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Differing Views of the Meaning of Digital Transformation in Manufacturing Industry

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Abstract. In the literature there is no consensus regarding the meaning of the term digital transformation. Therefore, the purpose of this paper is to explore the differing views of the meaning of digital transformation. A case study has been conducted in collaboration with four Swedish manufacturing companies. The results shows that digital transformation can have different meaning within a company and the main challenge when performing digital transformation is knowledge. This study is the first investigation in a research project focusing on coordination of digital transformation. Therefore, is the underlaying goal to identify how the participating companies in the research project describe digital transformation in comparison with the literature. The research intention is not to define digital transformation rather to explore differing views of digital transformation and highlighting similarities and difference in comparison with the literature reviewed. The findings are practically relevant for manufacturing companies by highlighting differing views of digital transformation and in the creation of a common language within a company.

Keywords. digitalization, case study, manufacturing industry, Industry 4.0, Smart Manufacturing

1. Introduction

When Industry 4.0 was launched 2011 by the German government the meaning of the term "Industry 4.0" was more blurry than concrete [1, 2]. Since 2011 the meaning of Industry 4.0 has become more concreate and many researchers proposes key design principles and technology trends [2] as well as the Industry 4.0 concept [3]. For example, Castelo-Branco, et al. [3] describe Industry 4.0 as "a concept that represent the adoption by industrial companies of techniques and processes allowed by digitalization, cloud computing, the internet of things and big data to gain completive advantages in domestic and global markets". Also, Ustundag and Cevikcan [4] discuss that transformation to Industry 4.0 is based on eight foundational technology advances: adaptive robotics, data analytics and artificial intelligence (big data analytics), simulation, embedded systems, communication and networking such as Industrial Internet, cloud systems, additive manufacturing and virtualization technologies. In the literature the terms Industry 4.0, Smart Manufacturing and Smart Factory are often used interchangeably.

From one perspective these terms describe a future wanted state that will create competitive advantages for manufacturing companies. This future wanted state is reached with help of the usage of digital technologies, i.e., enablers for the digital

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transformation [5]. De Carolis, et al. [5] describes that digital technologies are the core driver for the manufacturing transformation, and Vial [6] highlight the unclear meaning of digital technologies and many authors use the term digital technologies without explicit clarification. What to be considered as a digital technology will not be covered in this paper and digital technologies are seen as enablers necessary for the digital transformation.

Another research stream closely related and overlapping to Industry 4.0 is the concept of digital transformation. In recent years, the concept of digital transformation has gained increasing interest from both researchers and practitioners, resulting in independent research in emerging areas [7]. Focus areas in the field of digital transformation ranges from value creation [6, 8], business strategy and models [8-10], maturity models and characteristics [8], digital technologies [6, 9], and organizational aspects [6] etc. In the research field of digital transformation there is currently no commonly accepted definition of the term digital transformation, and the terms digitization, digitalization and digital transformation are often used interchangeably [9, 11, 12]. In a similar vein as the term Industry 4.0, the meaning of digital transformation is not well defined and unclear. Both Aguiar, et al. [13] and Gong and Ribiere [11] point out that the concept of digital transformation does not generate consensus, and its implementation is still unclear to both researchers and practitioners, thus calling for further research.

Differing views and meanings of digital transformation cause problems for both researchers and practitioners. Since there is a lack of consensus of the meaning of digital transformation, intra- and inter-organizational communication is challenging. Therefore, the purpose of this paper is to explore the differing views of the meaning of digital transformation. The underlaying goal is to understand the differing views and meanings of digital transformation from a theoretical and industrial perspective. Data is analyzed based on a black box model and following questions are addressed (see Figure 1).

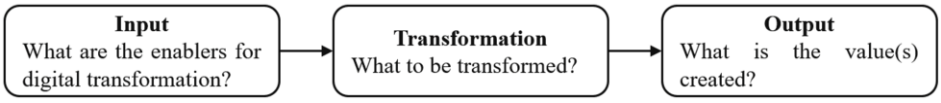

Figure 1 Black box model adapted from Ahlskog, et al. [14]

The paper contributes with a discussion around differing views of digital transformation by presenting a comparison between the literature and four manufacturing companies view of the term digital transformation.

The paper is outlined as follows. First, the theoretical framework is outlined followed by a description of the research methodology. Thereafter, the empirical findings are described leading to key elements representing digital transformation from an industrial perspective followed by differing views of digital transformation. Finally, we discuss the implications of our findings and make specific recommendations for management practice and our article concludes with research limitations and future research.

2. Theoretical framework

2.1. Digitization vs digitalization vs digital transformation vs Industry 4.0

In the literature, many authors discuss the differences and meaning of digitization, digitalization, and digital transformation as well as their interrelationships [11, 12]. These three terms are associated with the use of digital technologies and it is commonly accepted that the meaning of digitization is to convert from analog information to digital information [12]. However, when it comes to digitalization, this term is often used interchangeably in the literature with both digitization and digital transformation [12, 15]. According to Bloomberg [12], digitalization does not have a single clear definition while i-SCOOP [15] describe three contexts in which the term digitalization is used. Gong and Ribiere [11] describe that digitalization is mainly focused on the work at the operational level, whereas digital transformation emphasizes the results at the strategic level. Further, Stark [16] conclude that there could be a need for several definitions of digital transformation depending on type of change. In the literature the term digital transformation is often described as a change process enabled by digital technology and in this change process value is created. This description has many similarities with Industry 4.0 literature. According to Calabrese, et al. [17] is Industry 4.0 a transformation enabled by a series of technologies, which provide new and improved approaches to value creation, proposition, and capture (e.g., enhanced productivity, better quality products, better working conditions, sustainability, development of innovative capabilities and new revenue models) [17]. Also, Trotta and Garengo [18] discuss that Industry 4.0 could be defined as the integration of technologies (i.e., big data analytics, cloud services, 3D-printing, cyber security, autonomous robots, internet of things, augmented reality, simulation, horizontal and vertical integration), which allows the transformation of organizations to operate along with changes in business models and manufacturing processes. The core of Industry 4.0 is the integration of digital technologies and often the term Smart Manufacturing is used. The term Smart Manufacturing or Factory is generally used as synonym of Industry 4.0 with no link to any specific government plan, but with the goal to increased connectivity of production [18, 19]. According to Comission [19] the vision of a Smart Factory is to create a factory of connected and intelligent machines where waste, defect, and downtime are equal to zero.

From a theoretical perspective, the main enabler for digital transformation is the usage and integration of digital technologies. The end goal of this change process or transformation is to create value that enables competitive advantages.

2.2. Differing views of digital transformation

In recent years several literature reviews have been performed to explore the meaning of the term digital transformation [6-9]. Vial [6] reviewed 282 articles and found 28 sources offering 23 unique definitions. Chinotaikul and Vinayavekhin [7] explored digital transformation as a field in business and management research and found that the field is young but is growing rapidly. They reviewed 456 journal articles and found that the most common keywords used by authors in the field of digital transformation are digital transformation, Industry 4.0, digitalization and innovation. Babar and Yu [8] reviewed 36 journal articles and identified eight concrete characteristics for digital transformation (business strategy and models, enterprise agility, customer centricity, rapid cycles of

product and solution delivery, multi-speed organizations, data-driven decision making, social and organizational aspects, business process automation). Schallmo, et al. [9] discuss that there is currently no common accepted definition for the term digital transformation and the authors propose a definition of digital transformation. The most recent work exploring the many definitions of digital transformation is conducted by Gong and Ribiere [11]. Gong and Ribiere [11] identified and analyzed 134 definitions of digital transformation. When analyzing their results from the black box principle addressed in the introduction, the main enabler for digital transformation is digital technology, the main part to be transformed is the organization, and the main value is new offerings.

3. Research method

This section describes the research design and company selection followed by data collection and analysis.

3.1. Research design

Since the overall purpose of this paper is to explore the differing views of the meaning of digital transformation, a qualitative real-time case study was carried out. A case study method was chosen because it can provide a detailed understanding of the phenomenon studied [20, 21] and it provides the opportunity to use different techniques for data collection and sourcing of data supporting the ability to gather a rich set of data from observation, interviews, documents, etc. [22]

3.2. Selection criteria and company selection

This study is a part of a research project conducted in collaboration with four manufacturing companies located in Sweden (see Table 1). The production at the manufacturing companies are spread globally with both local and global support functions. In order to understand how the participating companies view the term “digital transformation” this study tries to capture the different views and company language. Data have only been collected from the company representatives participating in the research project, which is a limitation. The project participants work actively with digital transformation at different levels (local and global) and focus areas, ranging from strategy development to IT (information technology)/OT (operations technology) integration in production systems.

Table 1 Company description and project participants in total

Company	Business	Located in no. of countries	Title of project participants/Total no. of participants in the project
A	Discrete	130	Team Lead, Manufacturing IT, Technical Lead Manufacturing IT, Manager Reliability & Future Factory, Director Regional IT/6
B	Rail industry	70	Production & logistic planner, Head of Industrialization and Manufacturing Engineering/6
C	Automotive	180	Director process & IT operations, Process & IT Local & Regional Manager, Manufacturing Engineering, Manager Manufacturing Technology Development/9
D	Automotive	33	Manufacturing Engineering, Manufacturing Engineering Manager, Technology Transformation Manager, Global R&D, Program Office Manager /10

3.3. Data collection and analysis

First, a theoretical framework was developed for this study. Main search string used was "digital transformation and literature review". This search string was used in the databases SCOPUS and IEEE. The reason for using "literature review" in the search string was to rapidly cover the state-of-the-art in the area of digital transformation and to identify definitions/descriptions of digital transformation. Even though SCOPUS is a multidisciplinary database it was necessary to include IEEE in order to cover another spectrum of areas such as aerospace, data science and robotics. Another filtration parameter was that only publications later than 2017 were reviewed.

Data was collected through a survey and two knowledge sharing sessions with the research project participants (see, Table 2). The collected data was then cross analyzed with the theoretical framework focusing on definitions and descriptions of digital transformation. Data was collected and analyzed in following steps:

1. **Knowledge sharing session 1**: The participating companies in the research project presented the company, how they approach digital transformation and challenges with digital transformation.
2. **Survey:** The survey consisted of 12 questions, but for this paper data from 2 questions have been used. Following questions:
    - What is digital transformation to you? Describe your view of what digital transformation implies in a production context or your company context.
    - Has your company defined the term digital transformation? (Yes/No)
3. **Analysis**: Based on the literature reviewed and data collected, a cross comparison of the differing views of digital transformation was performed. The data was analyzed based on following questions. What are the enablers for digital transformation? What to be transformed? What is the value(s) from this transformation?
4. **Knowledge sharing session 2**: The survey results were compiled, presented and discussed with the participants.

Table 2 Summary of data collected

	Topic and Length	**No. of participants**
Knowledge sharing session 1	Company presentations (180min)	Company A/6, B/2, C/7, D/8
Survey	Digital transformation – 12 questions	17 answers
Knowledge sharing session 2	Presentation and discussion of the results (180min)	Company A/5, B/2, C/4, D/6)

4. Empirical findings

At the first knowledge sharing session the companies presented how they manage digital transformation from a strategic and organizational perspective as well as challenges related to this. The result from the first knowledge sharing session showed that all companies had a vision of creating a smart factory even though different words for this was used. In order to achieve this future vision of a smart factory, all companies had recently made organizational changes or adaptions. These organizational changes were in some cases still under establishment when it comes to way of working and defining responsibilities between functions.

As a follow-up to the first knowledge sharing sessions a survey was designed and sent out to the participating companies in the research project. The aim with the survey was to capture both how the companies view digital transformation and the project participants. The result from the survey question "What is digital transformation to you?" show that different frequent keywords are used like digitalization, data-driven decision, way of working, and digital technologies. The word "digitalization" was followed up at the second knowledge sharing session, and a conclusion is that the word digitalization is more frequently used at the participating companies than digital transformation. Also, the terms "digitization", "digitalization", and "digital transformation" had different meanings for the respondents. Moreover, all the survey answers were clustered into three categories based on the description. Category 1 described new ways of working through automation and usage of digital technologies. Category 2 described the use of digital technology and value creation for different stakeholders. Category 3 described a process or journey to a future wanted state with help of digital technology. This category was also described as a cultural and competence journey.

The result from the second survey question "Has your company defined the term digital transformation? showed mixed answers (7 Yes, 8 No, 2 Don't know). Only participants from one company answered yes regarding that the company had defined the term digital transformation.

At the second knowledge sharing session, a theoretical perspective was first given followed by presentation of survey results. One discussion in the session was around the second survey question (Has your company defined the term digital transformation?). The mixed answers depended on how each participant viewed both the term digital transformation and the company description. I was quite clear that the word digitalization was used more frequently at the companies. The participants from the company who all answered yes to the question described that they had spent a lot of time on communication and creation of a common language. For example, they described that the term Industry 4.0 have existed for a long time without a clear meaning, and everybody has their opinion of the meaning of Industry 4.0. Therefore, have they tried to avoid the term Industry 4.0 in the creation of a common language and in communication.

In the end of the second knowledge sharing session, main challenges with digital transformation were discussed. During the first knowledge sharing session the participating companies highlighted challenges with digital transformation from their perspective and during the second session several of challenges related to digital transformation were mentioned. Therefore, a final question was asked – "If you only can pick one challenge as a group, which is the main challenge with digital transformation?" The answer became "knowledge". Knowledge in form of how to perform the digital transformation, degree of standardization, technology knowledge, technology selection, etc.

5. The meaning of digital transformation

In the literature the main enablers for digital transformation are digital technologies and the people actually performing the digital transformation work. Both, Vial [6] and Gong and Ribiere [11] discuss that many author use the term digital technologies without a clear description or definition. In this paper digital technologies are seen as enablers necessary for the digital transformation without further description.

The empirical findings showed that all companies worked with digital technologies at different levels in the organization and with different degree of complexity. When it comes to what to be transformed the empirical findings shows that new organizational structures are needed. All manufacturing companies had started to change their organizational structure in order to support the digital transformation. Organizational change can be viewed from both a support perspective necessary for the digital transformation or a new work environment enabled by digital technologies that requires organizational change. Both these types of changes are related to each other, and the empirical findings indicate that the support perspective had started at all companies.

The actual transformation described in the literature ranges from organization, culture, business models, etc., [9]. In similar vein, in the literature the value from the digital transformation is described within a broad spectrum. Digital transformation can create different types of value and have different degree of impact on a company. The empirical findings showed that digital transformation and creation of a future wanted state like a smart factory, was a matter of increased competitiveness for all companies.

In short can digital transformation be viewed as an organizational change enabled by usage of digital technologies and in this transformation, value is created for different stakeholders. Digital transformation implies cyclic development and change with the goal to create competitive advantages without an end goal for this journey.

6. Discussion and implications

The purpose of this paper was to explore differing views of the meaning of digital transformation with a focus to understand the views from a theoretical and industrial perspective. Based on the empirical findings and literature reviewed, no solid conclusions can be drawn when it comes to the definition of digital transformation. In short, digital transformation can have different meanings and be viewed from different perspectives. The lack of consensus in the literature makes it challenging research-wise, but from a company perspective, the most important part is to have a common language for internal communication that enables the organizational understanding of what digital transformation mean. This paper has tried to discuss and develop an awareness of differing views and meanings of digital transformation from a theoretical and industrial perspective.

6.1. Theoretical implications

In the literature the meaning of digital transformation is described, but the definition of digital transformation is still not well defined and several definitions can be found [6, 11]. At a high-level, digital transformation is a change process in which value is created. In this process, different parts of a company are transformed into a new state. From a theoretical perspective, there is quite clear what is the main enabler supporting digital transformation. The use or integration of digital technologies is the most frequently used descriptions. When it comes to what to be actually transformed the main areas are organization (competence, culture, structure), process (way of working, manufacturing), and business (models, activities). The value creation part consists of a broad spectrum of areas ranging from new ways of working, offerings, and improved efficiency and effectiveness etc. The value creation is context dependent and can be described in many different ways depending on the context.

6.2. Industrial implications

From an industrial perspective, the most important part of the digital transformation is the actual value creation from it. For that a clear picture of what digital transformation means inside the company, what to be done, and having a common language for communication is needed. As highlighted from one of the case companies – "*we have worked a lot with communication and tried to create a common language. The meaning of Industry 4.0 is fuzzy, and everybody have their own opinion, therefore have we tried to avoid the term Industry 4.0 in the description of our future digital transformation journey*." This quote indicates one thing. 1) the research community have not managed to clarify the meaning of Industry 4.0 for the last 10 years and the term is still understood as having different meanings. In similar vein the differing views of digital transformation in both industry and literature seems to follow the pattern as with the term Industry 4.0.

6.3. Limitations and future research

An important limitation of this study is worth mentioning. This study was conducted at four manufacturing companies with limited data sample from each company. Thus, the actual view of the term digital transformation at the manufacturing companies is not covered. The empirical findings only indicate how the participants in the research project view digital transformation and not the whole organization at the four different companies. A proposal for future research is to conduct a systematic literature review of literature reviews in the area of digital transformation. As a part of this study, it has been noticed that there is a growing number of literature reviews in the area of digital transformation. Therefore, a literature review of literature reviews could support trends and areas covered in this research field.

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