productivity improvements but large displacement effects rendering them increasingly labour displacing[3] (Acemoglu and Restrepo, 2018).

3 Automation and skills-displacing technological change

3.1 Impact of technological change in EU labour markets

Even though the digital sector as a whole accounts for a small share (3–4 percent) of total EU employment, the process of digitalisation permeates most economic activities and occupations in labour markets. The recent European skills and jobs survey (ESJS)[4], carried by the European Centre for the Development of Vocational Training (Cedefop), revealed a remarkable degree of innovation going on across the board in EU workplaces. The survey showed that 43 percent of EU workers saw the technologies they use (machines, ICT systems etc.) change in the past five years (or since newer recruits started their current job), while 47 percent experienced changes in their working methods or practices.

More than a half of employees in Finland, Malta, Ireland, Slovenia, Sweden and the UK felt the impact of changing technologies at their work. Contrary to the predictions of job polarisation theory (Autor et al., 2006; Goos et al., 2009), which emphasises that technology and automation are having a detrimental impact on the skill demand of medium- to lower-skilled workers, the occurrence of technological change is evidently more prevalent in high-skilled sectors and occupations, such as the rapidly changing ICT sector, where 57 percent of all jobs have experienced change (Figure 2). Several other high-end economic activities, industrial or not, including gas, electricity and mining (51 percent), financial, insurance and real estate services (51 percent), professional, scientific and technical services (51 percent) and manufacturing (49%), have also experienced widespread technological innovation.

3 Acemoglu and Restrepo (2019a) cite automated customer service ("chatbots") and other recent AI applications as constituting examples of so-so technologies, given that they are generally deemed to be of low quality and unlikely to have generated large productivity gains.

4 The European skills and jobs survey (ESJS), carried out by Cedefop in 2014, is a unique dataset of about 49,000 EU adult paid employees, containing information on their skill formation and skill mismatches, workplace changes and other relevant demographic and socioeconomic characteristics. For further information see https://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey and Cedefop (2015, 2018a).

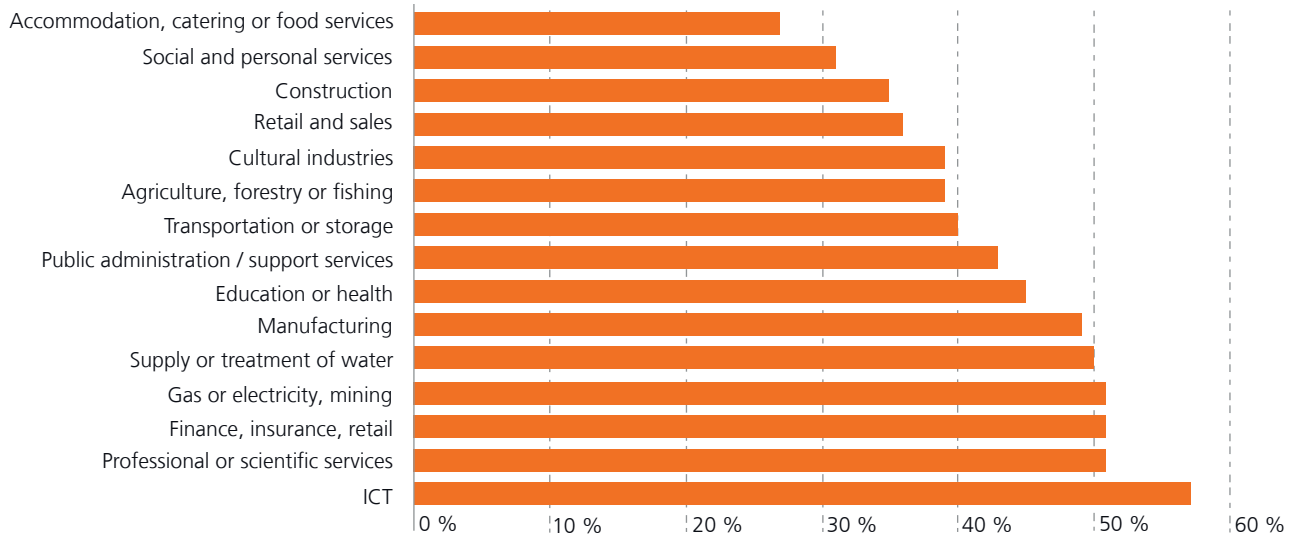


Figure 2: Adult employees (%) with technological change in workplace in last five years by sector, EU28. Notes: Share of EU adult employees who experienced changes to the technologies (machinery, ICT systems) they used in the past 5 years/since they started their main job.Source: Cedefop European Skills and Jobs survey (ESJS) http://www.cedefop.europa.eu/en/events-and-projects/projects/european-skills-and-jobs-esj-survey)

3.2 Estimating the risk of automation for the EU labour market

Given the extent of such technological change, many studies have thus sought to estimate the susceptibility of jobs to automation by correlating the mix of their task characteristics with their likelihood of substitution by robotic or algorithimic processing. In their widely cited study, Frey and Osborne (2013, 2017) argued that 47 % of occupational categories in the U.S. labour market are at high risk of automation. However, Arntz et al. (2017) and more recently Nedelkoska and Quintini (2018) have dismissed such high computerisation risk figures, on the grounds that they potentially exaggerate the extent to which occupations as a whole can be automated. Once the heterogeneity in job tasks within occupational groups is taken into account, a high risk of automation is only evident for about 9–14 percent of jobs, although about one third of all jobs face some smaller degree of task transformation.

Pouliakas (2018) has similarly sought to measure the susceptibility of the EU labour market to algorithmic/AI substitution, building on unique information in the ESJS data on the skill demands of EU employees' jobs[5]. The author finds that jobs most likely to be transformed by automation are typically reliant on routine tasks and with low demand for transversal and soft skills, in particular the 4 Cs of communication, collaboration, creativity and critical thinking (Figure 3). The opposite holds for jobs demanding worker autonomy and more planning and customer-service skills. The hardest to automate seem to be occupations such as care workers; legal & social professionals; CEOs and senior officials; health professionals and teaching professionals. The best possibilities for automation, by contrast, are provided for tasks carried out by assemblers; plant and machine operators; electro-engineering workers; metal and machinery workers and technical labourers.

5 In estimating the risk of automation in EU labour markets, the author uses valuable information on tasks and skills needed within EU employees' jobs, collected by the ESJS. Another key novelty is that the ESJS data allowed for the use of highly disaggregated job descriptions provided by about a third of the employees in the ESJS sample. This information is subsequently matched, using simple text mining, to a selected set of 70 detailed occupations – for which Frey and Osborne (2013) obtained information on their "true" likelihood of automation based on assessment by machine learning specialists. This enabled the author to generate a "training dataset" on which he could estimate the underlying relationship between the "true" automation risk of occupations as a function of the tasks/skill requirements of EU employees' jobs.

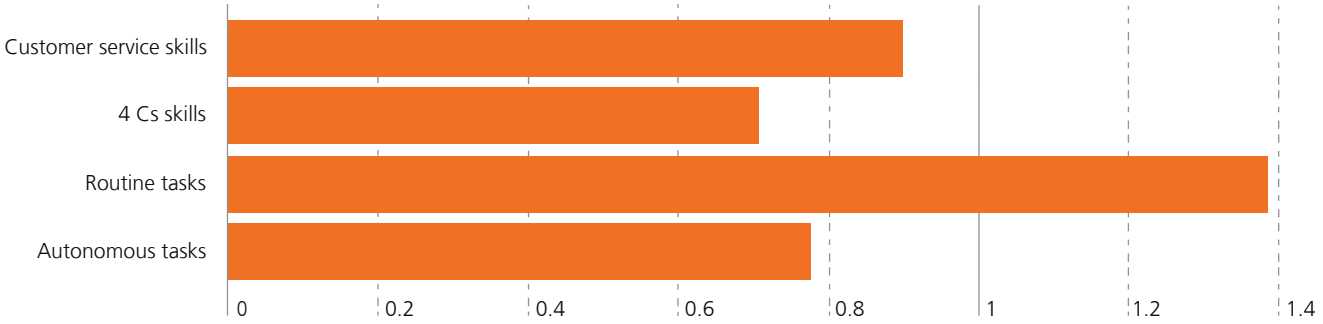


Figure 3: Tasks and skills associated with higher automation risk. Notes: 4 Cs skills = communication, collaboration, creativity, critical-thinking skills; odds ratios shown based on logistic regression – a value higher than one implies higher odds of automatability. Source: Pouliakas (2018)

Using estimates of the underlying relationship between jobs' skill requirements and their discrete chance of being automated, as evaluated externally by machine learning experts, Pouliakas (2018) subsequently extrapolates the predicted probability of automation from a "training sample" to the whole universe of EU jobs. He finds that only 14 percent of EU jobs (amounting to about 30 million jobs) are faced with a very high risk of automation, as the majority of their tasks can be substituted by machine learning algorithms (Figure 4). For approximately 18 million EU workers the risk is severe, as their employers also fail to provide any accommodative training (as measured by the ESJS) – further accentuating their vulnerability. Even though AI and automation may not primarily destroy jobs, it is likely to transform them: for 4 in 10 EU jobs part of their tasks and skill demand set will be automated, entailing new skill needs to complement AI technologies.

Workers in jobs with high automation probability are found to bear significant negative labour market consequences, such as fearing that they will lose their jobs and suffering from lower job satisfaction. Employees in highly automatable jobs are also found to receive about 3.5 percent lower hourly wages than those with similar sets of skills in lower-risk jobs (ibid., 2018). In a similar spirit, Bessen et al. (2019) confirm the negative outcomes of automation; they detected greater job separation rates and cumulative wage losses due to fewer annual days worked (though no effect on wage rates) among incumbent Dutch workers affected by significant automation spikes in their firm.

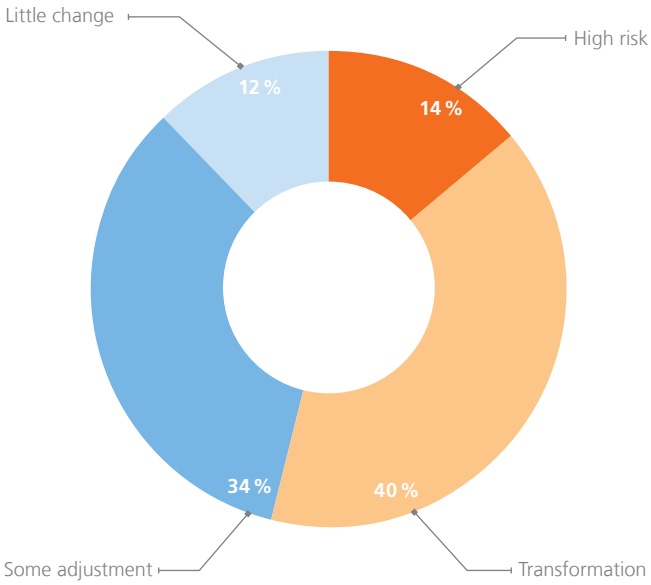


Figure 4: Share of EU workers at risk of automation. Notes: Automation clusters are defined according to the estimated range of the probability of automation as follows: High risk = over 70 percent automation probability; Transformation = 50–70 percent; Some adjustment = 30–50 percent; Little change = below 30 percent. Source: Pouliakas (2018)

3.3 Measuring skills-displacing technological change

Despite the focus of most research and public media on individuals with middle and lower skills, recent research based on Cedefop's ESJS data has further sought to capture which part of technological change that affects workers may actually result in displacement of part of their skills set (McGuinness et al., 2019). Not all technological change is skills-displacing and, in fact, recent evidence has tended to increasingly focus on the fact that new digital technologies typically generate new job titles and tasks – the reinstatement effect mentioned in section 2 above (Acemoglu and Restrepo, 2019a). The study of McGuinness et al. (2019) confirms that not all technological change transpires into changing skill needs at the workplace; about one third (36 percent) of EU adult workers recently affected by changing technologies at their workplace consider it very likely that part of their skillset will become obsolete in the next 5 years. For the remaining part of the sample, technological change is likely to be skills-neutral – changing the way a worker performs their job tasks but without entailing a marked deviation in the skills demanded to carry them out.

On average, 16 percent of EU workers – ranging from 28 percent in Estonia to less than 5 percent in Bulgaria – are impacted by technological change that may render their skills outdated, and a smaller share of about 5 percent fear that such skills-displacing technology will materialise into imminent job loss (i.e. they may lose their jobs in the next year). And contrary to the above-mentioned risk of automation studies, skills-displacing technology is found to typically affect highly educated workers and is associated with high-skilled jobs that undergo significant task transformation and provide upskilling opportunities (Figure 5).

Hence, despite recent technological alarmism that has focused on the job-destroying potential of technological innovation (Mokyr et a., 2015), the above evidence highlights that technological change can be a source of job transformation and a generator of skill development, higher earnings and job satisfaction. It is nevertheless still associated with higher perceived job insecurity among workers, highlighting the need for policymakers to be wary of the contrast between the tangible benefits and intangible costs for societal welfare induced by technological change.

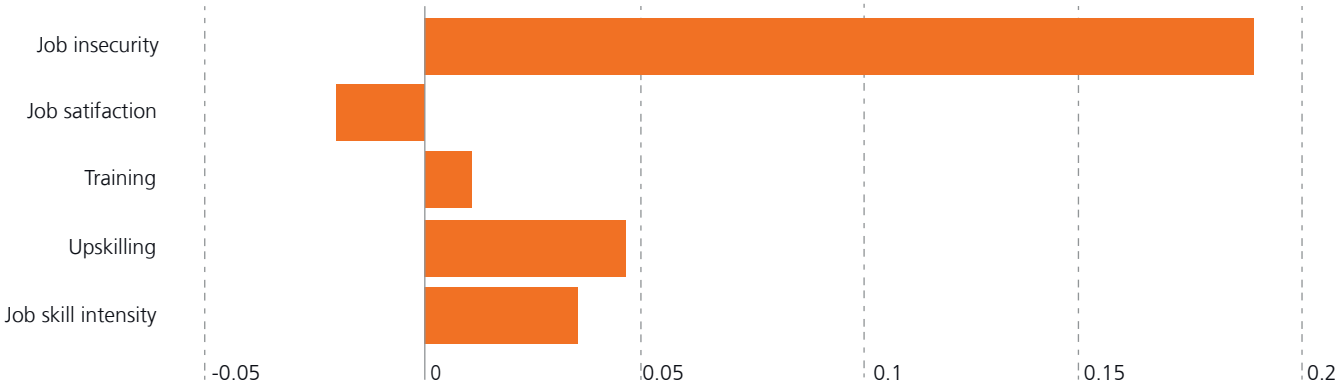


Figure 5: Impact of skills displacing technological change on jobs and skills. NB: Difference in probability between EU adult workers affected by skills-displacing technology vs. those not affected, based on estimation of probit model using ESJS data. Source: McGuinness, Pouliakas and Redmond (2019)

4 How will future skill demand evolve in the EU?

Cedefop's European Skills Forecasts looks at the future employment trends by sector and occupation in the period 2016–2030, taking into account a whole array of external drivers including GDP growth, sectoral restructuring, demography and labour supply bottlenecks in addition to technological advancements (Cedefop, 2018b). As testament to the growing impact of digitalisation in EU economies, the forecast model predicts that IT, science & engineering professionals, which Cedefop also refers to as "high-tech occupations", are expected to grow the fastest and their growth can be linked to growing innovation expenditures and further adoption of digitalisation technologies (Figure 6).

Other high-skilled occupations, such as medical doctors, teachers or business and administration professionals are also expected to benefit from greater job creation. This may be linked to technological progress and greater digitalisation, as it is an enabler of their future employment growth and since the nature of their tasks is such that it renders them relatively insulated from automation. Sales and service workers are also expected to experience growth. Their outlook with regard to technology adoption is, however, mixed: occupations like cashiers and clerks are more prone to automation than, for example, care workers or hairdressers.

The picture is clearer for skilled manual workers, for whom the model predicts some job losses. In accordance with the aforementioned predictions of where most of automation will take effect, given that such jobs usually entail a lot of routine/technical tasks that can be carried out in a controlled environment, giving robots and machines a comparative advantage, the model predicts that 3 percent of medium-skilled jobs will decline. This modest reduction in employment at the middle of the occupational distribution seems to highlight the importance of taking into account the broader labour market context (e. g. wages, labor scarcity, ease of substitution between different labour types, etc.) when making predictions about the future impact of automation on jobs and skills.

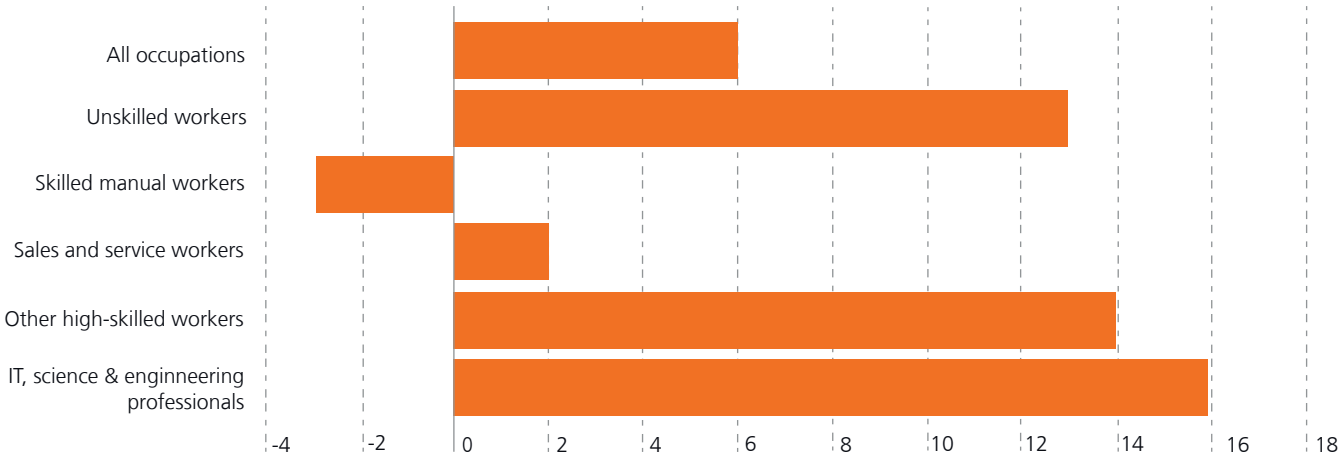


Figure 6: Cedefop's forecasts of employment growth (2016–2030, in %). Source: Cedefop Skills Forecasts, authors' own calculations

5 Digital skill gaps of the EU labour force

As the demand for more high-tech jobs increases and technology transforms jobs, the question is if an ageing EU population has or will be able to acquire the skills needed to find good jobs in the digital age. If not, who will be on the wrong side of the "digital divide"?

Cedefop's ESJS has showed that more than 80 percent of adult workers in the EU need a fundamental level of digital competence to perform their jobs (Cedefop, 2018a). Despite this spread of technology and high ICT skill demand, 43 percent of them lack basic digital skills or do not use the Internet (European Commission, 2018b) and around one third of EU workers are at risk of digital skills gaps (Pouliakas, 2016). A worryingly high share of the EU workforce is also excluded from the digital economy; 56 percent of workers in elementary occupations, 33 percent in agriculture, and 25 percent in service and market sales do not need even basic ICT skills in their jobs.

Some groups are further disadvantaged in their ability to keep up with the digital technologies of their jobs (Figure 7). Women, older-aged and lower-educated workers, as well as professionals in high skill-intensive jobs who need to update their skills continuously, have a higher likelihood of digital skill gaps. Enterprises are more likely to provide continuing training for employees at risk of digital skill gaps, irrespective of their level of education. This highlights the relevance of vocational training for mitigating skill gaps.

The ESJS evidence further highlights that to keep up with digital developments, simply improving digital literacy is not enough. The data shows that adults in jobs that require at least moderate level ICT skills also require a strong level of complementary skills, such as foundation skills (literacy, numeracy), soft skills (planning and organisation) and behavioural skills (communication and teamwork). Jobs requiring advanced ICT skills (e.g. programming and coding) also depend heavily on people being able to solve problems, learn, adapt and apply new methods and technologies (Cedefop, 2018a).

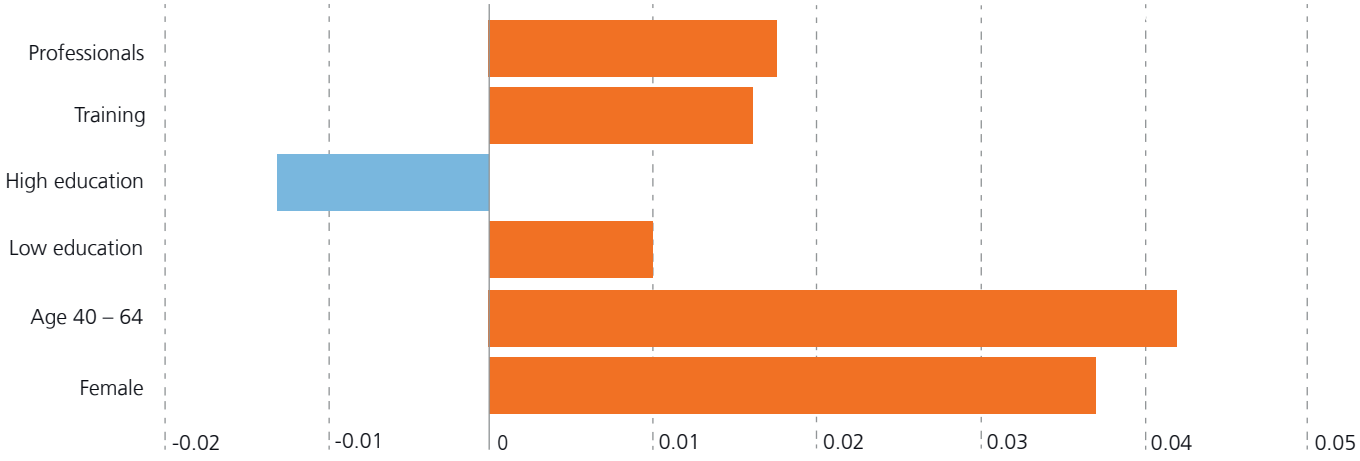


Figure 7: Risk of digital skill gap, adult workers, EU28. Notes: Estimated probability (based on probit model) of an average EU worker reporting that his/her skills are lower than those needed to carry out the level of digital skill needed by their job. Source: Pouliakas (2016) based on Cedefop European skills and jobs survey

6 Conclusions

Much of the existing research and popular media has focused on the substitution or displacement effects of technological change. In doing so, it has generated and sustained a "false dichotomy" about the impact of technological progress on labour market outcomes (Acemoglu and Restrepo, 2018). In particular, it has side-tracked the debate from a fuller understanding of the impact of technological change on labour and skill demand and its associated effect on labour productivity. As acknowledged and recently modelled by Acemoglu and Restrepo (ibid, 2019a), the history of automation and technological change in the 19th and 20th centuries has been one of task (re)generation, whereby the task content of production has been expanded.

In addition, the debate has generally been weak in fully acknowledging the extent to which incentives for automation and digitalisation are affected by the overall labour market context, interplay of different macrosocial drivers and underlying competition, industrial and vocational training policies.

For instance, a strong wave of automation in the automotive sector in Europe has already taken place in previous years, so with slowing median wage growth across Europe it may be the case that EU companies will have fewer incentives to automate their production lines further in the medium-term. For many medium- and lower-skilled workers and in some of the EU's weakest labour markets, investment in automation may also be less profitable due to low unit labour costs. In addition, immigration to Europe may continue to provide a strong supply of workers often employed in manufacturing and low-skilled jobs (Cedefop, 2011) – further compressing wages and incentives for replacing capital for labour across some EU firms. Furthermore, attitudes and shared investment in continued vocational training and learning differs markedly across EU countries (Cedefop, 2019a), affecting their ability to ensure a continued supply of well-trained personnel that can become complements to machines and/or adjust to them via effective reskilling policies.

Overall, predictions of the extent to which there will be job destruction due to automation involve a high degree of uncertainty and speculation. What seems certain is that with many advanced economies fundamentally struggling with low productivity, the advancement of digitalisation and AI holds significant promise for expanding efficiencies and new economic activities or markets. But policymakers face a key challenge in ensuring that individuals can transition from a "semi-analogue to a digital world" with as little disruption as possible.[6] Modernising education and lifelong learning systems is admittedly a critical parameter of the equation. Building high quality skills anticipation systems for making better policy decisions by also harnessing the power of digitalisation, such as via the extraction of real time data on emerging jobs and in-demand skills, is another one (Cedefop, 2019b).[7] In ensuring the move towards a new desirable "future of work", such as a post-work or full employment society instead of polarised labour markets, skills and reskilling policies cannot do it alone however; a whole arsenal of innovation, competition, employment and wage policies will have to be implemented, together with forward-looking skills strategies, to ensure equitable and widespread access of people to the opportunities of the I.4.0 era.

6 Cedefop has recently risen up to this challenge by setting up a new "Digitalisation and Future of Work" thematic activity. It aims to provide a more nuanced narrative and informed insight into the opportunities made available by ongoing technological advances. A key output of this initiative is the launch in 2019 of the 2nd European skills and jobs survey, which will collect new data on the impact of digitalisation and automation on EU workers' jobs and skills. Cedefop has also set up in 2019 a new pan-European Online Vacancies Analysis Tool for Europe (Cedefop, 2019b), which collects information from online job vacancies using AI methods to explore employers' emerging skill needs in EU countries.

7 When building such systems, policymakers must however put in place safeguards so that there is adequate trust, transparency and governance in the interpretation and use of AI-generated intelligence in policy decisions.

Indeed, whether job creation or destruction will prevail as a result of new technologies will depend on a number of factors, notably whether R&D investments will continue to breed product innovation, which is job friendly, as opposed to embodying them in capital goods (machinery and equipment) (Vivarelli, 2014). It is also critical that new innovation feeds into falling unit costs and prices and superior services, which will stimulate buoyant demand in product markets. This intrinsically depends on preserving a healthy degree of competition in markets, preventing oligopolistic/monopolistic practices. It will be shaped by the regulatory and institutional infrastructure as well as social barriers put in place by humans. For example, the wider proliferation of models of employee shared capital ownership, or stronger collective bargaining institutions, could enable humans to enjoy more hours of leisure in the future, ultimately reducing inequality and technological unemployment created by just a few people "owning the robots" (Freeman, 2014).

It is also clear that the widespread transformation of the future world of work will depend on how EU governments manage the potential displacement and skills obsolescence of those affected by digitalisation and automation – and this will require policy actions across the full spectrum of skill levels – low, medium and high. The reform of vocational education and training (VET) systems in Europe will, in particular, play a key role in terms of enabling individuals to meet emerging skill needs in labour markets, spurred by digital and AI technologies. Ultimately, the extent to which technological progress translates into a jobless society will depend on the effectiveness with which education and training reforms will empower individuals' digital and human literacies and other key competencies, rendering them "robot-proof" (Aoun, 2017; Cedefop, 2019c).

References

Acemoglu, D. and Restrepo. P. (2018). "Artificial Intelligence, Automation and Work", NBER Working Paper No. 24196.

Acemoglu, D. and Restrepo. P. (2019b). "Robots and jobs: Evidence from US labour markets", Journal of Political Economy, forthcoming.

Acemoglu, D. and Restrepo. P. (2019a). "Automation and New Tasks: How Technology Displaces and Reinstates Labor." Journal of Economic Perspectives, 33 (2): Vol. 33, No.2, pp. 3–30.

Agrawal, A., Gans, J. and Goldfarb, A. (2019). "Prediction, Judgment, and Complexity: A Theory of Decision-Making and Artificial Intelligence", The Economics of Artificial Intelligence: An Agenda, Chicago: The University of Chicago Press.

Aoun, J.E. (2017). Robot-proof: Higher education in the age of Artificial Intelligence, The MIT Press.

Arntz, M., Gregory, T. and Zierahn, U. (2017). "Revisiting the Risk of Automation". Economics Letters, Vol. 159, pp. 157–160.

Autor, D.H, Katz, L. and Kearney, M. (2006). "The Polarization of the US Labor Market", American Economic Review, Vol. 96, No. 2, pp. 189–194.

Autor, D.H. (2015), "Why are there still so many jobs? The history and future of workplace automation", The Journal of Economic Perspectives, Vol. 29, No. 3, pp. 3–30.

Autor, D.H. Dorn, D., Katz, L.F., Patterson, C. and Reenen, J.V. (2017). "The Fall of the Labor Share and the Rise of Superstar Firms". NBER Working Paper No. 23396.

Bessen, J.E. et al. (2019). "Automation reaction – what happens to workers at firms that automate?" CPD Discussion paper, February.

Brynjolfsson, E., & McAfee, A. (2014). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. New York: WW Norton & Company.

Brynjolfsson, E. Rock, D. and Syverson, C. (2019). "Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics" in Agrawal, A., Gans, J. and Goldfarb, A. (2019). The Economics of Artificial Intelligence: An Agenda, Chicago: The University of Chicago Press.

Cedefop (2011): Labour-market polarisation and elementary occupations in Europe. Cedefop research paper No. 9, Luxembourg: Publications Office.

Cedefop (2015). Skills, qualifications and jobs in the EU: the making of a perfect match? Evidence from Cedefop's European skills and jobs survey. Luxembourg: Publications Office.

Cedefop (2018a). Insights into skill shortages and skill mismatch: learning from Cedefop's European skills and jobs survey. Luxembourg: Publications Office.

Cedefop (2018b). Skills forecast: trends and challenges to 2030, Luxembourg: Publications Office.

Cedefop (2019a). Continuing vocational training in EU enterprises: developments and challenges ahead. Luxembourg: Publications Office. Cedefop research paper; No 73.

Cedefop (2019b). Online job vacancies and skills analysis: a Cedefop pan-European approach. Luxembourg: Publications Office.

Cedefop (2019c). Artificial or human intelligence? Digitalisation and the future of jobs and skills, Cedefop Briefing note no. 9140, June.

Dauth, W. et al. (2017), "German robots-the impact of industrial robots on workers", IAB DP 30/2017.

European Commission (2017). Attitudes towards the impact of digitalisation and automation on daily life, special Eurobarometer 460, March.

European Commission (2018a): "Less labour, more capital? Existing evidence". In: Employment and Social Developments in Europe. Annual Review 2018. Luxembourg: Publications Office of the European Union.

European Commission (2018b). Human capital: digital inclusion and skills. In Digital Economy and Society Index Report. https://ec.europa.eu/digital-single-market/en/news/digital-economy-and-society-index-2018-report

Ford, M. (2015). Rise of the robots: technology and the threat of a jobless future, Basic books: New York.

Fossen, F.M. and Sorgner, A. (2019). "New Digital Technologies and Heterogeneous Employment and Wage Dynamics in the United States: Evidence from Individual-Level Data", IZA DP. No. 12242.

Freeman, R.B (2014). "Who owns the robots rules the world". IZA World of Labor 2014: 5.

Frey, C. and Osborne, M. (2013), The future of employment: how susceptible are jobs to computerisation, University of Oxford.

Frey, C. and Osborne, M. (2017), "The future of employment: how susceptible are jobs to computerisation", Technological Forecasting & Social Change, Vol. 114, pp. 254–280.

Goos, M. (2018). "The impact of technological progress on labour markets: policy challenges", Oxford Review of Economic Policy, Volume 34, No. 3, pp. 362–375

Goos, M., Manning, A., Salomons, A. (2009). "Job polarization in Europe", American Economic Review, Vol. 99, No. 2, pp. 58–63.

Gordon, R.J. (2016). The Rise and Fall of American Growth, New Jersey: Princeton University Press.

Gordon, Robert J. (2000). "Does The "New Economy" Measure Up To The Great Inventions Of The Past?". Journal of Economic Perspectives. Vol. 14, No. 4: pp. 49–74.

Graetz, G. and Michaels, G. (2018). "Robots at Work", The Review of Economics and Statistics, Vol.100, No. 5, pp. 753–768.

Karabarbounis, L. and Neiman, B. (2014). "The Global Decline of the Labor Share", The Quarterly Journal of Economics, Volume 129, Issue 1, pp. 61–103.

Kassi, O.A. and Lehdonvirta, V. (2018). "Online Labour Index: Measuring the Online Gig Economy for Policy and Research", Technological Forecasting and Social Change. Vol. 137, pp. 241–248.

Keynes, J.M. (1930). Economic possibilities for our grandchildren (1930). Essays in persuasion. New York: W.W.Norton & Co., 1963, pp. 358–373.

McGuinness, S., Pouliakas, K. and Redmond, P. (2019). "Skills-displacing technological change and its impact on jobs: challenging technological alarmism?, research paper, Economic and Social Research Institute, Dublin.

Mokyr, J., C. Vickers and N. Ziebarth (2015). "The History of Technological Anxiety and the Future of Economic Growth: Is this Time Different?" Journal of Economic Perspectives, Vol. 29, pp. 31–50

Nedelkoska, L. and G. Quintini (2018). "Automation, skills use and training", OECD Social, Employment and Migration Working Papers, No. 202, OECD Publishing, Paris.

Pouliakas (2016). The great divide: Digitalisation and digital skill gaps in the EU workforce, #ESJsurvey Insights No 9, Cedefop, Thessaloniki, Greece.

Pouliakas, K. (2018). "Automation risk in the EU labour market: a skill-needs approach", in Hogarth, T. (ed) Economy, employment and skills: European, regional and global perspectives in an age of uncertainty, Quaderni series, Rome: Fondazione Giacomo Brodolini.

Solow, R. (1987). "Growth theory and after", Nobel Prize lecture, available at: https://www.nobelprize.org/prizes/economic-sciences/1987/solow/lecture/

Vivarelli, M. (2014). "Innovation, employment and skills in advanced and developing countries: a survey of the literature", Journal of Economic Issues, Vol. 48 (1), pp. 123–154.

Vivarelli, M. (2015). "Innovation and employment", IZA World of Labor, Vol. 154.

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EDITORIAL NOTES

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