Digital Transformation of Software Development: Implications for the Future of Work

Samuli Laato, Matti Mäntymäki, Teemu Birkstedt, A. Islam, Sami Hyrynsalmi

Digital transformation of software development: Implications for the future of work

Samuli Laato[1[0000-0003-4285-0073]], Matti Mäntymäki[1], Teemu Birkstedt[1], A.K.M. Najmul Islam[1,2], and Sami Hyrynsalmi[2]

[1] University of Turku, Vesilinnantie 5, 20540 Turku, Finland
[2] LUT University, Lahti/Lappeenranta, Finland
sadala@utu.fi, matti.mantymaki@utu.fi, teemu.birkstedt@utu.fi, najmul.islam@lut.fi, sami.hyrynsalmi@lut.fi

Abstract. In this work we explore digital transformation in software development. A set of interviews were conducted among industry experts to identify and elucidate the drivers and trajectories of digital transformation within the software industry. Using the Gioia method for qualitative analysis and synthesis, two major trajectories were found: (1) automation increasingly impacts several key activities related to software development; and (2) the importance of software and digital products is increasing in sectors where the core product or service has not traditionally been software-intensive. The findings have implications for the future of work in the context of software business. First, software developers and operators are increasingly needed, and more heavily involved across industry sectors. Second, as the level of automation becomes higher, the roles of automated testing and governance are highlighted, meaning a significant portion of development time will be spent in creating and validating automated tests. Third and finally, the importance of digital skills will increase also in non-IT roles as digital elements infuse into traditionally physical goods and services.

Keywords: Digital Transformation, Artificial Intelligence, Software Business, Software Development, automation, Future of work

1 Introduction

The transformative power of new engineering accomplishments has been known for decades [27, 29]. Advances in information technologies (IT) and automation enable various industry sectors to streamline their processes and operate more efficiently [10]. However, despite a certain technology existing, it may be too expensive to adopt it into use in the industry. Careful review and balancing is needed by decision makers in which technologies are practical and applicable [7]. It is therefore crucial for businesses to understand the current trends in software business and development for making informed decisions, in particular when choosing optimal strategies in the context of digital transformation. The body of academic literature on digital transformation is huge, largely due to the complexity and ever changing nature of the phenomenon [27]. Still, surprisingly few works focus on the digital transformation of software development,

and recent studies have called for more research on the topic [3]. One reason for this may be that software development is typically viewed as a driver of digital transformation, not its recipient.

Among pertinent transformative trends in software engineering are cloud computing [2] and artificial intelligence (AI) [10]. Cloud computing is a key technological driver of digital transformation of businesses, as it accelerates software production and supports key digital activities. In recent years, cloud computing platforms such as Google Cloud, Microsoft Azure and Amazon Web Services (AWS) have gained significant traction, have revolutionized the way software is written, and hence, also influenced the skill requirements of software engineers. Despite this paradigm shift, cloud computing remains a small but growing part of the overall software business landscape [4]. Another major trend largely discussed in the digital transformation literature is AI [20]. It has also been predicted by futurists and technology forecasters to be an unprecedented transformative technology [9, 10, 12]. Accordingly, it also has influence on the way software engineers operate and write software. Other impactful categories of technologies include blockchain and data analytics [1] among others.

To evaluate the impact of transformative trends on software development and related business, it is important to identify the key drivers and trajectories of digital transformation in software development. This facilitates an enhanced understanding of the implications of digital transformation on the work of software engineers and data scientists. In doing so, our work contributes to the literature on the digital transformation of software development [3, 15] and the transformation of work of software professionals [18]. We summarize the purpose of this study with the following research question:

What are the main drivers and trajectories of digital transformation of software development and what implications do they have on the work and roles of software professionals?

The rest of this study is structured as follows. First, we go through the previous literature on the digital transformation and the role of software in it. Then we present the materials and methods for our empirical study followed by the results. We discuss the key findings and implications of our results, limitations and future work.

2 Background

2.1 Digital transformation

Digital transformation can be defined as "a process where digital technologies create disruptions triggering strategic responses from organizations that seek to alter their value creation paths while managing the structural changes and organizational barriers that affect the positive and negative outcomes of this process" [27]. While certainly digital technology plays a crucial role in this process, scholars have argued that the primary driver of digital transformation is company strategy, not technology [17, 26]. Indeed, as new technologies and opportunities to use technology emerge, almost all industry sectors need to stay alert and explore how they can utilize and exploit the available opportunities [24]. Adopting new technologies on their own is not enough,

but holistic changes throughout the company are needed. This means significant changes to the workforce.

According to Matt et al. [24], there are four dimensions in digital transformation that companies need to consider: (1) use of technology; (2) changes in value creation; (3) structural changes; and (4) financial aspects. Building of these four dimensions Hess et al. [16] elaborate on 11 key decisions that companies need to make when evaluating their strategy. They expand on (1) the use of technology to cover the aspects of whether the company is the enabler or supporter of IT and what is the level of their technical ambition [16]. For (2) the changes in value creation, they open it up to cover how diverse the company wishes to be in their adoption of available digital tools, what revenue model they will select, and what the scope of their future business is [16]. For (3) structural changes, they name the following decisions: who is responsible for the digital transformation within the company, will the digital technologies be integrated or separated, what will be the focus in their operation, and what competencies they need to build [16]. Finally, they clarify the fourth dimension (4) with the two aspects of what is the current level of financial pressure they have, and who will be financing the transformation [16]. In summary, as new technologies and opportunities surface, companies need to operate within the specified dimensions. The digital transformation is never finished, and rather, is a gradual process that evolves over time, and with technology.

2.2 Digital transformation in software engineering

Among pertinent technologies in software engineering, AI has received a lot of attention lately. While there is a lot of hype going on around AI and its promises [6, 10], recent work has also framed AI as just one technology among others that supports companies' existing business strategies [6]. Thus, even though there is public interest towards AI and many promises of disrupting effects [12], it takes time, advances in AI research and related infrastructure among other factors for the promises to manifest [6]. Other technologies besides AI that currently are predicted to drive the digital transformation of companies are blockchain, cloud computing and data analytics [1]. These four are intertwined in many ways, as data-focused operations support both analytics and AI. Subsequently AI, with the exception of e.g. rule-based systems and reinforcement learning, are trained with data. Cloud platforms are able to support the development of AI solutions, and blockchain can be a way to store, access and manage information. Furthermore, approaches in software development such as DevOps also heavily influence how IS projects are carried out [15]. All in all, it seems that for a reliable analysis on the currently relevant digital transformation of software development, a holistic approach that covers a wide range of technologies and development practices is needed.

Despite the technology existing to automate production to a high degree, most current factories with complex machinery still require human operators. Only certain straightforward systems such as warehouses have been fully automated [5]. There are several reasons for this. First, the tasks machinery would be required to do may still be too difficult to fully automate. Second, human labour can in some cases be so cheap that replacing it with a machine is not worth the investment. Third, transformation of a

business towards automation is not straightforward. Several barriers exist from employee rights and ethical issues to risks associated with heavy reliance on automation. For example, AI addresses in particular the first given reason, as it enables automating tasks that otherwise could not be automated. The resulting increased automation capability adds to the relevance of the third reason, as major organizational changes do not happen overnight [16, 24].

Automating processes requires scalable technologies. For example, AI is reliant on several technologies, including software such as development platforms and learning algorithms, and hardware such as processing capability, data storage, cooling systems and on a yet more fundamental level components such as CMOS transistors and their raw materials [28]. Therefore, it is unsurprising that only lately AI has been considered as a disrupting technology (e.g., [10, 23, 25]) despite basic machine learning algorithms being created already during the last millennium. From here we can predict that as the fundamental technological infrastructure develops, technologies operating at a higher abstraction level will become more relevant.

3 Materials and methods

Previous work on digital transformation of businesses has utilized existing real world cases to accrue knowledge (e.g. [6, 12, 16]). Here, our aim was similar in that we wanted to obtain knowledge from high level professionals who have been working in the industry or academia, overseeing, developing, or otherwise experiencing the impact of AI, automation and the digital transformation. To this end, we collected data from expert informants through interviews [8]. We chose this approach, because any industry transition or disruption is a complex process, and to understand it, a plethora of data sources are needed. Experts are able to provide this data in an already processed and synthesized form, and are thus suitable and valuable informants.

To answer our research question *"What are the main drivers and trajectories of digital transformation of software development and what implications do they have on the work and roles of software professionals?"* we came up with three interview themes. These were (1) changes in the software business and software development, (2) drivers of change, and (3) the role of the change drivers in software development.

3.1 Data collection

We wanted to ensure that the research participants had sufficient expertise to provide comprehensive insights about the studied phenomena. Thus, we agreed on specific expertise criteria which participants had to fill in order for them to qualify for interviews. First, they had to have worked in a responsible position in the software business or software education at least during the entirety of the past five years. Second, their work had to be related to data science or software development. Third, we sought to recruit people in leading positions, and people in unique positions with respect to one another

to obtain diverse perspectives into the studied phenomena. With these criteria, we recruited 10 participants for in-depth interviews. Participants were found utilizing the extended networks of the authors.

The participants were interviewed in an online video call for 45 minutes to 90 minutes in a semi-structured fashion by the first author. The interviews took place in the first quarter of 2021. All interviews were recorded and subsequently transcribed. Notes were also taken during the interviews, which totalled 20 pages (A4). Descriptive information of the participants is displayed in Table 1. To protect participant anonymity, only general level information is given.

Table 1. Study participants

Title	**Description**	**Company**
1. Professor	Responsible for AI education at the university. Expertise on the societal impact of AI.	University A
2. Professor	Listed among the top authorities within the IT field in his country.	University B
3. Principal data scientist	Experience in leading and developing data science and AI related projects.	International software consulting corp.
4. Insurance mathematician	Expertise on statistical methods and ML. Has been present and seen the company transition towards AI tools.	International insurance company
5. Analytics & AI consultant	20+ years of experience on analytics & AI in the industry.Top consultant for AI companies.	Several startups
6. Software architect	Responsible for the development and operation of both new systems and legacy products within the company.	Nation-wide food chain
7. Competence lead	Experience on overseeing and consulting projects primarily in the health sector.	International software consulting corp.
8. Chief technology officer	Experience as a software developer and recently as a technology leader in the company.	Nation-wide IT-focused business
9. Professor	Listed among the top authorities within the IT field in his country.	University C
10. Business lead	Responsible for overseeing the development, testing and production of embedded products shipped in the millions.	International IT-focused business

3.2 Analysis

For analysis, we utilized the Gioia method, which is designed to bring rigor and structure into qualitative data analysis [14]. The Gioia method uses semi-structured interviews as its primary data source, but can also manage external data [14]. The method has been successfully used in recent work in the IS field (e.g., [22]), which makes it applicable in the current case.

The analysis process was as follows. First, we familiarized ourselves with the interview content by watching the recordings of the interviews and reading the notes made during the interviews. Based on the familiarization process we listed 1st order concepts that appeared in multiple interviews and were related to the research question of the study. Guided by trends disclosed by the expert participants and prior literature, we connected these concepts into second order categories. Here in particular, we looked to connect the 1st order concepts to the discussed trends of AI, cloud computing [1] and the DevOps paradigm [3] that have been highlighted as important trends in software business by recent academic studies. However, not all concepts could be mapped into these (e.g., economics of scale), in which case the 2nd order categories were named by the authors. This process was iterated until comprehensive 2nd order categories were reached. Looking at the digital transformation literature, technology can disrupt businesses in two main ways: (1) through automation which replaces human labor; and (2) by coming up with new practises. We used this approach to guide the clustering of the 2nd order categories into aggregate dimensions. Consequently, we ended up with two dimensions: automation of software development; and re-orientation of business. The results of this analysis process are depicted in Fig. 4. In the next section we discuss our findings in detail and present selected illustrative quotes from the informants.

4 Results

4.1 Automation of software development

The first aggregate dimension relates to the main factors identified by the interviewees to accelerate automation. Three central 2nd order categories driving automation were identified, and are displayed in Fig. 4: (1) AI-powered automation of tasks that could not previously be automated, and the future skill requirements of engineers; (2) availability of cloud platforms that automate a significant proportion of the workload of software systems, enabling engineers to start developing from the platform as a service (PaaS) level, and providing tools that guide automatic development thereafter; and (3) the increased popularity and use of software development paradigms such as DevOps and MLOPs which direct developers to create systems with built-in high level of automation.

Skill set of engineers. AI, cloud computing and other major technology trends in software engineering [1] are changing what skills developers are expected to have. First, participants agreed that knowledge of cloud computing systems and various software development tools has been highlighted in many software engineering jobs, and

the ability to write algorithms has less and less significance. Second, participants believed the ability to make use of data and AI is slowly becoming a core skill for software engineers, if it is not that already. This included the ability to build AI tools, but also to use AI tools to assist programming and code maintenance. As an example, Participant 2 stated the following:

"With AI a set of things can be made easier for humans. (–) At some point this will be harnessed to help software development as well."

Third, perhaps surprisingly, software engineers specializing in some specific area such as user interfaces or data science could become less needed. Participant 10 explained on this topic further:

"At least all developers should closely work together. (–) Too clearly defined roles in a development team lead to problems sooner or later. Of course sharing [responsibility] is not always easy either. (–) At some point there might be a situation where you need to call a friend if you're doing something where own expertise is insufficient."

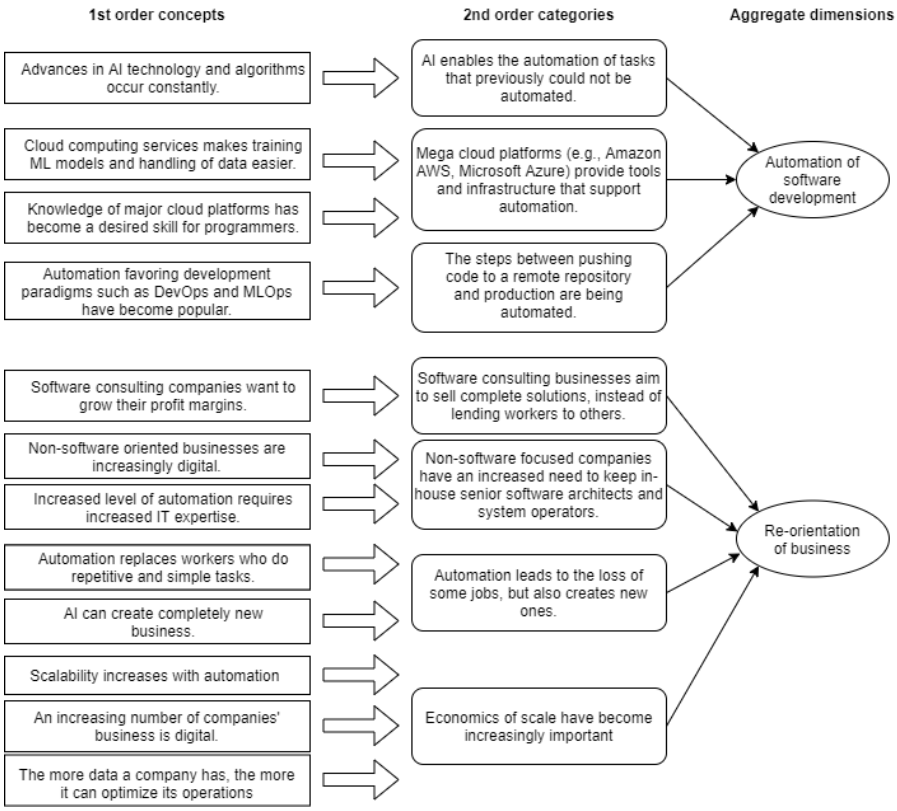

Fig. 1. 2nd order categories arising from the main 1st order concepts, and their aggregate dimensions visualized according to Gioia et al [14]

Cloud computing. The majority of participants attributed the popularity of AI solutions to the easy handling of data and availability of processing power, which are provided by large cloud service vendors (e.g. AWS, Azure). For example, AI training can be made easier through being able to access software APIs such as Keras (built on the TensorFlow API) and PyTorch, as well as computing hardware (e.g., Googles' tensor processing units). These solutions remove two essential barriers for training ML models which are the high technical skill requirement associated with understanding the mathematics behind the training routines and having access to sufficiently powerful hardware for executing the required computations. In addition to AI, cloud platforms provide various other benefits ranging from reducing development costs to guiding developers to use well-tested efficient development practices. Participants all agreed that knowledge related to popular cloud platforms has become essential for software engineers working in the consulting business, and furthermore, that the clients of software projects should also have general level knowledge about them.

Role of DevOps. Several participants brought into discussion the role of DevOps in software development. Whereas AI and cloud computing are related to technical tools and systems that increase automation, DevOps is a way of working which relies on built-in automation in systems [3]. DevOps was seen as one of the most important changes in software development practices from the past five years due to its guidance to streamline and automate steps that previously took a lot of manual handling. The importance of it was emphasized by arguments that it is a holistic approach that guides the entire software development life cycle from the initial steps to the final outcome and its operation.

4.2 Re-orientation of business

The second aggregate dimension displayed in Fig. 4 relates to the re-orientation of businesses across industry sectors. Due to advances in technology, businesses will need to make several adjustments into their modi operandi. The 2nd order categories supporting this dimension were the following: (1) software consulting businesses aim to transition from lending workers towards providing full software as a service (SaaS) to their customers; (2) by contrast, non-software focused businesses should hire in-house IT experts, preferably senior level software architects, as the proportion of digital technology of their overall business increases; (3) while automation leads to to the loss of some jobs, it also creates new ones, but the type of jobs is heavily context-dependent and difficult to predict; and (4) there are several factors currently at play which increase the magnitude of economics of scale in an unprecedented way, providing enormous growth opportunities for companies which embrace, and are able to make use of, digital transformation.

The tension between SaaS and in-house developers. .Participant 5: *"Previously IT has been some kind of a support service, but today when we look at, for example banks, software is in fact their core service. In this case it is almost impossible to outsource the programming."*

There was a lot of discussion on what the composition of future software engineering teams is like. This discussion oftentimes focused on so-called hybrid teams and whether there will be more or less of them in the future. There were several factors that influenced the outcome of this question according to the interviewed experts. For example, it would be wise for companies to increase the level of their digital expertise along with the increased proportion of digital tools and services of their business. Participant 2 explains:

"I think they [enterprises who increasingly use and offer IT products] really should employ their own IT people, but when we look at the company landscape today, we do not see this happening in practise"

However, according to the expert, many companies still cling on to ordering SaaS solutions instead of hiring in-house experts. Participant 7 gave the perspective of a software consultant company, arguing that it is in their business interest to provide SaaS to customers instead of lending them workers:

"[Our company] wants to move towards providing entire software and platform products as a service. (–) But for this, we would need to increase the level of our competence to extend beyond mere programming, more towards business transformation and life cycle support."

Automation can lead to a loss of some jobs, but open up new job opportunities. With regards to the impact of AI, data and automation on employment, participants highlighted that it is difficult to make accurate predictions, but seemed to agree that complex jobs will remain in the hands of humans. The work of software engineers and other IT professionals was one such job. On this subject, Participant 8 explained the following:

"Ever since industrialization we have seen jobs disappear and new ones coming to replace them. I cannot say what the net impact [of AI technology] is here. But from the perspective of IT companies, we can say that a major proportion of enterprises' actions will move from the physical realm to the digital. And everything that's digital requires someone to handle that. So certainly the work in IT will not disappear anywhere."

Economics of scale. Since industrialization, economics of scale have favoured large scale operation, but the increased scalability, increased proportion of companies' business being digital and the ability to optimize performance the more data businesses have via AI and other tools, all can accelerate the impact. In addition, those companies who make use of modern software tools and automate processes gain business advantage over their competitors. These factors together enable enormous growth opportunities, but at the same time may result in a more uniform landscape, as highly digital enterprises are able to rapidly and cost-effectively expand their business in a way where competitors have a difficulty to respond.

An additional topic that came into discussion with participants, also with regards to scalability, was the major cloud platform providers and their role in the re-orientation of software development. Most participants felt that these platforms are essential, and not making use of them made no sense. Participant 1 explained the following:

"It would be a waste [to not utilize the big cloud platforms]. They are big products, widely tested and not easy to do ourselves. (–) I pay for electricity as well, don't I?"

5 Discussion and Conclusion

5.1 Key Findings

As the main finding and the answer to the presented RQ, we consider the discovery of the factors that contribute to the two aggregate themes of (1) automation of software development; and (2) re-orientation of business. Many of the discovered factors were already discussed in prior literature such as automation and AI [10], blockchain, cloud computing and data analytics [1], but in addition to the identification of new factors, we also presented a conceptual data structure to describe the findings. The digital transformation of software business has vast influence for the future work of data scientists and programmers, as the changes also influence the developers' customers and their software needs. We summarize three main implications for the future of work of software professionals that arise from our findings:

- Software engineers, who with DevOps are typically both the developers and operators, are needed across industry sectors. They are also more heavily involved, as the relative proportion of digital tools and intelligence increases compared to other products and services that enterprises offer.
- The level of automation increases in both software development practises and the systems that are being developed. Developers are operating higher on the software stack and do less things manually. Because of this, the roles of automated testing and governance are highlighted.
- Digital skills will be increasingly needed across industry sectors. Software developers working in specific industry sectors also need knowledge in that field. For example, to make best use of data and AI, both technical and domain knowledge are needed.

5.2 Implications for theory

According to Vial [27], digital transformation focuses in particular on organizations adapting new digital technology into use and the various challenges related to this process. Previous work has shown that physical work is becoming more digital [21], which transforms physical work. This has led to increased calls for non-technical disciplines to study technologies such as AI [19]. We contribute to this vein of research by looking at the situation from the perspective of software development, an area which is commonly seen as the enabler of digital transformation [1], not its target. We highlight the symbiotic relationship between the software engineering industry and businesses in digital transformation, with changes in either party impacting the other. Thus, we answer the call of recent work to study the digital transformation of software development [3]. With regards to AI as a transformative technology, our findings support previous work [6] in that AI is currently still just a technology among many which influence the on-going digital transformation in the industry. However, the potential of AI as a disruptive technology [10] exists.

AL-Zahrani and Fakieh argued that through adopting DevOps practises, companies automatically embark towards digital transformation, and that DevOps indeed requires holistic digital transformation [3]. Similar findings were reported by Guşeilă et al. in the context of multi-cloud IoT applications, who argued that the automation that comes with DevOps companies are actively engaged in digital transformation [15]. Our findings contribute to this body of literature by taking a holistic view of the main trends influencing the work of software engineers. We show that DevOps is one piece of the complex puzzle that constitutes factors impacting the digital transformation of software development. Another vein of research to which our findings relate to is that of the transformation of work of software engineers. The development teams need to not only transform the way of their working [18], but also the composition of development teams are likely to change due to the factors detailed in Fig. 4. As individual business sectors re-imagine the way they work [11], software engineers need to adapt. Likewise, advances in software engineering provide new digital transformation opportunities for companies.

5.3 Limitations and future research

Concerning the limitations of our empirical study, one of the main points is that the discovered concepts and trends are tied to the viewpoints of the interviewed experts. Hence, they are influenced by factors such as a limited cultural and geographical location as well as their own experiences being tied to the field of software business. To address this limitation, participants dealing with software outside the software business industry could be interviewed, as well as experts from other geographical regions.

As this work is connected to technological forecasting, research methods that could increase the reliability of the findings, such as the delphi-method [13], could be harnessed. The advantage of this approach would be that as we iterate the findings together with the experts, they have the opportunity to make corrections to our interpretation of the results and collectively make adjustments to the presented trends and their drivers.

5.4 Outlook

No matter how advanced technologies are out there, unless significant automation is created to enable their cheap use, they will not transform businesses. For this reason, cloud computing and other solutions that lower development costs and increase the success rate of automation-driving software projects are essential in accelerating digital transformation. Whether we see the full utilization of AI and its capabilities is therefore highly dependent on the platform providers. The future work of software engineers is a complex equation with various variables, but the mega trends we see today can help forecast what kinds of skills are needed in the future.

References

1. Akter, S., Michael, K., Uddin, M.R., McCarthy, G., Rahman, M.: Transforming business using digital innovations: The application of ai, blockchain, cloud and data analytics. Annals of Operations Research (2020) 1–33

2. Al-Ruithe, M., Benkhelifa, E., Hameed, K.: Key issues for embracing the cloud computing to adopt a digital transformation: A study of saudi public sector. Procedia computer science **130** (2018) 1037–1043.
3. AL-Zahrani, S., Fakieh, B.: How devops practices support digital transformation. International Journal of Advanced Trends in Computer Science and Engineering 9(3) (2020)
4. Asay, M.: Cloud remains a small percentage of it spending, but its gravitation pull is huge. Tech. Republic (2019)
5. Azadeh, K., De Koster, R., Roy, D.: Robotized and automated warehouse systems: Review and recent developments. Transportation Science 53(4) (2019) 917–945
6. Brock, J.K.U., Von Wangenheim, F.: Demystifying ai: What digital transformation leaders can teach you about realistic artificial intelligence. California Management Review **61**(4) (2019) 110–134
7. Buchalcevova, A., Doležel, M.: It systems delivery in the digital age: Agile, devops and beyond. Proceedings of the 27th Interdisciplinary Information Management Talks (2019) 421–429
8. Coombes, L., Allen, D., Humphrey, D., Neale, J.: In-depth interviews. Research methods for health and social care (2009) 197–210
9. Duan, Y., Edwards, J.S., Dwivedi, Y.K.: Artificial intelligence for decision making in the era of big data–evolution, challenges and research agenda. International Journal of Information Management **48** (2019) 63–71
10. Dwivedi, Y.K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., et al.: Artificial intelligence (ai): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. International Journal of Information Management (2019) 101994
11. Finelli, L.A., Narasimhan, V.: Leading a digital transformation in the pharmaceutical industry: Reimagining the way we work in global drug development. Clinical Pharmacology & Therapeutics **108**(4) (2020) 756–761
12. Frick, N.R., Mirbabaie, M., Stieglitz, S., Salomon, J.: Maneuvering through the stormy seas of digital transformation: the impact of empowering leadership on the ai readiness of enterprises. Journal of Decision Systems (2021) 1–24
13. Gallego, D., Bueno, S.: Exploring the application of the delphi method as a forecasting tool in information systems and technologies research. Technology Analysis & Strategic Management **26**(9) (2014) 987–999
14. Gioia, D.A., Corley, K.G., Hamilton, A.L.: Seeking qualitative rigor in inductive research: Notes on the gioia methodology. Organizational research methods **16**(1) (2013) 15–31
15. Guşeilă, L.G., Bratu, D.V., Moraru, S.A.: Devops transformation for multi-cloud iot applications. In: 2019 International Conference on Sensing and Instrumentation in IoT Era (ISSI), IEEE (2019) 1–6
16. Hess, T., Matt, C., Benlian, A., Wiesböck, F.: Options for formulating a digital transformation strategy. MIS Quarterly Executive **15**(2) (2016)
17. Kane, G.C., Palmer, D., Phillips, A.N., Kiron, D., Buckley, N., et al.: Strategy, not technology, drives digital transformation. MIT Sloan Management Review and Deloitte University Press **14**(1-25) (2015)
18. Klünder, J.A.C., Hohl, P., Prenner, N., Schneider, K.: Transformation towards agile software product line engineering in large companies: A literature review. Journal of Software: Evolution and Process **31**(5) (2019) e2168

19. Laato, S., Vilppu, H., Heimonen, J., Hakkala, A., Björne, J., Farooq, A., Salakoski, T., Airola, A.: Propagating ai knowledge across university disciplines-the design of a multidisciplinary ai study module. In: 2020 IEEE Frontiers in Education Conference (FIE), IEEE (2020) 1–9
20. Magistretti, S., Dell'Era, C., Petruzzelli, A.M.: How intelligent is watson? enabling digital transformation through artificial intelligence. Business Horizons **62**(6) (2019) 819–829
21. Mäntymäki, M., Baiyere, A., Islam, A.N.: Digital platforms and the changing nature of physical work: Insights from ride-hailing. International Journal of Information Management **49** (2019) 452–460
22. Mäntymäki, M., Hyrynsalmi, S., Koskenvoima, A.: How do small and medium-sized game companies use analytics? an attention-based view of game analytics. Information Systems Frontiers (2019) 1–16
23. Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R., Sanghvi, S.: Jobs lost, jobs gained: Workforce transitions in a time of automation. McKinsey Global Institute **150** (2017)
24. Matt, C., Hess, T., Benlian, A.: Digital transformation strategies. Business & Information Systems Engineering **57**(5) (2015) 339–343
25. Schwartz, J.H., Wool, J.: "reframing the future of work". MIT Sloan Management Review. https://sloanreview. mit. edu/article/reframing-the-future-of-work, February 19th (2019)
26. Tabrizi, B., Lam, E., Girard, K., Irvin, V.: Digital transformation is not about technology. Harvard Business Review **13** (2019) 1–6
27. Vial, G.: Understanding digital transformation: A review and a research agenda. The Journal of Strategic Information Systems **28**(2) (2019) 118–144
28. Wu, S.Y.: Key technology enablers of innovations in the ai and 5g era. In: 2019 IEEE International Electron Devices Meeting (IEDM), IEEE (2019) 36–3
29. Zuboff, S., et al.: In the age of the smart machine. Basic books, New York, NY (1988)