MASTER GRADUATION THESIS

DOCUMENT NUMBER:

2021.08.27

Extended Abstract of

DEVELOPING A UTEACHING CASE

Challenges in the implementation of Industry 4.0 at HYDRO

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Introduction

In recent years, Industry 4.0 has increasingly been examined by academic studies (Habraken, 2020). Industry 4.0 is a new digital industrial technology that ensures connectivity and interaction among parts, machines, and humans, and this technology will transform the manufacturing from single automated cells to fully integrated, automated facilities that communicate with one another (Yu & Schweisfurth, 2020, p. 77; Russman et al., 2015). Organisations are constantly adapting to technological innovations to maintain their competitive position in their dynamic environment. Industry 4.0, or Smart Industry, is technology that provides useful information to the manufacturing system, based on real-time data (Frank et al., 2019; Lee et al., 2015). This integrated technology has the ability to improve product quality, increase flexibility, increase automation, enhance participation within the value chain and enhance interaction with customers (Huizinga et al., 2014, p. 25). However, these advantages can only be realised when the objectives are clear, stakeholders are involved and users understand the new routines that the technology brings along (Trullen et al., 2020).

In the near future, Industry 4.0 will become the new standard across regional organisations, since many organisations are dealing with a growing staff shortage (Regio Twente, 2020). However, so far there is only little experience in practice with purposeful and successful Industry 4.0 implementation (Veile et al., 2020). In particular, the alignment of organisational interests and employee perceptions seem to be challenging. The aim of this case study is to design a teaching case about the challenges in the implementation of Industry 4.0 for organisations and employees. A teaching case is a neatly packed snapshot of an actual management situation at an organisation, whereby the protagonist faces a problem, an issue, challenge, or a potential opportunity. By taking the role of the decision maker, students have to think as if they were him or her, and be analytical and creative in providing solutions (Yue, 2016). This way of teaching provides students with the opportunity to address real-world problems by putting theory into practice. Industry 4.0 is a new industrial phenomenon that has a growing impact on industries, however currently there are not many teaching cases available on this subject. One of the focus areas of the BMS faculty of the University of Twente is research on industry and thus there is a necessity to teach students about industrial challenges, such as Industry 4.0. Furthermore, the available teaching cases about Industry 4.0 focus often only focus on technological issues, which makes them only useful for one discipline only. However, teaching cases are particularly suitable to teach multidisciplinary subjects due to the often high (technological) complexity. In this way, the case will be suitable for undergraduate and Master students with an educational background in business, computer science, society or technology. This study aims to answer the following research question: *How to design a teaching case about the challenges for organisations and employees during the implementation Industry 4.0?*

Theoretical background

Teaching case

Teaching cases are snapshots that reflect managerial situations whereby the protagonist faces a problem, an issue, a challenge, or a potential opportunity (Yue, 2016). Case-method teaching (CMT) stimulates participants to employ a more dynamic role in learning educational content and materials used. One of the key differences between this way of teaching and traditional teaching is the active role of the participants in the learning process. In traditional teaching, the participants receive information from the lecturer while this information from the lecturer while this information might not satisfy their real needs and they may feel that the training is boring and useless (Afsouran et al., 2018 p. 711). While CMT has the potential to enhance the quality and quantity of an individual's learning through its active way of teaching (Afsouran et al., 2018). CMT introduces complicated, obscure real world or fabricated cases (scenarios) in an educational setting in which a protagonist is encountered with a significant decision

(Razali & Zainal, 2013). It provides the opportunity to immerse participants into realistic managerial situations in order to detect how they make decisions while having incomplete information, time constraints and conflicting goals. In this method, not only the instructor is able to see how participants react differently to a challenge or problem, but also it helps participants to see their points of view vary concerning different organisational issues (Afsouran et al., 2018).

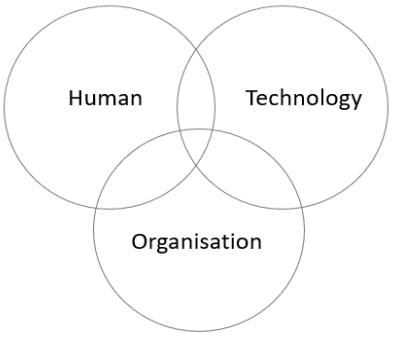
The standard components of a case are straightforward, there is an opening, some information on the industry and organisational background, the case story and the closing. Usually a case addresses one or more research questions (Eisenhardt, 1989). The opening section is the most important part, usually it has between one and three paragraphs, in this part of the case the protagonist is introduced (name and position), the kind of decision he or she has to make, when and where this is happening (date and place), and why and how this will happen. The opening needs to be brief, direct, and have a dramatic twist, which motivates the reader to keep on reading. In the following sections a framework will be developed. This framework usually has a funnel structure, moving from more general information to more specific information. The teaching case will be designed about the phenomenon Industry 4.0. We identified three implementation pillars of industry 4.0: organisation, technology and human. These three aspects are the starting points of our funnel structure. Short, descriptive, and straightforward section headings will be used to help the students to follow the story and locate data. The closing section gives a short summary of the case.

Industry 4.0

Industry 4.0, or the forth industrial revolution, is a technology that is based on Cyber-Physical systems, which change the human-machine interface into machine-to-machine communication, digitalisation into cyber-physical systems, and automation into autonomous self-organising systems. The implementation of Industry 4.0, goes beyond technological developments, ICT and business models. Scholars have introduced an approach that integrates human, technological and organisational aspects (Oks et al., 2017). This indicates that the implementation of Industry 4.0 is not one particular point in time, but a process whereby many stakeholders are involved. According to Klein and Sorra (1996, p. 1057), implementation can be defined as a 'transition period during which targeted organisational members ideally become increasingly skilful, consistent, and committed in their use of an innovation'. In this process, several stages can be distinguished, starting from the initiation or adoption of the technology, continuing with the adaptation and acceptance by the users, and ending with the routinisation, incorporation, compliance, or stabilisation (Trullen et al., 2020). This definition of implementation incorporates the overlap between the dimensions, organisation, technology, and human (Figure 1). Neglecting one single dimension potentially blocks the entire implementation process since all the dimensions are interrelated.

Figure 1

Industry 4.0 dimensions



Note. This model was produced by Oks et al. in 2017, summarizing three factors that influence the process of implementation. From "An application map for industrial cyber-physical systems," by S. J. Oks, A. Fritzsche and K. M. Möslein, 2017, Industrial Internet of Things, 21-46.

Methodology

A case study is used to answer the research question: *How to design a teaching case about the challenges for organisations and employees during the implementation of Industry 4.0?*. To answer this research question several selection criteria have been developed. Our first criterion was that the case should be multidisciplinary, which would made the case suitable for different educational backgrounds at the University of Twente. Therefore, we designed the case around the concepts organisation, technology and human. Secondly, the case should be written about a regional organisation that already implemented Industry 4.0. Students can identify themselves better with regional organisations and it provides the opportunity for long-term cooperation between the University and regional organisations. Third, this teaching case should be useful for undergraduate students of various educational programmes offered by the BMS faculty. The case should therefore be rich and contain a lot of background information (Yue, 2016). The aim was to design a problem-identification case, meaning that the purpose is to get students to prioritize information and identify, define, or re-define a problem. This type of cases are popular in management classes with a strong emphasis on problem solving, because it can help students learn to distinguish between significant and trivial information (Swiercz, 2000).

Based on the abovementioned criteria a regional organisation has been selected that has already implemented Industry 4.0 in her production process. This case study has been performed at HYDRO which is an industrialised manufacturing organisation located in the Netherlands. The case is selected because it was in the process of implementing Industry 4.0 in their production facilities. In order to develop a strong and multidisciplinary case with enough depth in the experiences of the organisation and her employees, some more criteria were designed for the respondents. First of all, the interviews were held with employees from different hierarchical levels to gain different perspectives on the implementation process. Fifteen employees with different jobs have been interviewed, such as the Managing director, Line Managers, Operational Employees and the HR manager. This provided us with detailed insights on employees' perceptions towards the technology at the organisation. Secondly, the employees should have a permanent contract at HYDRO and work for HYDRO since the move to the new high-tech factory in 2016. This meant that the tenure of an employee should be a minimum of five years. Three out of the fifteen participants had a tenure of less than five years. However, these participants had a managing role and were thus relevant for our research.

We performed a qualitative research with semi-structured in-depth interviews. After the data collection had been finalised, it has been transcribed with otranscribe.com and analysed with the coding programme ATLAS.ti. The teaching case has been developed based on a framework that relates to the theoretical concepts human, technology and organisation by Oks et al. (2017). The coding process was data-driven, this refers to an approach where the concepts, codes, and sub-codes are determined and specific parts of the interview transcripts have been transformed into a story covering these concepts and related theories. The data that we gathered for this research was mainly primary since it was based on interviews. We collected some secondary data on the employee base (2015-2021) and on job descriptions before and after moving to Hengelo. In order to ensure the trustworthiness of this research, credibility has been taken into account. Credibility was achieved by practices like a thick description, multivocality, member reflections, and triangulation or crystallization (Tracy, 2010).

Results and Discussion

Several concepts, modes, and models have been discussed to explain the challenges in the implementation of Industry 4.0. The bottlenecks in the implementation process were analysed, identified, and diagnosed, as well as the potential risks and challenges of Industry 4.0. The case story has been designed around the three pillars: organisation, technology, and human (Oks et al., 2017).

Organisation

In the organisational part, we discussed the concept of implementation of Industry 4.0. The implementation of Industry 4.0 at HYDRO is an ongoing process. HYDRO created a support base for the adoption of new technology by setting up project groups. The acceptance of the users has been created by user involvement and facilitating conditions provided by the organisation. The performance of employees has increased through Industry 4.0, however conflicting goals, caused by a changed demand, create a feeling of being less efficient at the employees. In general, the employees have a positive attitude towards technology, because it is easy to learn the new skills. However, within some of the departments there is no routinisation or stabilisation of industry 4.0 usage, because the technology increased the complexity of the processes. Over the last years, HYDRO has noticed a change in demand, customers are now looking for personalised products at a low price. At the same time, customers are asking for a continuously increased flexibility. This increased complexity of automation and machinery requires a more detailed order-preparation and skilled operators. Last-minute order changes heavily impact the efficiency of the production process, but it provides the customer with the option of detailed engineering. As for the machines in the high-tech factory, it has shown that suppliers need to have excellent knowledge about the technology that is provided by them. Most of the implemented projects that failed are related to the suppliers of the technology. A successful implementation process seems to be dependent on the expertise of suppliers and the knowledge of employees within the organisation. Based on the story of HYDRO, we can conclude that a successful future Industry 4.0 implementation requires skilled suppliers of integrated technology. Furthermore, companies should aim to process as much data as possible, preferably automatically, towards customers and suppliers to reduce labour intensive work.

Technology

In the case story, the technology at the office and the factory is being discussed. Technology has been analysed with the Smart Industry Maturity Model (SIMM) by Zhu (2017). With this model, one can identify the status of the processes and technologies in relation to Industry 4.0 (Zhu, 2017). The high-tech factory has been designed to standardize and improve efficiency in the manufacturing process. In case of HYDRO, the supply chain partners have barely been involved in the digital interconnection, which can be dedicated to the fact that these organisations are competing in an industry that is lagging behind. On the other hand, the customers of HYDRO are forerunners in their industries and are demanding more production information about the ordered valves, which affects the administrative processes of HYDRO. Their customers are thus exerting some form of pressure on HYDRO to further automate their production process. The Project Expediting and Logistics Department provides the customer with specific order information which needs to be registered in customer portals. Internally, HYDRO connected the different departments of the organisation, i.e. the office and the factory, with Isah. Isah is an ERP package in which printed traveller-sheets have been exchanged with digital administration. Digital administration in Isah directs the one-piece-flow production throughout the factory, administration can be registered via 2D codes that connect individual valves with Isah. On the one hand, technology has shown to make the production process easier, and valves can be tracked down by Isah. On the other hand, it has shown that to be more challenging. The information in Isah is essential for controlling the system, if one minor detail has been forgotten, the system stops working and affects the whole factory. In general, we can conclude that the implementation of Industry 4.0 requires optimal data processing in order to produce efficiently, since there is no opportunity to work around the technology.

Human

In the final part of the case story, the experiences of the employees have been addressed. Employees' perceptions towards technology can be analysed with the Unified Theory of Acceptance and Use of Technology (UTAUT) model. In general, the productivity of the employees has increased. Most of the (younger) employees appreciate working with smart technology, because it makes their job more challenging which positively influences the acceptance of Industry 4.0. However, in some cases the technology gives the operators the feeling that they are less productive, due to the cadence of the conveyor system, which seems to slow down particular steps of the Painting and Expedition process. This works against the acceptance of the technology and the creation of a support base for Industry 4.0. In most cases, the technology has simplified the job. Operators who have worked for HYDRO for a long time do not like working with the new technology, because their jobs have become less challenging, which has a counterproductive effect on the acceptance of Industry 4.0. On the other hand, some jobs have become more complicated, because these operators need to possess programming skills. The administrative tasks have increased and finding the right information in Isah seems to be quite complex. In general, it be concluded that the jobs have not become much more complicated, but the effects of the technology change the content of the job. Most employees with a permanent contract have negative perceptions towards Industry 4.0. The new high-tech factory relies on technology and all employees need to work with it, because integrated systems control the production process. HYDRO provides support to all employees in working with the machines and Isah with the HYDRO Academy and instruction manuals. Positive attitudes towards Industry 4.0 are being created in this way. Isah integrates the office with the factory and that works out well, however the example of the AGV has shown the complexity of implementing automated machinery. Furthermore, HYDRO experienced many challenges with suppliers that did not possess the right skills to make the fit with their other machines and systems. This heavily impacted the support base of the employees, which is essential in becoming a successful high-tech factory.

Conclusion

The aim of this case study was to design a teaching case about the challenges that organisations and employees face during the implementation of Industry 4.0. Teaching cases are particularly suitable to teach students about real-world issues. This teaching case about Industry 4.0 has been designed in a way that it can be utilized for undergraduate and Master students in different study programs offered by the BMS faculty, such as (International) Business Administration, Engineering, and Philosophy. There is a growing market demand for product diversity and customization while at the same time companies are having issues with finding suitable personnel. Many companies are responding to these changes by integrating automated technology, or Industry 4.0, in their production processes. This case builds awareness and understanding of the issues faced by one organisation and her employees as they attempt to evolve with changing market dynamics. From this study, we can conclude that the implementation of Industry 4.0 is an ongoing process. Conflicting goals, due to changing market conditions, have increased the complexity in specific departments of the organisation, which hinders the final stabilisation of Industry 4.0. Technology has shown to work, as long as it is used for its initial purpose, such as being more efficient. The technology integration requires more detailed order processing in order to direct the internal production process. At the same time, customers requires more detailed specifications about the (end) product which is quite labour intensive as long as this is not processed automatically. Suppliers of the technology also play an important role in having a successful implementation process. The automated technology seems to perform better if the supplier can implement its standard product instead of providing individual solutions to an organisation. Most of the individual solutions failed in the implementation, which negatively affected the acceptance of Industry 4.0 by employees. Even though

the employees of HYDRO have become more productive in the new high-tech factory, in some departments the conflicting goals negatively impact the acceptance of Industry 4.0. HYDRO facilitates her employees as much as possible, and the technology itself is not difficult to work with in most cases in general, but it can be concluded that technology changes the content of the job. All in all, a second implementation process will fulfil the current market demands, who knows what happens in the future.

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