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Procedia CIRP 00 (2021) 000–000

www.elsevier.com/locate/procedia

55th CIRP Conference on Manufacturing Systems

Future competence at shopfloor in the era of Industry 4.0 - A case study in Norwegian industry

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Abstract

Industry 4.0 technologies with the vision of smart factories will dominate the manufacturing industry for the next decades. Hence, the application of digital technologies of modern IT and communication technologies to enable machines, products, and human being exchanging information with each other will be of high importance. Consequently, more complex manufacturing processes will evolve and affecting the interplay of humans and technology. Thus, we argue that the competence needed for the future will change to successfully integrate industry 4.0 technologies. From this perspective, sufficient and correct competence will be a critical success factor enabling to integrate and to apply required new digital technologies at shopfloor. Hence, both technical professionals and operators at shop floor will be involved. Case studies from six Norwegian industry companies are used to illustrate how future competence at shopfloor must fit into the era of industry 4.0. Our empirical evidence shows that both upskilling and reskilling is necessary to success with the digital transformation and a good starting point is the operators' positive attitude to upskill their competence. How to manage this has to be included in a digital strategy. This article will provide an important contribution on how companies can solve the issues as evolution of competence for future success in the era of industry 4.0, which should be relevant to both industry and academia.

Keywords: Industry 4.0; smart factory; manufacturing industry; shopfloor, competence; case study

1. Introduction

The era of industry 4.0 will be driven by the application of digital technologies including numerous technologies and associated paradigms, aiming to build the future factory – smart factory [1]. Vision about smart factories includes intelligent automated and robotic factories in additional to its comprehensively integration with all of the logistics processes in the supply chain.

As such, the level of complex manufacturing technologies will increase even more and lead to advanced production processes becoming more complex and integrated. As a result, the role of the operators at the shopfloor will changed from executing simple repetitive tasks to handling more complex task [2]. Consequently, the operator's ability to fully understand the manufacturing technology will be more difficult and this will raise new demands within the area of competence [3]. At the same time, the competence is an essential prerequisite for effective integration of industry 4.0 technologies [2]. Consequently, this involve technical professionals who are designing, implementing, and maintaining the technologies.

Much research has been carried out to investigate opportunities for digital technologies aiming for smart factories [4]. However, there appears to be little empirical research exploring how the competence at shopfloor level have to be evolved simultaneously [2, 5, 6]. Romero and colleagues research on operator, states the needs for competence and outlines the challenges and opportunities. Thus, the aim of this article is to explore the future need for competence at shopfloor based on the experiences of digital technologies in the era of Industry 4.0.

To guide the investigation, we adopted the following research questions: *How do Norwegian manufacturing companies cope with the needed evolution of competence for operators and technical professionals involved at shopfloor level when embarking on the digital transformation?*

2. Industry 4.0

The industry 4.0 initiative has received a substantial attention and is well accepted in the manufacturing industry as a forthcoming wave of industrial improvement to remain competitive [4]. This will be driven by the application of digital technologies including numerous technologies and associated paradigms, aiming to build the future factory – smart factory. Vision about smart factories includes intelligent automated and robotic factories in additional to its comprehensively integration with all of the logistics processes and the supply chain.

One of the essential components of the industry 4.0 is the Internet of Things (IoT) with inter-networking of physical devices embedded with electronics, software, sensors, actuators and network connectivity which enables these objects to collect and exchange data [4]. Along with this, and the exponential growing amount of data available to manufactures this enabling the machines to communicate (M2M) and with promising systems to be more and more self-behaving. In addition, an important breakthrough is the communication between machine and the human enabling collaboration and decision-making process.

Another essential technology in the concept of Industry 4.0 is the Cyber physical system (CPS) with the integration of physicals process and computing – fusion of the physical and virtual world [7]. An important feature of CPS is to respond any feedback generated between the physical and virtual world.

All these technologies described above, bring about more consistent, robust, agile manufacturing systems with intelligent capabilities [4].

3. Competence on the way to industry 4.0

3.1. Critical competence

To cope with all promising Industry 4.0 technologies and the vision of smart factories, manufacturing industry need to identify critical competencies for the future [8]. One definition of competence is: *"a set of skills, abilities, knowledge, attitudes and motivations an individual need to cope with job-related tasks and challenges effectively"* [8]. In a competence-based view this can be classified in four main categories: technical competence, methodological competence, social competence, and personal competence [8].

Technical competence including all job-related knowledge and skills. One specific competence is within data science management, which include applications and tools for Big Data analytics (e.g., Phyton) [9]. A Swedish study by Holm [3] provides future demands specific for the operators at shop floor. This study highlights that a 3-years high school preferable with technical orientation is necessary to be able to interact with the intense technical environment and be part of further development.

Methodological competence includes skills for problem solving with employees who are able to identify sources of errors and improve the processes. More and more complex processes need to be solved efficiently by analyzing growing amounts of data enabling for decision making [8].

Social competence includes skills enabling for communication (including virtual communication), cooperate and support each other. The growing teamwork and shared work on platforms, expects the ability to understand different culture and communicate with global partners and customer.

Personal competences including attitudes, motivation and sustainable mindset. Regards to a forthcoming increased degree of a virtual workplace making employees more place and time independent, this will require increased flexibility within their work responsibilities [5].

3.2. Development of competence

Industry 4.0 technologies are generating new pressures on traditional professions and their associated competence. One of the identified barriers to successfully digital transformation is lack of competence [10]. Thus, it will be a critical for the manufacturing industry to cope with competence development according to the need of Industry 4.0 [9].

A study by Pinzone et al. [11] shows that there still is lack of knowledge on how manufacturing companies should deal with the competence gap that is being created. One of the solutions identified in literature from existing research is the potential to applying a comprehensive competence model [8]. More specifically, a model visualizing the most critical required competencies and compared with the actual competence for the work force. Thus, this type of a competence model will reveal all existing gaps regards to critical competence, aiming to show the readiness for the digital transformation and what to focus on.

4. Research design

The aim of this study was to learn from Norwegian manufacturing industry in how they ensure valuable competence within the field digitalization. Specifically, to identify: *How do Norwegian manufacturing companies cope with the needed evolution of competence for operators and technical professionals involved at shopfloor level when embarking on the digital transformation?*

Given the how-type research question, an exploratory multiple case study approach was chosen [12]. Our purpose was to look for relevant evidence on how Norwegian manufacturing industry companies consider the needed evolution of competence in the era of industry 4.0 and the promising vision about smart factories. Thus, the unit of analysis is managers and professional involved in the processes of implementing and applying digital technologies at shop floor level in manufacturing industry. Six Norwegian manufacturing companies were chosen (see table 1.), being considered among the leading manufacturers in Norway. All of the companies have been on the podium of the national competition - the smartest company of the year.

As data collection method, semi-structured in-depth face to face interviews were chosen. A semi-structured interview is sees as an important tool, inasmuch as one can ask key professionals about facts of matter as well as their opinions about events [12]. The aim was to create an informal setting in which the interviewee would open up and provide rich data.

Pre-developed questions were developed in advanced and formulated to cover both topic about competence when implementing new digital technologies and issues on applying those afterwards to produce product with desired quality and with efficient production processes. In respect to this, each of the case companies chosen a common project were all the respondents were involved in some way. The goal was to get insight into how they approached the implementation process of digital technologies regards to competence.

The interviews were conducted at case company's production site or through conference call (Teams). Least five interviews were performed at each company, including factory manager, production manager, technology manager or R&D manager, operators and a representant from the union. All the interviews were recorded enabling for more accurate representation of the conversation. Permission was obtained in advance from participants before taping of the interviews.

5. Case description

The companies included in this study represent manufacturing industries in different markets (see table 1), but all are part of a competitive industry and are global players. They are of different size, organization, experience, and history and are in different levels in their digital development. This probably also affects their approach to the digital transformation. But even though the companies have different starting points, they also have some common features. They have cutting-edge expertise in their specialized fields. They largely base today's productivity on efficient organization, automation and robotization of labour-intensive processes. They have survived for more than a decade, thus showing an ability to change and develop.

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

6. Results and discussion

6.1. Future competence in general

All of the case companies admit that Industry 4.0 is a big concept, and they will not yet describe themselves as "4.0 company". Regardless, they all have started on their digital transformation in some way and agree on upon the need for a different competence for the future to successfully integrate industry 4.0 technologies. One of the companies has changed the name of its ICT department to "ICT and Digitalization", with the main purposes to emphasize the need for a new type of competence for the future.

Another important factor revealed in this study is that the case companies are struggling to have sufficient overview of the need of future competence within the field digitalization for the entire organization. The primary reason for this is the lack of a clear picture of what is the concept of industry 4.0 for them in detail. This is in line with existing research which has identified a lack of clear vision and strategy for the forthcoming digital transformation [10]. Along with this, what should be prioritized to start with – a digital twin of the production process or sensorics enabling for predictive maintenance? Neither of these are "quick fixes" and both involve management support, investment, strategic decisions in addition to competence building. This is true for any attempt at building an Industry 4,0 solution. And it is also very difficult for an enterprise to follow several transformation activities at the same time. A choice is needed. Regardless of the choice of type of industry 4.0 technology, all involved companies in this study see the necessity of both - reskilling and upskilling their works force.

6.2. Access to digital competence

As pointed out above, competence within digitalization is one of the prerequisites for successful digitization. All companies agree on this, but how to get access to the needed competence? Broadly speaking the companies can get access to digital competence either by hiring and build internal competence or from external consultants/ scientists/ experts. While no one can have all needed competence in-house all agree on the benefit and need of building their own digital competence. This is however far from easy.

Case company D and F have both employed a data scientist working with development of a dashboard as a decision support tool at shop floor level, enabling operators to make better decisions by application of data. Case company D highlighted that access to internal competence provides high flexibility and fast communication between developer and user. Previously, the production unit had used consultants, with the experience that the development work took too long and resulted in too little interaction with the company's own employees. Along with this, after ended development period the competence is not available in the same way. Respondent from company F mentions that it is advantageous to have an easily accessible data analyst who, together with the production theme, can optimize solutions after these have been put into operation.

Company A and E struggle with access of digital competence due to acceptance from the management team to employ one with digital competence. One argument from the management perspective, is the challenge to calculate the profit based on an investment analysis, such as for a digital twin of a production process. What will the profit be? What type of competence do we need and how much resources is needed?

Company C has taken a decision to collaborate with technical providers and be a part of research program to get access of digital competence. This is because they are too small company to carry the financial part of it. Despite this, they do not disregard that they have to invest for internal competence later, to be able follow future change in the market within digital solution to still be competitive. An example is regarding new business model, where they take over the maintenance of their products at the customer's location. This will require internal competence within digitalization to be able to deliver expected quality.

6.3. Competence building for the rest of the organization

An interesting result from our study is the view on the forthcoming change in competence for operators at the shop floor. It is apparent that the operators see that digital technologies are evolving, and simultaneously the need for upskilling of competencies evolves. This is in line with the Swedish studies by Holm et al. [13] identifying the views of the future shop floor operator. Operators are unequivocally positive about participating in this journey so that they can still carry out production in the best possible way.

Several of the operators and all from the union pointed out that the future skilled worker education, especially the vocational education, must take care of the industry's future competence needs. "*We need to change our education system, because we need upskilling for the future."* Some of the companies have already come a long way in facilitating this.

A common opinion prevailed among the respondents, was the importance of the learning process in the implementation phase of new digital technologies. Such processes provide a lot of learning and competence development. If they included their own professionals for such projects and with sufficient competence, this created an in-depth learning about the production processes and after finishing the implementation they still were available when needed.

Such processes provide a lot of learning and competence development. If this competence is built up internally, it will sit in heads that are present throughout the project - and not least afterwards if necessary. Now that external suppliers have completed the implementation, they are subsequently not available to the same extent as internal resources.

All emphases the preferable solution – internal competence enabling to implement the technologies but not always possible. For the company C this was not possible due the size of the organisation. To solve this, they normally collaborated in national research projects and with technology providers.

Several of the companies have made external technology providers as an important partner in the learning process. An interesting finding in our cases is the willingness to share competence between the external provider and the involved people in the companies. It is apparently that there is " a culture for shearing" independent on the role in such implementation processes. The operators in particular are pleased that they are involved and receive a transfer of competence from these professionals.

But despite this, it appears that the operators lack a more systematic and targeted approach to competence transfer. Today there is too much "learning by doing". The learning process is often based on the challenges that arise along the way on the implementation process when new technology is to be tested.

From the above discussion one could argue that such learning processes are of high importance regarding sharing of competence enabling upskilling of both - technical professionals and operators involved at shop-floor level. Consequently, companies that use external providers to develop and implement digital technologies should maximise the involvement of their personal and should try to use the external providers to develop competence alongside whatever technology they are building.

4. Concluding remarks and limitations

The forthcoming digital transformation including technologies from the concept of Industry 4.0, enabling intelligent machines, products, and human being exchanging information with each other. To success with this at shop floor, development of needed competence will be one of the critical success factors. This will include operators and technical professionals involved at shop floor level, since they all are involved more or less in the implementation and application phase.

Although much research has been conducted on technologies for Industry 4.0, little focus has been directed towards identifying future need of competence for successfully implementation of these technologies at shop floor. The focus on reskilling and upskilling of competence ought to be increased for the future as a means of successfully integrating industry 4.0 technologies. More specifically, it ought to be closely related to one substantial component: The link between a digital strategy choosing prioritized forthcoming digital technologies for the company and the respective need for upskilling and reskilling of competence for technical professions and operators at shop floor level.

Everyone wants to have their own expertise in their organization, but it is not always possible to implement, especially for smaller companies. Those are more dependent on technical providers and should maximise the involvement of their personal and using the external providers to develop competence alongside whatever technology they are building.

The main limitation of this study is that all case companies represent manufacturing industries in different markets and from the same country. To enhance the results and to increase generalizability, future research should include companies from the same marked and from different countries, exploring how they cope with future competence for successfully integration of industry 4.0 technologies.

Acknowledgements

The authors would like to thank to all companies which took part of this study and the national research projects: "*CRI*

Manufacturing" and *"The lean-digitalization paradox: toward strategic digitalization"*. Both of the research projects were funded by Research Council of Norway.

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