Barriers hindering an efficient implementation process of digital technologies; a case study at Norwegian manufacturing companies

Eirin Lodgaard[1], Hans Torvatn [2][0000-0002-0996-4805], Johanne Sørumsbrenden[1] and Gaute Andreas Knutstad[1]

[1] SINTEF Manufacturing, Enggata 40-2830 Raufoss, Norway
[2] SINTEF Digital, SP Andersens vei 5 7031Trondheim, Norway
eirin.lodgaard@sintef.no

Abstract. The existing wave of improvement in manufacturing industry is strongly driven by the application of digital technologies. Unfortunately, the implementation process is not straightforward. To understand the barriers which hinder a smooth implementation process is essential for successful implementation of digital technologies. Our study aims to identify the major barriers based on a case study performed at six Norwegian manufacturing companies, to know what to solve enabling a smoother implementation process. The findings shows that both technical and organizational aspects are of importance to consider, where the organizational aspects are seen as the most underestimated. The lack of digital competence alongside underestimated need for organizational development of involved people emerges as prominent barriers. Some technical problems were also pertinent, like system integration. Sharing of data was seen as a potential asset, but both legal, strategic and technical issues hampered this. The results of this study may help managers and practitioners to address the major barriers highlighted, paving the way for successful implementation and integration of digital technologies in the manufacturing industry.

Keywords: Industry 4.0, digitalization, manufacturing industry, barriers, case study.

1   Introduction

The industrial development has so far undergone three revolutions and is in the start-up phase for the fourth one, named as Industry 4.0. Each of them is related to the breakthrough of new technologies which have become the pillars of a new industrial era, where also new organizations and working methods have been developed simultaneously. The first was triggered by steam, the second by electricity, the third by computers. In the fourth revolution which is triggered by the Internet of Things (IoT), equipment, objects and users are connected to each other through advanced information and communication systems linked into the entire industrial value chains. The leaps in

industrial development as each of the revolutions are representing are closely intertwined, and the technologies they opened to are still evolving.

The existing wave of improvement in manufacturing industry, is strongly driven by the application of digital technologies, affected by the concept of Industry 4.0 [1]. Digital technologies open a wealth of opportunities for the manufacturing industry, from the use of smart sensors and IoT, radio-frequency identification (RFID), big data analysis, artificial intelligence and machine learning, virtual reality, digital twins, autonomous robots, and data sharing in the entire value chain. Hence, this place new demands on the organization in terms of competence, adaptability, and innovation [2].

Upon implementation of chosen new digital technologies, efficient implementation processes are of high value. Trying to avoid pitfalls regards to the implementation process, it is a need to explore factors that determine what prevents this. Existing literature agrees upon this as a largely unexplored field and the necessity of more knowledge building [3]. Therefore, there is a need to identify the barriers inhibiting the implementation process to know what to solve, enabling a smoother implementation process of digital technologies in the era of Industry 4.0. Based on this, our research aims to answering the following research questions: *What are the most prominent barriers preventing an efficient implementation process of digital technology at shop floor level?* This gives us valuable knowledge about how to succeed with the existing digital transformation from a holistic view form a manufacturing perspective.

2 Barriers to implementation of digital technologies

The implementation process of digital technologies is normally a complex process, and many organizations are facing issues due to different influencing barriers. In additional, these factors influence each other's and are intertwined and thus complicates the implementation process [3]. Several authors emphasize the complexities that will arise from the increased and intertwined human and technical interaction. This is not understood well enough and needs to be considered in the implementation process [4].

Existing literature has identified several types of barriers which will inhibiting the implementation process [3, 5, 6]. Extant findings state that barriers include both technological and organizational factors. So far, the majority of the scientific papers has dealt with technologies barriers and less on organizational barriers [7].

Regarding organizational barriers lack of knowledge and skilled workforce has been identified by several authors [3, 6, 8]. Other research studies has identified the resistance among employees' due to fear of loss of work if digital solution are able take over their work tasks [6, 7]. Resistance is also linked to the lack of skilled workforce where you react with resistance to a change due to lack of training and competencies needed for new work tasks.

Increased digitalization will change the way of working in manufacturing, and this is identified as a barrier regards to resistance to use this new technologies and the following new way of work practice [9]. One example could be use of real-time data to monitor and optimize processes, which will affect workers on several level [6]. If keeping up with traditional roles and working condition it will hampering the

implementation process. It is necessary to have a process to rethink what is the new way of working and effective change management would be a key challenge for organization [3].

The lack of digital strategy alongside lack of resources are identified as the most prominent barriers by a study from Raj et al. [3]. This shows the importance of managers role of creating a roadmap and plan strategically in order to guide actions and investment in resources to manage the implementation process.

Regarding technical barriers the poor understanding of integration and systems architecture is identified as central barriers [6, 10]. Implementation of big data analytics is one concrete example, with the need of a clear understanding of the architecture of all operating IT system that potential generates the relevant data to apply. In additional, data quality is a challenge, needed to obtain quality of the decision-making process [3]. Another study shows that existing infrastructure with to old machines could be a problem in terms of the needed conversion [6]. Another key barrier is when implementing a digital technology, normally use of several different technology is needed due to dependency between each other and this will make the implementation process more complex [6]. Here you need to understand how they function with each other.

3   Research Design

The purpose of our study is to learn from how the Norwegian manufacturing companies successfully implements digital technologies. Specifically, to identify: *What are the most prominent barriers preventing an efficient implementation process of digital technology at shop floor level?* By identifying the most pertinent barriers then we know what to solve, and simultaneously enabling a more efficient implementation process.

Given the what-type research question, an exploratory multiple case study approach was chosen [11]. Our purpose was to look for relevant evidence on what prevents an efficiency integration processes function in Norwegian manufacturing companies. Thus, the unit of analysis is the implementation processes of digital technologies at shop floor level in manufacturing industry. For the case study, six Norwegian manufacturing companies were chosen, being considered among the leading manufacturers in Norway.

Semi-structured in-depth interviews were chosen as data collection method. Well informed interviewees can provide important insight into facts of a topic in additional to their opinions [11]. Pre-developed questions were developed and formulated to cover barriers for efficiently implementation process of digital technologies. The goal was to get insight into how they approached the implementation process of digital technologies to understand theirs perceived barriers and what could be done in a better way. Least five interviews were performed at each company, including factory manager, production manager, technology manager of R&D manager, operators and a representant from the union. The interviews were conducted at case company's production site or through conference call (Teams). All the interviews were recorded enabling for more accurate representation of the conversation.

4 Case description

The Norwegian manufacturing companies included in this study represent manufacturing industries in different markets (see table 1), of a different size, organization, experience, and history and are in different levels in their digital development. This probably also affects their approach to digital technology. But even though the companies have different starting points, they also have some common features. They are part of a competitive industry and are global players. They have cutting-edge expertise in their specialized fields. They largely base today's productivity on efficient organization, automation and robotization of labor-intensive processes.

Table 1. Overview of the case companies.

Case	Industry	Ownership
A	Defense	Subsidiary of a Nordic corporation
B	Subsea	Subsidiary of a global corporation
C	Shipping	Subsidiary of a global corporation
D	Food	Norwegian corporation
E	Metallurgy	Subsidiary of a Norwegian group
F	Metallurgy	Subsidiary of a global corporation

To address the question about the most prominent barriers to the implementation process about digital technologies at manufacturing area, each of the case companies chosen a common project were all the respondents were involved in some way.

5 Findings and discussion

5.1 Goals and attitude towards digitalization

Before we discuss the barriers preventing implementation process, we should briefly discuss the overall goals and attitude towards digitalization in the six companies. The major overall goal for all six companies is improved efficiency in their production. Theirs is a world of intense competitiveness, where cost cutting innovation is needed to survive. This focuses their digitalization efforts most towards "Smart Production", and less towards "Smart Products", new business models and digital transformation. It might of course be argued that Smart Products, new business models and transformation would in the long run give the enterprises better long-term survival options, but this seems to be a steep step for the enterprises. Rather they focus on improved efficiency in existing processes. Within such a mindset of digitalization they are interested in understanding their own production system and optimize it, for which digital tools can be very useful. Further they want to cooperate better with suppliers and customers, exchange of various data is seen as very useful for that. Finally, and here we see the enterprises bordering on towards more transformative digitalization, they see "green" and "sustainable as important and interesting goals to work towards. Partly because of

concerns about the environment and resource expenditure, partly because they feel it is a market. Again, data collection and analytics are useful.

Regarding digital readiness and attitude towards change the whole enterprise is aware of the need, ready and willing (able being a more open question). The need for continuous improvement is accepted by all and institutionalized in the cooperation between unions and management. The Norwegian work life model and short way between management and shop floor supports broad involvement in idea generation, acquisition of knowledge and assessment of ideas. This should lead to easy implementation of digital improvement projects, but as we shall discuss more in detail there are several important barriers slowing the efforts.

When we asked about the most prominent barriers preventing an efficient implementation process of digital solution, the respondents express numerous problems they had already faced or feared, would arise.

5.2   Leadership and human resources

Three of the case companies highlight that the managers do not see the scope and the complexity of digitization. Thus, they are perceived as a bottleneck regarding prioritizing of technologies, hampering the implementation process and allocation of skilled resources. One reason for this emphasized from the informants is their lack of knowledge, and this is also seen as possible threat to the needed forthcoming digital transformation enabling their competitiveness.

An interesting finding in our study is the employee's acceptance of the forthcoming digital transformation, which was identified at all case companies. This is not in line with existing studies by [6, 7] which have identified resistance among employees' due to fair of loss of work. One explanation for this is the low level of hierarchical in the organization and the involvement of employees at shop floor level who are applying apply the technology at daily basis. Another explanation is the strong emphasis on the collaboration between employees, managers, and union in the Norwegian life work model [12]. This has turned into a culture based on trustful collaboration and this may be different than in the study by [6, 7]. The existing employee's acceptance of the forthcoming digital transformation in Norwegian manufacturing industry for the future is a good starting point.

5.3   Lack of competence and systematical learning process

One specific barrier was lack of competence within the field digitalization, and the explanation was about the forthcoming digital transformation requires new type of knowledge and competence. One example was within data analytics, algorithms and interaction design. This also created a longer implementation process due to more unexpected problems due to absence of competence.

As the case companies were very much aware of this problem, they had developed strategies to solving in it. Their strategies here could be divided in two: Hire external competence (consultants, technology suppliers, and researchers) or acquire in-house competence by hiring people. An experience from use of consultants is the difficultness

of creating a systematical learning process in the implementation phase due to lack of continuous presence. In additional, in the end of the implementation process they lack access to the expertise. Undoubtedly, the case companies preferred in-house competence, but this was not always as easy for them to hire. For the future, they were convinced that digitalization would be one of their core competences.

5.4   Also an organizational issue

Another interesting finding is that the main focus in the implementation process is on technical issues and less on organizational issues. Several leaders in our study highlighted that leaders of technology projects struggle to relate to the projects as organizational development projects. They believe this is an underestimated area, which is important to understand and address. They also argued that if they had focused more on the organizational issues, they may have used less resources in total. Digitization is not just about technology, but also about how people should use the technology. In practice, this means that we have to think differently about organization due to roles and distribution of functions between employees are changing. How the individual works, and who works together on the various tasks, will thus change. Therefore, it becomes important that the company analyzes the work processes and finds the best possible division of work internally and across departments.

5.5   Technical issues

Some technical problems were also pertinent, like system integration. Systems must be integrated with other systems and here the technology suppliers have not come far enough. Another barrier was the challenges of the acquisition of data to actually obtained the needed data and with sufficient quality, enabling solution for decision support.

Sharing of data was seen as a potential asset, but both legal, strategic and technical issues hampered this. This was also a challenge within their own group due to different maturity level between the enterprises and different regulation, both due to location in different countries.

6   Concluding remarks

The existing wave of improvement in manufacturing industry, is strongly driven by the application of digital technologies, affected by the concept of Industry 4.0. However, the implementation process for digital technologies at shop floor level is not a trivial task.

The above review indicates that both technical and organization aspects have to be taken care of in the implementation phase, where the organizational aspects are seen as the most underestimated. Undoubtedly, the need for digital competence was the most worrisome prominent barriers due to new area of knowledge the industry does not normally possess today and the lack of availability. Furthermore, this study reveals that

organizational development is underestimated in the implementation process. More specifically, digitalization is not just about technology, but also about how the humans should use the technology. In additional it requires new ways of performing leadership due to the complexities that will arise from the increased and intertwined human and technical interaction. This is not understood well enough and needs to be considered in the implementation process. Some technical problems were also pertinent, like system integration. Sharing of data was seen as a potential asset, but both legal, strategic and technical issues hampered this. All the identified barriers are intertwined and interdependent and this shows the need for development of a digital strategy [3] enabling to overcome barriers as shown in figure 1.
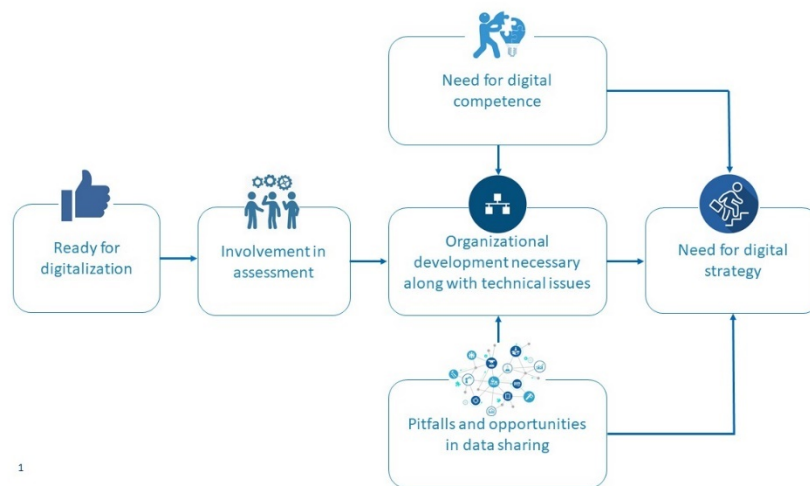

Fig. 1. The dependences of the prominent barriers and the need for a digital strategy to overcome those.

Rising awareness of these prominent barriers may help manufacturing companies to enabling a smoother implementation process of digital technologies in the era of Industry 4.0. Notwithstanding, more research is needed to enhance the results and to increase generalizability.

Acknowledge

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