Facilitating an Industry 4.0 Implementation

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Abstract

We are today facing an industrial revolution called Industry 4.0. Earlier in the human history, we have seen multiple industrial revolutions, but only after they actually happened. This is the first time we can see that an industrial revolution is on its way. With this knowledge, we have the chance to prepare for this large-scaled technological change that we are standing in front of.

Because of the impact that earlier industrial revolutions had on organizations, we can assume that Industry 4.0, as well, will impact and change work, tasks and the organizations themselves; especially when it comes to new high-tech knowledge and skills that need to be learnt.

Implementation, change, and high-tech learning, together with a constantly running production can be stressful for anyone involved. For this reason, the purpose of this study is to come up with solutions on how you can facilitate the implementation of Industry 4.0, for employees and in an organizational point of view. We do this by conducting a literature study as well as interviewing organizations within the Swedish manufacturing industry. The structure of the analysis is built upon Lewin's Three-stage Model of Change. Here, we discuss and present solutions according to the stage in which they fit during the change process. Additionally, we investigate the concept of gamification as a tool to facilitate change.

From our research, we conclude that motivation and engagement are keys in a technological change project such as Industry 4.0. Involvement, transparency and clarity are important aspects to make employees engaged throughout the project. Additionally, we present practical solutions for how organizations can educate their employees within Industry 4.0 techniques, as well as increase their motivation and engagement.

Keywords: Industry 4.0, big data, artificial intelligence, augmented reality, virtual reality, cyber-physical systems, cloud computing, change management, technological change, competence development, motivation, Lewin's Three-stage Model of Change, gamification.
Sammanfattning

Vi står idag inför en industriell revolution som kallas Industri 4.0. Tidigare i historien har vi sett industriella revolutioner först efter att de inträffat. Det är nu första gången vi kan se att en industriell revolution är på väg. Med denna kunskap har vi idag en möjlighet att förbereda oss för den teknologiska utveckling som vi står inför.

På grund av de tidigare industriella revolutionerna och den stora påverkan som de har haft på organisationer, kan vi anta att Industri 4.0 också kommer förändra jobb, uppgifter och organisationer – framför allt när det kommer till den nya teknologiska kunskap som nya maskiner och system kommer kräva av de som använder dem.


Detta arbete kommer fram till att det viktigaste för att genomföra ett förändringsarbete i denna omfattning är motivation och engagemang från både anställda och ledning. Involvering, transparens och tydlighet är viktiga delar för att göra anställda engagerade genom hela projektet. Vidare presenterar vi lösningar för hur man kan utbilda sina anställda inom Industri 4.0-tekniker, och även för hur man kan öka motivation och engagemang.

Nyckelord: Industri 4.0, big data, artificiell intelligens, augmented reality, virtual reality, cyberfysiska system, molnlagring, förändringsledning, teknologisk förändring, kompetensutveckling, motivation, Lewins trestegsmodell för förändring, gamification.
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Glossary

AGV  Automated Guided Vehicle
AI   Artificial Intelligence
AR   Augmented Reality
CPS  Cyber-physical Systems
CRM  Customer Relations Management
CSR  Corporate Social Responsibility
I4.0 Industry 4.0
IIoT Industrial Internet of Things
IoS  Internet of Services
IoT  Internet of Things
PDM  Product Data Management
PIS  Production Information System
PoC  Proof of Concept
VR  Virtual Reality
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1 Introduction

1.1 Background
Over the last 200 years, society has gone through considerable technological developments in all areas. The first industrial revolution occurred at the end of the 18th century, when mechanical processes entered the industries and when the economic structure of societies started to form. The second revolution involved the development and the use of electricity, gas and oil, which became the foundation of combustion engines. The third, in the end of the 20th century, brought microprocessors, telecommunication and computers. The above described revolutions are the foundations of modern industry. They all had an impact on the shape of organizations, work environments as well as the knowledge that employees need in their daily tasks (Sentryo SAS, 2017).

Today, we are standing before a technological revolution that has come to be called the Fourth Industrial Revolution, or Industry 4.0 (I4.0). This revolution represents an extensive technological development within all industries. Industry 4.0 consists of several building blocks, such as artificial intelligence, machine learning, cloud computing, big data analysis as well as augmented reality and virtual reality. Because of the impact that earlier industrial revolutions had on organizations, we can assume that I4.0 also will imply changes in work, tasks and the organizations themselves. In addition, the high-level technology requires employees to attain new knowledge, and the change itself requires dedication and motivation from both management and employees. For this reason, a key component of the I4.0 implementation will be change management.

Figure 1: The 4 Industrial Revolutions
1.2 Aim and Research Question
The aim of this study is to explore Industry 4.0 in the manufacturing industry, and whether gamification can be used to motivate employees during the Industry 4.0 implementation. With regards to this, the following research question is formulated:

In the employees’ as well as the organization’s perspective, how can an Industry 4.0 implementation be facilitated?

To help answer the research question, three sub-questions are formulated:

- What organizational obstacles do companies face, when going through an implementation of Industry 4.0?
- How should an organization manage a large-scale technological change project, from the employees’ point of view?
- Are there any practical solutions that can facilitate the Industry 4.0 implementation?

1.3 Delimitations
The scope of this study is limited to the Swedish manufacturing industry. Practical examples are taken from different industries that manufacture goods in Sweden. However, conclusions drawn can be generalized to be applicable internationally as well as in other industries.

1.4 Research Method
Due to the theoretical knowledge needed to be able to answer the presented research question, the study is partly conducted by a literature study. The focus topics for this literature study were Industry 4.0, change management, technological change, leadership and gamification. The databases used to find literature on the topics were KTHB Primo, which is the KTH Library search database, Google Scholar and AIMI Journals. The search words used were different combinations of the following: Industry 4.0, change management, technological change, leadership, leading change, gamification.

Knowledge about Industry 4.0 and its building blocks was imperative to understand the context in which the study aimed to apply gamification, and to understand the technical challenges that manufacturing organizations face during this technological development. Research on change management was helpful to understand the challenges organizations are faced with when going through any kind of change project, and how to work around those challenges. This mainly concerns management, people and leadership. Specifically, the research on technological change brought us to notice specific challenges that occur during a technological change project and how to manage those. Lastly, knowledge about gamification was imperative as well, to enable discussion and conclusions concerning
whether the concept can be helpful in the manufacturing industry before, during and after an Industry 4.0 implementation.

In addition, to find some concrete examples of the Industry 4.0 implementation and the use of gamification in the manufacturing industry, three interviews with different organizations within the Swedish manufacturing industry were conducted:

- **Volvo Powertrain** - manufacturers of transmission elements for the Volvo Group
- **Sandvik Coromant** - manufacturers of solid carbide tools
- **Orkla Confectionary & Snacks** - manufacturers of snacks

The interview questions were both of semi-structured and structured character. They were conducted with individuals in each organization that work with, or are otherwise concerned with, each organization’s production and technological development towards Industry 4.0. The interview questions may be found in the appendix.
2 Industry 4.0
The concept of Industry 4.0 has its roots in the German manufacturing industry. Its main purpose is to integrate the Internet of Things (IoT) and the Internet of Services (IoS) into the manufacturing environment. An Industry 4.0 vision is that organizations within the manufacturing industry will create global networks of machines, factories and warehouses in the form of cyber-physical systems (CPS), that communicate and share information with each other that impacts their function. (Gilchrist, 2016, p. 195)

Another key aspect of I4.0 is that of vertical and horizontal integration. Vertical integration refers to the integration of the different IT-systems within an organization that are used at different hierarchical levels. This includes everything from a machine sensor, to systems for strategic planning on a management level. Horizontal integration refers to the integration of IT-systems used in the different phases of the supply chain, such as logistics, production and marketing, i.e. the different functions within the organization. Horizontal integration includes the entire supply chain, all the way from suppliers to customers. (The Industry-Science Research Alliance; National Academy of Science and Engineering, 2013, p. 20)

Because of the flexibility that these smart factories will provide for the organization, the implementation of Industry 4.0 would be useful both in small- and large-scale organizations. The vertical and horizontal integrations, combined with smart products, allow easier decision making and dynamic process control. In practice, this means that last minute changes will be easier to perform, and more custom products will be possible to manufacture. It also enables manufacturing of smaller batches, that still are profitable and can be made to order. These possibilities are revolutionary to the manufacturing industry, as they create opportunities for innovative business models and propose new ways of creating value. (Gilchrist, 2016, p. 196)

In their conference paper, Armengaud et al. describe Industry 4.0 as the digitalization over the entire product lifecycle. They suggest that Industry 4.0 focuses on digitalization of the entire development lifecycle, including the product’s in-use and service phase. This way, the organization supports global optimization of all product lifecycle phases. In addition, the organization will add value and reduce costs for customers, and be able to reach quality, emission and legislation targets more easily. The organization’s integration of further technologies will also be more efficient. Finally, the production system will be increasingly flexible to allow more individualized products and quicker responses to deviations. (Armengaud, et al., 2017, pp. 3-14)

2.1 Big Data Analysis
Over the recent years, the possibility of data collection has grown. This is partly due to the use of credit cards and similar traces that people – and even machines – leave behind in their daily lives. Of course, the internet facilitates this data collection. At first, big data was mainly used in the retail industry, when internet shopping started to expand. Actors
within the industry realized that information about people’s shopping habits would be valuable. For example, booksellers in physical stores could track which books were sold and which were not, but as well, which books their customers searched for. This way, the industry’s understanding of its customers increased dramatically. Companies started to invest money to optimize their website layouts, to make their customers more likely to make purchases. They began to see the importance and advantages of reviews and promotions, in examining customer habits and similarities between groups. With all this data, the management of organizations could make better decisions and predict trends more precisely and quicker than ever before. (McAfee & Brynjolfsson, 2012, p. 4)

Today, it doesn’t matter what field or industry you are in to understand that there is value in all the information that is available to you. Within manufacturing, big data is used in the optimization of production quality and service, the reduction of energy consumption and finally the improvement of the efficiency of production processes. Companies in all industries cannot afford to not collect and use the data they have. (Gilchrist, 2016, p. 208)

Furthermore, it’s valuable to increase customer satisfaction as well as the ability to adapt quicker to trends, which in turn creates value for the company. (McAfee & Brynjolfsson, 2012, p. 4)

2.2 Artificial Intelligence and Machine Learning

With big data, we collect and store big amounts of information, and use this information to predict habits and trends. Artificial Intelligence (AI) has its base in big data. AI is when we let computers use the information collected, to change and adapt according to the different data points. This, by iterating over the same object many times. The computer can learn and understand what is supposed to come next and what the product, service or answer is supposed to look like. Moreover, the key aspect of artificial intelligence is that computer scientists teach the computer, depending on the data, what to do and how to adapt when the information changes. This way, you can say that computers can make decisions; but as of today, only decisions that the human brain programmed them to make. (Gilchrist, 2016, p. 57)

A basic example of AI is when you play a game where there are multiple questions. If you provide the wrong answer, the computer understands and gives you an easier question next time. It adapts after the user’s behavior, which in this case is your knowledge.

The human brain is great but gets easily tired and bored if the task is not interesting enough. AI makes the computer’s role both more important and better suited for the kind of work that could be considered as boring. When it comes to manufacturing, AI will take a lead in testing products. It also has potential in different kinds of tasks that today could be classified as repetitive. (Gilchrist, 2016, p. 58)
2.3 Cyber Physical Systems
Cyber Physical Systems focus on how to collect real-time information from the physical world and convert and synchronize it into the cyber computational world (Bagheri, et al., 2015, p. 1622). This way, systems can collaborate with each other and will be continuously updated. Manufacturing processes can use data-accessing and dataprocessing services available in the company cloud, which will make the process easy to follow for anyone in the organization, in real-time (Monostori, 2014, p. 9).

When it comes to the manufacturing industry, the use of advanced analytics and cyberphysical systems will create a connection between machines and their ability to perform more collaboratively, effectively and resiliently. Many people think that this technique will be the forefront when it comes to Industry 4.0, because it enables the collection and the cloud-storage of information, so that people in different places of the organization can follow the production in real-time. (Bagheri, et al., p. 1622)

2.4 Cloud Computing and Cyber Security
Many people claim that cloud computing and cyber security are going to be the biggest challenges in the future of Industry 4.0. A cloud system is defined as an online storage point for information, reachable from anywhere in the world. With the use of big data and AI, computers and databases will have to collect and store a greater amount of data than in earlier stages of history. Moreover, the integration of systems will allow different levels and functions in the company to access the information quicker and more frequently. As a result, the company will need to use more cloud storage and more data-driven services for their systems. The performance of cloud technologies will therefore have to improve and increase. (Boston Consulting Group, 2019:1)

Cyber security is what we call the safety around cloud computing. There will always be a risk with having valuable information online and understanding the risks when making changes in the way of storing information is therefore essential. Furthermore, developing efficient protection systems and realizing that 100% security cannot in reality be attained, is important as well. All possible weaknesses need to be evaluated, and an endto-end security plan for the stored information is necessary. An attack on the data collections can affect a company heavily and can be costly even for large-scale organizations. (Boston Consulting Group, 2019:2)

2.5 Augmented Reality and Virtual Reality
Augmented reality (AR) is used to view real-time information in a real-time environment. The common application of AR is through a pair of glasses, where you see the world around you, but additionally you can see and send information, for example when selecting parts in a warehouse. Today, this kind of technology is mainly used in entertainment and marketing applications. It has also been tested and used in productivity applications in factories, especially for spatial planning and navigation systems. (Paelke, 2015, p. 1)
Virtual Reality (VR) enables visualization of virtual objects or environments. For instance, glasses or large screens can be used to see a 3D-view of another reality. So far, VR has mainly been used in the entertainment industry. Today, this technology is being developed in different areas, such as in the design and construction of cars, and in architecture for designing buildings. In practice, the virtual reality itself is created by a combination of hardware and software. (Paelke, 2015, p. 1)

In the case of Industry 4.0, we mainly talk about VR and AR as ways to simplify learning, or to view places in the manufacturing environment that you cannot physically visit. Moreover, it can be used in the planning of new production lines, in the connection of new machines and in the introduction of new production or storage facilities. In these cases, VR helps to visualize and thereby provide a better overview when planning. (Kovar, et al., 2017, p. 1)

Figure 2 below shows a summary of all the Industry 4.0 aspects and building blocks.

Figure 2: Industry 4.0 building blocks
3 Change Management

An implementation of Industry 4.0 implies a great change within the manufacturing environment. Philips stated that companies that do not adapt to major change within their competitive environment can receive great penalties in the form of declining profits. On the other hand, companies that respond quickly to changes may be able to continue uninterrupted growth and even turn the changes to their advantage. For this reason, change management is imperative. Furthermore, Philips identifies three critical components for a successful organizational change. First, the company needs a new strategic vision. Second, the company needs new organizational skills to implement the strategic vision. Third, the people within the organization need to be deeply committed to the new vision and organizational skills. Otherwise, the change will not happen. (Philips, 1983, pp. 184-188)

According to McKinsey, 70% of organizational change efforts fail (Bucy, et al., 2016). Examples of pitfalls, they say, include lack of employee engagement, poor or nonexistent cross-functional collaboration as well as lacking accountability and inadequate management support. They add that an organizational transformation requires major resets in behaviors to be sustainable, which leaders have problems achieving. Continuing, change efforts are 30% more likely to stick when people are genuinely invested (Ewenstein, et al., 2015).

Society today is changing at a rapid pace. A need for flexibility and innovation has never been greater; whether it is a new technology, an update of existing products or services or any other changes. Change affects people in different ways and is for many people stressful. Therefore, different kinds of leadership for different types of change and personalities may be needed. No matter the type of change, there is a risk of meeting resistance from the people involved. Change can be drastic and sudden, but if it is expected, different tools can be used to make it smoother for everyone involved. (Nahavandi, 2015, p. 303)

An important concept to minimize resistance is the concept of champions of change. Champions of change are individuals within an organization that voluntarily show great engagement during a change process. They promote new projects, products or ideas, and do this with great visionary qualities and enthusiasm. Change champions are especially important because of their ability to influence others to support the change; they adopt the projects as their own and advocate them relentlessly. These champions cannot be forced to be engaged – they must find their own cause to why they want to support the idea. (Thompson, et al., 2006)

Kurt Lewin stated that a successful implementation of change can only be conducted when the forces for change are stronger than those that resist change. Consequently, leaders need to either motivate, or reduce and neutralize the forces that resist change. (Nahavandi, 2015, p. 304)
Another key aspect of change management is feedback from managers to their employees. Russberg & Angelis define the law of the strength of consequences as follows: a consequence has the greatest effect if it is, in the perspective of the individual, positive, close in time after the performed behavior, given and meaningful. This gives the incentive that positive feedback from a manager could be very effective in organizational change. Angelis & Russberg also state that positive reinforcement is the key to affecting the behavior of employees. (2018, pp. 58, 64)

3.1 Lewin’s Model of Change
There are several models for leading change. In this study we will use one of the most common ones – Lewin’s Three-stage Model of Change (Nahavandi, 2015, p. 304). According to Nahavandi, Lewin views human behavior as a dynamic balance; forces that are working in opposing directions. To push employees in the right direction during a change process, it is important to encourage forces that work for implementing change, and to restrain forces that work against the change (Kritsonis, 2005, p. 1). Kurt Lewin’s Three-stage Model of Change consists of the following stages (Nahavandi, 2015, p. 304):

- the unfreezing stage,
- change,
- the freezing stage.

The unfreezing stage can be conducted in three steps. The first step is to increase the driving forces for change. This involves convincing the followers that the change is needed. The second step is to decrease the negative forces, which can be done by developing and motivating a need for change among followers. The third and final step is to engage the followers in the change process and to cooperate with them to create a plan and structure the change. Ray Williams, a consultant and coach in leading change, stated that “to embrace change, [employees] must also engage in a process that changes how they think about themselves, not just their jobs”. (Nahavandi, p. 304)

The second stage is the process of change itself. In this stage, Kritsonis states that it’s important to encourage everyone involved to view the problem from new perspectives (2005, p. 2). She states that management and employees need to agree that the status quo is not beneficial, and that the change is needed. Here, she adds, it is important to work together for the change and collect important information, as well as to connect the views of the group to leaders that also support the change. Nahavandi adds that in this stage, new policies, practices and skills need to be learned, and that the leader’s role is to be supportive and to continue to emphasize the importance of the change (2015, p. 305).

The last stage, freezing, takes place after the change has been implemented. Kritsonis states that here, the importance is that employees don’t go back to their earlier behaviors (2005, p. 2). She states that the purpose of this stage is to stabilize the change, and that the actual integrations become new routines. Nahavandi adds that the focus in the freezing stage is to use new skills frequently (2015, p. 306). He also states that the leader’s
role in this stage is to provide resources for training and coaching, as well as to use reward systems to continue motivating the employees to learn.

3.2 Technological Change
An implementation of Industry 4.0 implies a large-scale change within an organization. It affects not only the processes within a manufacturing organization, but the roles of the employees as well. Pisano & Teece (2007, p. 281) mention that as the pace of technology speeds up, an important task is changing the nature of the management. During this change process, leadership is a key factor. Especially within a technological evolution, leaders can introduce new ideas, set up goals and sub-goals as well as inspire employees to deliver innovation initiatives. (Hanafi, et al., 2018, pp. 1-2)

In 2016, PwC published the “Global Industry 4.0 Survey”, in which they state that implementing I4.0 requires transformation throughout the entire organization. They add that a digital culture needs to be fostered; that employees need to think and act digital, experiment and learn new ways of operating. From an interview that PwC conducted with some manufacturing organizations, they identified the most extensive challenges to be internal issues such as organization, leadership, culture and skills. (PwC, 2016, pp. 10, 17)

An implementation of Industry 4.0 will bring smart objects and machines, as well as increase interactions with and between products, machines and processes. Because of this high-level technology, the industrial environment will change, and the competence required for the new systems will change. For this reason, one of the key factors of the implementation will be to educate the employees in the new procedures, machines and systems. Some examples are the demands for deeper understanding of the processes, and the use of smart media, such as smart glasses, in everyday work. There is also an increased need for employees with coding skills and with knowledge about cyber security and how to use different media in a safe way. (Hecklau, et al., 2016, pp. 2-4)

3.3 Learning and Competence Development
To implement a technological change like Industry 4.0, employees will need to interact with more complex products and systems. Therefore, new competences will be needed, which requires learning by training and education. (Hecklau, et al., 2016, p. 4)

There are several models to illustrate the process of learning. The most common and well-known model is Kolb’s Learning Cycle. Kolb claims that people will always learn differently. Some need more concrete, hands on experiences, some more abstract conceptualization, some learn through reflection and some through experimentation. Kolb’s Learning Cycle is used both for individual learning as well as for learning in groups. Kolb states that to fully learn and understand; you need to go through a set of rules. The first rule is about turning actions and results into experiences. The second is a complete reflection about the experience, to continue to develop and create a plan for the next action. Finally, the key is to repeat this procedure to improve the acquired skills along the way. (Drejer, 2000, p. 212)
4 Gamification

The concept of gamification comes from the world of video games. Its main idea is to use the elements of game design in non-game contexts, services and products to motivate the desired behaviors. Gamification has caught the interest of HR professionals and marketers, i.e. those who are interested in driving motivation and engagement. The common implementation of gamification is to simply add leaderboards, points and badges to activities. However, for gamification to work in practice, it needs not only to include games components such as leaderboards and badges, but also game design itself. (Deterding, 2012, pp. 14-16)

In game design, uncountable amounts of positive reinforcement are present. A player receives direct and continuous feedback for each activity, in the form of lights, sounds, movements and pictures, as, for example, a visual point system. Thanks to the fact that these reinforcements occur connected to certain actions and behaviors from the player, the player learns what specific actions are rewarded. (Russberg & Angelis, p. 65)

In the implementation of gamification, it is essential not to forget the organizational aspect. It is important with a great understanding of the business goals, of what user activities that drive value for the business (directly and indirectly), and lastly and understanding of the users themselves and what motivates them. It is also important that the entity being gamified already has some value to the users. If so, gamifying it can increase motivation and engagement. Understanding why the users engage within certain things within the organization helps to reach conclusions on different ways to reward them. (Deterding, 2012, p. 17)

An important ingredient of gamification is rewards. Wang & Sun define rewards systems as player motivators as well as compromises for easing disappointment. In addition, they identify eight different types of rewards: score systems, experience points, virtual items, resources (wood, stone, additional lives), titles, on-screen feedback messages, plot animations & pictures and finally, unlocking mechanisms. (Wang & Sun, 2011, pp. 1-5)

Chou states that rewards can be physical, emotional or intellectual. These rewards do not necessarily have to be in the form of badges. The most effective rewards, he states, are boosters that let people go back into the system and – in the context of a computer game – play more effectively. (Chou, 2016, p. 70)

Chou presents several gamification techniques that are possible to use in practical situations. One of them he calls Beginner’s Luck, which focuses on the concept of calling. Calling makes people feel like they are uniquely chosen to do something, that they are destined to the task. If a computer game player receives a very special weapon at the beginning of the game, he or she will likely keep playing to be able to use that weapon. Chou evaluates this metaphor further, saying that once the player receives the weapon, perhaps he or she is only allowed to equip it once he or she defeats a certain number of enemies. (Chou, 2016, p. 45)
Another game technique presented by Chou is that of Appointment Dynamics, which is a technique that harnesses the scarcity of time. In game design, appointment dynamics use a recurring or formerly declared schedule where users must take desired actions. Appointment dynamics form a trigger built around time. Chou exemplifies this with the garbage truck that comes every Tuesday morning. Because of this, the automatically takes the trash out Monday evening. (Chou, 2016, pp. 74-75)

Practical Applications of Gamification

There are several examples of practical implementations of gamification. Elizabeth Lawley states the following (Deterding, 2012, p. 16):

“When we set out to create Just Press Play, an achievement system for students in games and media at the Rochester Institute of Technology, we began by thinking about the behaviors we wanted to reward and encourage, as well as the ways in which a game could allow our students to reflect on their accomplishments and strengthen their sense of competence and progress.”

Within this achievement system, Lawley introduced an achievement for freshman students to pass the introductory programming course, because the pass rate had only been around 85%. This initiative motivated junior and senior students to spontaneously organize study groups, which they enjoyed so much that they asked to run study sessions in the future as well. (Deterding, 2012, p. 16)

Chou presents some modern examples of practical applications of gamification in enterprise workplaces. He mentions the customer relations management (CRM) system Salesforce and its sub-system Salesforce Motivation, which replaces manual processes with a user-friendly sales application. This application includes a progress bar, a team leaderboard, a customizable featured challenge as well as team standings that shows which team is in the lead. It also has a rewards tab, where employees can select from virtual or real-life goods. This way, sales teams can get real-time feedback, which helps them to achieve both short and long-term sales goals. (Chou, 2018)

Another example presented by Chou is Badgeville, a company specialized in gamification, that created an online service in which enterprises may configure and customize their own task related goals. These goals could for instance be completing work related reports or levelling up a key industry skill. An enterprise social network called Yammer is also integrated, allowing employees’ achievements to be published so that the entire organization can see them. (Chou, 2018)

Yet another example is the business application company SAP and their community network SCN. Users gain points through contributing and communicating within the network, and employees using the network are indicated with SAP badges. As their employees gain points and ‘level up’, it was decided that rather than getting a free T-shirt, they would donate their points to charity. This has allowed SAP to engage their employees’ inherent motivations of accomplishment and social status, and is a great
example of how badges, progress bars and leaderboards – basic game mechanics – can be effective if aligned to already existing inherent motivations. (Chou, 2018)

Finally, we present an example of a gamification approach that involved not only employees, but the general public. In 2009, Volkswagen initiated the campaign “Theory of Fun”, in which they installed piano stairs in a Stockholm subway station, each step playing a note when a person would step on it. The aim of this campaign was to get more people to use the stairs rather than the escalator, and to show that people are more likely to change when they have fun. Image 1 below shows this piano-staircase. (Design of the World, 2019)

*Image 1: The piano-staircase in Stockholm, Sweden (Design of the World, 2019)*
5 Interview Results
This section presents some information about each organization that has been subject to our interviews, as well as a summary of the interviews conducted.

5.1 Volvo Powertrain
Volvo Powertrain manufactures powertrain components for the Volvo Group, including engines, transmissions and drive shafts. The Köping factory specializes in transmission elements and has around 1500 employees divided across functions such as product development, logistics and production. The facility opened in 1856, although as part of another company, and started manufacturing transmission elements for the automotive industry in the early 20th century. The factory’s collaboration with Volvo began in 1926, and Volvo purchased the facility in 1942. (Volvo Group, 2012)

Volvo Powertrain state that their employees are their most important resources, and that they value diversity and teamwork. For instance, the factory puts a lot of resources into devices that facilitate their employees’ work, such as lifting equipment. (Volvo Group, 2012)

Volvo Powertrain - Summary of Interview
The Volvo Powertrain factory in Köping (henceforth Volvo) sees big potential for an implementation of Industry 4.0 and claims it’s a must have for the future. Volvo has not yet implemented any kind of artificial intelligence or machine learning but does see a good use for these technologies, especially for changing tools in their cutting machines. For instance, they could use them to be able to change the tools when they get worn out, instead of when the machines have been used a certain amount of times. Even if those techniques haven’t been implemented yet, Volvo has, over the years, invested in machines that are prepared for I4.0 manufacturing. In addition, they are collaborating with different universities in research projects about I4.0 techniques.
When it comes to VR and AR, Volvo has a team working part-time with this, and has several ongoing projects. For instance, they are building a virtual showroom where their products can be shown. Additionally, they have, and are using AR-glasses to help with operating machines as well as component assembly. When it comes to VR, Volvo has 3D scanned their factory. This, to get a good overview over the production environment and to make digitized plans in 3D. They then use these plans as tools for investments, development, or implementation of new machines and lines in the production.

Volvo is collaborating with a company taking care of their IT-security. They take cyber security very seriously but mention that it can sometimes be an obstacle. As an example, when they are connecting parts of their factory online to show their suppliers, there are problems with sharing screens because of different security reasons. Because of this, it can be difficult and time consuming to work with.

When it comes to horizontal integration, Volvo is currently integrating a new system. This new system will be able to collect different information along the production line and will be able to connect with other systems further on. When it comes to vertical integration, they have an older system where they are building, rebuilding and adding new systems on top of another. Volvo claims that this it is a bit hard to get rid of, and if they do, it will be costly and time consuming.

At Volvo, they have a remanufacturing facility where they can send parts that can potentially be reused. To minimize waste, they sell leftover material such as aluminum and chemicals.

When it comes to the Industry 4.0 implementation, they think that we will see a big change in manufacturing already in the upcoming three years. As well, they claim that they will never be fully finished with an implementation of Industry 4.0, since development that will always be moving forward.

The organization at Volvo in Köping is made up of the production department and the development department. In the production department they have a production manager, management team, area managers, section managers and operators. In the development department it is similar, but with fewer middle managers.

Volvo’s production is getting more complex and precise for every year. This enables them to have fewer people working on the line but increases their quality requirements and level of responsibility. As the production systems and machines will get even more complex with Industry 4.0, one of the key challenges will be to train and teach people to get the right competences. However, these systems will also be able to perform complex tasks automatically, which in the long term will make the employees’ work easier.

Before, Volvo had a strategy in which production technicians were responsible for pushing the development of I4.0 forward. Unfortunately, the daily production took too much of their time, so it did not work. Therefore, they are today looking for several specialists to be responsible for questions regarding I4.0. One of those is a machine
engineering developer, who will only work with getting Volvo internally ready for the future, working with digitalization, simulation, PDM-systems and other parts of Industry 4.0. Further, they are also looking for someone to deal with transmission integration and electromobility. This is basically a person who can create a roadmap on how today’s products and production need to get in line with the ones of tomorrow. In addition, they are looking at bringing someone to work with in-line quality, seeing how Volvo can use modern tools to see real-time information in their manufacturing.

At Volvo they have curious and driven employees who think these questions are exciting and fun. Volvo claims it’s up to them as a company to give their employees the right tools to execute their tasks. They work with change management in times of change and think it’s important to let the people who have time, and the right people, drive those projects forward.

Many of the employees at Volvo have been working there for 20-30 years, and a few have been there only for a couple of years. They say that it’s very good to have a mix in ages. This, thanks to the different mindsets that create an environment where a lot of ideas and solutions arise.

When it comes to gamification, they are not using this in the organization. From Vilhelm’s earlier experiences, things like competitions and leaderboards is fun in the beginning but gets boring in the end if it’s too repetitive. At Volvo, employees are instead working with different goals defined together with their managers and have development talks three times a year. Here, they get guidance and tools to work on how to reach their personal goals.

5.2 Sandvik Coromant

Sandvik Coromant is part of Sandvik Group and manufactures tools and machining solutions (Sandvik Coromant, 2019). The Gimo facility specializes in tools and cemented carbide inserts. The factory opened in 1951 and has 1500 employees. With its 200 Automated Guided Vehicles (AGV), and shifts run only with robots and AGVs, the plant is highly automated. (Sandvik Group, 2017)

In 2019, the World Economic Forum recognized the Gimo production unit as an advanced Industry 4.0 facility. The site has been named a lighthouse site, meaning that it “deploys a wide range of Industry 4.0 technologies ... while keeping humans and sustainability at the heart of innovation”. They announce that the facility has raised labor productivity significantly by creating a digital thread through its manufacturing processes. For instance, their touchless changeover allows for design patterns to be changed automatically, even when machine operators are not present. (Sandvik Group, 2019)
Sandvik Coromant – Summary of Interview

Sandvik Coromant (henceforth Sandvik) sees a lot of potential when it comes to Industry 4.0. They see that it is profitable, and that increased automatization gained from, for instance, machine learning algorithms, will create new tasks for operators and new possibilities for increased production volume in the form of extending the factory. They don’t agree with the fact that machines steal the employees’ work and point out that it’s only the repetitive and boring aspects of work that will be replaced, such as transportation of inserts/orders from one operation to another. These specific tasks will be made more efficient than when done manually, and machine operators will work with something of more value. There is not a single case where Sandvik has fired someone simply because they don’t have anything to do. Sandvik believes that a full implementation of Industry 4.0 will take them maximum 10 years.

Sandvik has already implemented some aspects of Industry 4.0. For instance, they make use of data analysis, although mainly for statistical purposes. For this, use statistical tools such as CoroPlus™, which is a suite of data analytics solutions developed by Sandvik Coromant themselves, aimed to improve the control of productivity and costs (Sandvik Coromant, 2016). In addition, Sandvik has a Production Information System (PIS) that gathers data. For instance, they can see how their ovens are doing and what RPM their grinding wheels are rotating at. A red lamp flashes when the RPM is too low, and so the machine operator can investigate. However, there is room for improvement. Currently, Sandvik replace their grinding wheels periodically, independently of how worn they are. If they would develop predictive maintenance, they would be able to tell when the component needs to be replaced. For instance, a warning could be shown if the component is at 80%, if it usually breaks at 75%.
Sandvik also uses cloud computing, through OneDrive and SharePoint (by Microsoft). They have local data servers but are starting to move into the cloud completely. It varies what data and how much they store. For Sandvik, cyber security is of great importance. Cloud storage is done within their domain, and employees need to go through a VPN certification to reach the data.

Regarding vertical and horizontal integration, Sandvik has a little bit of both. They gather data at different hierarchal levels (sensor data excluded), and all levels within the organization can reach it. Regarding horizontal integration there are systems such as order and tap systems that are integrated.

From a sustainability perspective, Sandvik considers it important to keep track of the product life cycle. When tools are worn out, Sandvik buys them back from their customers, grind them down, separate and recycle them. Their CoroPlus™ system helps them to integrate sensors within the tools that they produce, which during use collects information about temperature, speed and degree of wear. They have ideas on how to make this idea smarter, so that the margin before the tool needs to be replaced is minimized.

Some aspects of Industry 4.0 are not yet implemented at Sandvik, such as AI and machine learning. Since the beginning of the 21st century, Sandvik has been using automated guided vehicles (AGVs), in the form of trucks that collect and deliver items automatically. They are now looking into using AI to improve the AGVs, so that they, for instance, take another available route if something is in the way. Currently they just slow down if that's the case. Sandvik stresses that a Proof of Concept (PoC) approach is important here, testing whether things work and whether they will be profitable.

AR and VR are not yet implemented at Sandvik. They are looking into AR and are in contact with companies that can help them out with it. Sandvik mentions that the concept doesn't currently feel very mature, and that a lot needs to change before it has a chance to be profitable. Creating a virtual model of the facility could for instance be useful for the AGV trucks mentioned earlier, so that they can develop their routes.

Regarding the organizational aspect, Sandvik sees some challenges specific for their organization, that will affect their journey towards Industry 4.0. Most workers at Sandvik are of the older generation. There is some resistance in learning new systems, especially when comparing to younger generations. Most of the employees who are around 50 or 60 years old have never heard of machine learning and AI. Sandvik sees the importance of communication, education, patience and acceptance. It’s not possible to simply throw new systems at their employees. An additional challenge is resources, since production and volume is always prioritized at Sandvik. Sandvik has an organizational structure in between flat and hierarchal, with operators, shift-leaders, production leaders and managers. This is difficult to avoid in a manufacturing environment.
The aspects of Industry 4.0 that have already been implemented partly at Sandvik has affected the roles of their employees. Before 14.0, employees needed to create a ton of Excel files and send those to each other to view data. Now, everyone can see the same data, using data analytics software to visualize. Before, Sandvik didn’t have any good way to look at their production, and managers needed to take notes on paper. Now, production information is updated every 10 minutes. This is important for both managers and machine operators. Managers can quickly move employees to a different workstation if that station is lagging. Operators can make quicker decisions.

Sandvik states that to motivate their employees towards change, they focus on talking and informing. They let their employees know why they are implementing a certain change, how it makes their work easier, what improvements it will bring and what this means to the stakeholders. Sandvik has a bottom-up approach – they go to the machine operators and ask them what they need. If the operators say, for instance, that it needs to be easier to see when the machine needs maintenance, Sandvik uses this information and attempts to develop a machine learning solution.

The difficulty of motivating the employees at Sandvik varies. Everyone isn’t in favor of the change, but if they are kept informed enough, they are pretty propulsive. Generally, it seems like the employees think that changes are good. After all, without change, the organization wouldn’t be around today. When it comes to differences between generations among employees, it’s fairly equal how willing they are to change. However, the technical aspect seems to be more difficult for the older generation, as mentioned earlier.

Gamification is not so present in the production environment at Sandvik. They point out that implementing it would be a challenge. If you put up, for instance, a leaderboard, it becomes very visual and evident who is better and who is worse. Then, issues will arise regarding salaries and whether better performing employees should have better salaries, which isn’t very helpful for their well-being. However, creating teams that work together to reach a goal would be much more efficient. It’s important that it happens at a team level and not at an individual level. In any case, someone would need to take initiative for something like that to be implemented.
5.3 Orkla Confectionery & Snacks
Orkla Confectionery & Snacks is a part of Orkla, and is the leading snacks- and biscuit manufacturer in Sweden. The Filipstad factory specializes in snacks and has 150 employees. At the time of its opening in 1997, the facility was the northern Europe’s most modern factory within its industry. Orkla Confectionery & Snacks has three more facilities on top of the one in Filipstad, they are in Kungälv, Nöbbelöv and Solna. In Sweden, Orkla is divided into different branches and together they own brands in several industries. Those are Orkla Confectionery & Snacks, Orkla Care, Orkla Foods and Orkla Ingredients. Their production facilities are spread out around the country. (Orkla, 2019)

Orkla Confectionery & Snacks – Summary of Interview
Orkla Confectionary & Snacks in Filipstad (henceforth Orkla) is using OneDrive for cloud storing in as many ways as possible. Thanks to a safety department dealing with questions about cloud computing and cyber security, they are not so worried about safety issues. Orkla is not working with AI today. They use sensors and are storing information about production stops online. However, the operators must write the reason to why the stop happened by hand into their digital system. They see potential in storing data, to find patterns and to make the production more efficient. They are currently discussing how they can store data from other parts of their manufacturing environment.

When it comes to horizontal and vertical integration, Orkla has a program called Colos that measures the production volume and sends this information to the overhead system SAP. However, they are in the process of integrating all of the production data into SAP, replacing Colos and increasing vertical integration. This system will be integrated
throughout all the 103 of the Orkla Group’s factories. When it comes to horizontal integration, they are today able to control the whole production line from one place.

As Orkla manufactures food with 6-month total lifecycle, they work with CSR (Corporate Social Responsibility) to see their ecological footprint and try to make it easy for their customers to take care of the waste from their products.

For Orkla, it’s right now all about learning and understanding the techniques behind I4.0. They say that the biggest challenge will be to change themselves and the organization. The big difference as they see it is the change in tools. Orkla has today a project group called Unified – this team has extra responsibility when it comes to new ideas that can make the production more efficient. Orkla’s production organization is built as follows: operators, shift leaders, production managers and section managers.

In the Filipstad factory machine park, there are some new and some older parts. Today, these machines are working well together, but when it comes to implementing new machines or systems, Orkla want to make sure that they can stand the challenges of the future. A challenge that they face is the employee’s roles, and how the employees can get used to a high-technological environment.

When it comes to change, Orkla wants engagement from their employees. They value getting their employees involved from the start of projects and to let them come up with solutions to their own problems in their daily tasks. Orkla says that their employees are curious and open when it comes to the manufacturing development and claim that their employees are not reluctant to implement changes. However, they do mention that the younger generation is more comfortable with change thanks to, they say, their digital fluency. At Orkla, there is a mixture of employees that have been working for 20-30 years and those that have been working for only a few years.

Orkla is working with gamification in different ways and has several internal competitions. This year, they sponsored the Swedish song contest Melodifestivalen, and had a quiz to get the employees more engaged in their marketing campaign. Additionally, across the Orkla Group, each factory gets a color – green, yellow or red – based on their results in a security audit. This is organized to make everyone understand the importance of safety, as well as learning more about the topic. The result encourages the Filipstad factory to work well with safety, because they want to stay in the green zone.
### 5.4 Answers to Structured Questions

Questions answered on a scale from 1 to 5.

<table>
<thead>
<tr>
<th></th>
<th>Volvo Powertrain</th>
<th>Sandvik Coromant</th>
<th>Orkla Confectionery &amp; Snacks</th>
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<tbody>
<tr>
<td>To what extent has I4.0 been implemented in your organization?</td>
<td>3</td>
<td>3-4</td>
<td>2</td>
</tr>
<tr>
<td>To what extent do you think I4.0 will be implemented in your organization?</td>
<td>4-5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>How much do you think I4.0 will change the human's role in your organization?</td>
<td>4</td>
<td>4</td>
<td>5</td>
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<tr>
<td>To what extent are your products individualized/customized?</td>
<td>2</td>
<td>4</td>
<td>5</td>
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<tr>
<td>How willing to change do you perceive your management to be?</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>How willing to change do you perceive your employees to be?</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>To what extent do you consider your organization to be leading in technology?</td>
<td>2</td>
<td>4</td>
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6 Analysis and Discussion

The first part of this chapter will give a current-state analysis of the organizations that have been subject to our interviews. The second will go through each step of the transformation towards Industry 4.0 according to Lewin's model. In each stage (unfreezing, change, freezing) we will discuss what the organizations should focus on, and what methods can be used to facilitate the advancement in the change process.

6.1 Current-state analysis

Volvo Powertrain in Köping has already implemented several parts of I4.0 and over the years, they have invested in several machines that are prepared to work with I4.0 techniques. Volvo thinks that there will be a big change in their manufacturing already in the upcoming three years. When it comes to VR and AR, Volvo has a team working parttime with this, and has several ongoing projects. They see great potential in artificial intelligence and are ready to implement it when the techniques are in place. Regarding horizontal integration, Volvo is currently integrating a new system that will be able to collect information along the production line. Volvo has a company taking care of ITRelated questions and the security around it. Volvo is taking IT-security very seriously but claimed that it can create obstacles when it comes everyday life. As the production will get even more complex with I4.0, one of the key challenges will be to train and teach people to get the right competences. New systems will require new knowledge for employees, for them to be able to interact with the new machines. Moreover, Volvo is today looking for specialists to be responsible for pushing the I4.0 implementation forward. The employees at Volvo are curious and driven, even though many of them have been there for 20-30 years. Volvo would like to have a bigger mix between ages in the organization, because when the mix happens, many ideas and solutions tend to come with it. Volvo does think that the employees’ roles in the organization are going to change with the I4.0 implementation.

Sandvik is pretty well along in their journey towards Industry 4.0. Of course, there are many aspects that they have not yet implemented, but they see great potential in I4.0 and are putting a lot of resources in the development towards it. The fact that the organization has been recognized as an advanced I4.0 facility is a promising step forward towards I4.0. Summarizing, Sandvik has already implemented parts of data analysis, cloud computing as well as vertical and horizontal integration. AI, machine learning, AR and VR are less or not at all implemented. Employees at Sandvik seem to be overall motivated towards change. The main challenge we see for the organization is education and competence development, since most workers are of the older generation and likely have more difficulties to learn new technological solutions. The general attitude that Sandvik has towards the future roles of its employees is something that we believe helps to motivate their employees. Especially since they seem to have no intention of firing their workers, but rather exchanging their repetitive tasks with tasks of more value. Their focus on communication and information is advantageous in motivating the Sandvik employees as well.
For Orkla, it’s right now all about learning and understanding the techniques behind Industry 4.0. They are using cloud computing in as many ways as possible and have sensors that store information from the production environment online. They do see great potential in storing data, mainly to find patterns and to make the production more efficient. They are in the process of integrating production data into their SAP-system, which will be integrated throughout all the 103 of Orkla’s factories. When it comes to horizontal integration, they are today able to control the whole production line from one place. Orkla want to make sure that if they invest in new machines, they can stand the challenges of the future. One big difference when it comes to I4.0 is the change in tools for the employees. They value getting their employees involved from the start of projects and to let them come up with solutions to their own problems in their daily tasks. Orkla says that their employees are curious and open when it comes to changes in the production. Some of the employees at Orkla have been working there for many years, while some are younger. They do mention that the younger generation is more comfortable with change thanks to, they say, their digital fluency.

6.2 The Unfreezing Stage
As earlier explained, the unfreezing stage is when the leader first engages and motivates her or his followers for the upcoming change. The key in this stage is to convince and make the followers understand why the change is needed. As Philip mentioned earlier in the chapter about change management, the people within the organization need to be deeply committed to the new vision and organizational skills. Otherwise, there is a chance that the change will not happen. Therefore, during the unfreezing stage the management needs to put efforts into making their employees committed towards the change project. This can be done in different ways and we will in the following text explain how we think organizations can do this in the best way, this, according to interviews, I4.0 and the high technological change that this implementation will bring.

Lewin said that successful implementations will only be conducted when the forces for change are stronger than the forces against change (see figure 3 below). Consequently, leaders need to either motivate their employees for the change, or reduce and neutralize they forces that resist change. To make this possible, motivation and engagement in an early stage is key, sometimes even before change is settled or decided. Because it is usually the employees that are working with the machines every day who know the machines and production lines the best, management should talk and listen to their employees regarding the advantages and obstacles of a specific change. The employees know what tasks are most time-consuming and where there is room for improvement. Then it’s up to the management to come up with suggestions for I4.0-ready solutions, such as an AI solution, and to figure out whether it’s suitable for the business and production as a whole. This kind of solution is used by Sandvik, as learned from our interview with them. It is important that the employees understand that the entire implementation cannot be done at once, and that their suggestions might not be prioritized first, but their information and knowledge is still valuable. With this kind of
solution, the employees’ voices are heard, and they feel included. It will also raise motivation and engagement among the employees and to understand that they are a part of the coming change.

As result from the interviews, all the companies strongly agree that Industry 4.0 will bring change when it comes to the employees’ role in the organization. This tells us that many jobs in the production line will be affected or changed. It is therefore important that this implementation is made in such a way that the employees can feel safe and not have to be worried to lose their job, if that is a risk. In changes as large-scale as Industry 4.0, it’s not always easy for the management to understand exactly what will be the outcome of the change, and even in those situations it is important to be transparent and let the employees be a part of the conversations, to let them get the information needed. Otherwise there is a risk that rumors start which cause even more confusion and conflicts among the employees. Therefore, we suggest that involvement, informing, clarity and transparency is important for the employees not to feel left behind or worried without reason. Moreover, it is important that the management sees their employees as an important part and asset to the development, and to make the employees understand that they need to grow and learn together with the change.

If management already has invested in machines or systems, they can involve the employees by talking about the implementation, and consult with the employees what they think it the best way to get it implemented. Can they help? Do they need external consultants? How do we learn it? The key here is to make them understand that the implementation is going to make the production better, and their job easier, after those techniques, machines or systems are implemented. Some might say this involvement and motivation will feel time consuming and unnecessary, but it is usually more important than they realize. This, because of the importance of having everyone works in the same direction and towards the same goal.

When the employees are involved and motivated it’s time to make a structured plan for implementing the change. In this stage, we suggest clarity and transparency about the plan. Here again, to get the company work together and to make the employees understand that they are a part of the change. It is crucial to let the employees be involved and for the management to be transparent.
Additionally, it is important to talk about the expectations that the management has on the employees during the change, but as well the other way around. What does the employees need from the management to be able to do what is expected, training, tools, extra consultants during a period or similar? This is especially important in companies where the production line is supposed to be running every hour of the day. Make strategic plans for what the employees need, to execute their tasks and expectations.

It is also essential that the right people are responsible for driving the implementation. With the right people, we talk about the people that are interested and engaged throughout the full process. Moreover, they are especially important because of their ability to influence others to support the change. We have referred to earlier as champions of change. It is also very important that these people have time to invest for the change. When the planning of the change is finished, you should be transparent with the information, all the way into the state of the actual change.

The unfreezing stage is in itself a fragile phase since nothing is set yet. Therefore, we do not see any use of gamification solutions here. The plan for the change is not yet finished, and so we believe it might get the employees more confused.

6.3 The Change Stage
As previously explained, the change state, according to Lewin, is when the actual change happens. New skills need to be learned, and leaders should be continuously supportive. In the context of Industry 4.0, the change stage refers to the time in which the implementation is conducted, including installation of I4.0 machines and systems, as well as learning and getting used to them.

As mentioned earlier, Heckdau et al. stated that because Industry 4.0 brings such highlevel technology, the industrial environment will change and thus, there is need for education and competence development. Here, we identify 2 aspects. The first is education about Industry 4.0 itself and its building blocks – AI, machine learning, AR/VR etc. This will help the employees understand what the implementation is all about and how it works. It will also allow them to, in the future, apply their knowledge in their work, to come up with solutions themselves that can help the organization. The second aspect is education about machines and systems that are to be implemented and integrated in the already existing manufacturing environment. This is crucial not only for production volumes and efficiency, but also for employees’ personal development as well as for their involvement in the I4.0 implementation, which in turn will make them more motivated.

In our interview with Sandvik, we learned that working with teams to reach goals would be more effective than competing individually. For this reason, regarding the aspect of education, we present a possible solution which we believe will contribute to the employees’ expertise and knowledge, as well as their involvement in the change and thereby motivation. When the organization is in the initial process of their change stage, they can arrange for Industry 4.0 education days. This education could first include one or more lectures on industry 4.0 and/or some of its building blocks. Secondly, we suggest
a workshop after the lecture in which employees are given a manufacturing problem statement, which they need to solve using what they learned about in the I4.0 lecture(s) – in teams, involving people that normally don’t work together. Later, the winning team could be rewarded in some way. This kind of competition is an example of a solution involving gamification. Employees know that there will be an award given (and perhaps some glory), and so they might be motivated to deliver the best solution. Likely, the fact that the problem statement is given within the context of their own production might make them even more motivated, since the problem is connected to their reality. We estimate that this kind of solution will make the employees more involved in the change process and, of course, more educated within the concepts of I4.0. Hopefully, they might even feel personally accomplished since they are learning. In addition, perhaps the employees deliver solutions that could be implemented, which is a significant gain for both the organization as well as for the involvement of employees. This kind of workshop solution also opens a new kind of learning, which might fit some employees better, according to what Kolb said about people learning differently. The team approach is better both for employee well-being, and for the outcome of the competition, as people with different kinds of expertise will contribute to the solution. The approach will also foster the development of cross-functional collaboration, which is important given the research from McKinsey saying that poor cross-functional collaboration is a common pitfall in failing change efforts (see change management chapter).

The second aspect – systems and machine education – allows us to present another solution. When the time comes to implement new machines and systems, certain employees could be given the responsibility over a certain machine or a certain system. Considering new machines, one employee per shift (preferably someone other than the shift leader) could be given a run-through of how to use the machine by an engineer from the company that manufactured the machine. This employee would now be responsible for teaching the rest of her or his team, as well as overseeing communication with managers or the machine manufacturing company when the machine doesn't run as it should. We believe that this responsibility will both make the employee feel more involved and give her or him the feeling of being chosen and good at what they do – this will spark their motivation. Of course, it is important that the selection process of which employee is to have this responsibility is done in a healthy manner, so that other employees don’t feel left out. Here, we again stress the importance of involvement, information and transparency. Perhaps the team can have an open dialogue, discussing who wants to have this responsibility and who has the most available time; maybe some employees are already responsible for something. This kind of open dialogue might make the employees feel like the decision is collaborative, so that resistance is minimized. Of course, in the end, the responsibility should be given to the employee that is most fitted. In the perspective of the organization, this would likely be a champion of change (described in the change management chapter), who shows great engagement and enthusiasm. This person will willingly involve and try to motivate her or his coworkers and has potential to be a good leader.
Regarding systems education, it is likely that a new system will be used by several teams, divisions and functions within the organization. Therefore, we find it reasonable to create a project group involving one person from each team that will be using this system – again, preferably someone other than the shift leader/manager. The employees in this project group could set aside a percentage of their working hours each week to work on learning this new system. Later, they could be responsible for teaching their respective teams and for error reporting etc. Again, this kind of responsibility, we believe will boost feelings of involvement and motivation.

Figure 4: Solutions for education and competence development

Another aspect of great importance during the change stage – apart from education – is feedback. As Russberg and Angelis said (described in our gamification chapter), video game design includes almost uncountable amounts of feedback of different kinds, and feedback is the most effective when it is close in time and meaningful. Additionally, as Kolb said, a reflection about the learning experience to continue to develop is key to optimize individual learning. We therefore believe that regular and frequent feedback meetings can boost motivation during an I4.0 implementation and that it will be important both for the organization as well as for the employees. During the change stage, we suggest one-to-one feedback meetings between employees and their managers once a week, or every other week. The meetings do not need to be very long; perhaps 15-30 minutes is enough. During these meetings, the feedback should go both ways. Managers should give their employees feedback on their personal development regarding the new I4.0 techniques – and employees should give feedback to the manager about the I4.0 implementation and how she or he feels that management is running the change. This two-way feedback enables an open and honest relationship between management and employees, so that the employees might feel more involved in the change process and more listened to by the management. Again, motivation will be sparked up. This might also give the management great insights on how the change is going, and even gain valuable suggestions on improvement. Those suggestions align with what Kritsonis said about the change phase; information should be collected, and the views of the group should be connected to the leaders. Of course, this requires regular and frequent followup meetings by management internally as well, so that they can go through possible issues and discuss how the change process should continue moving forward.
An additional and general solution that can be applied to boost motivation is that of a leaderboard within the manufacturing environment. This leaderboard could, for instance, show a measurement of efficiency for different production lines, or for the same product line but in different shifts. From our experience it is common to have this kind of measurement, but it is not always up for everyone to see. The leaderboard could then be continuously updated to see which line is doing the best. This is a gamification approach that we believe can make the employees more motivated to have their line be on top. It would also boost efficiency, as lines and/or shifts would be competing to keep their measurement high. We note that the competition here happens between teams; the employees of a certain production line work together to make their line run as smoothly as possible. This requires collaboration and problem solving, which we believe can be healthy for the employees. Additionally, it doesn't initiate unnecessary competition between individuals. The difficulty with this approach is that it can make people too competitive. If workers start running across the factory to solve issues, and if they take shorter breaks simply because of this leaderboard, there is a problem. Safety as well as the well-being of employees should be primary focus, which is why great thought should be put into how this kind of solution would be best fitted for a certain manufacturing environment.

One additional solution we recommend during the I4.0 implementation – although not necessarily directly to boost motivation – is that of a VR-solution for machine simulation. Assume that the organization is to install an I4.0-ready machine. If there were a simulation of the operator's display as well as a simplified version of the machine, operators could simulate manufacturing and learn how to use the machine in a virtual reality. Doing this, operators might be able to start manufacturing as soon as the machine is readily installed, increasing efficiency and minimizing down-time. However, these kinds of VR-solutions can be costly, and it would be imperative to forecast possible costs and earnings if this kind of solution were to be implemented, to make sure that the possible efficiency increase is worth it. In the employee’s perspective, this VR-learning will likely be different from normal work tasks, providing a nice variation that might make her or him more interested in I4.0 solutions, and in turn more motivated towards the change. A possible addition to this solution would be to incorporate some gamification aspects within the virtual environment; including visual feedback and/or progress bars, which has the potential of increasing the employee’s motivation.

Finally, as mentioned in the unfreezing stage, we would again like to stress the importance of a bottom-up approach. When new solutions and machines are to be implemented, managers should go to their factory workers to find out what they need. This will increase employee involvement, making them feel that they’re a part of the change and that the organization is listening to their concerns.
6.4 The Freezing Stage
As earlier described, Lewin defines the freezing stage as the stage in which the change project is completed. Here, the task is to reinforce the newly learned skills and practices and arrive to a state in which they are used frequently and regularly. The change should be stabilized, and new routines should be in place. In the freezing stage, it is key that employees don’t fall back into old habits and behaviors.

In the context of Industry 4.0, this would be when the new systems and machines are already implemented and in use. However, it is important to remember that perhaps, Industry 4.0 will not be finished. There will likely be recurring new technological advancements in the future, so perhaps it will take a while for the organizations to reach the freezing stage. In any case, we suggest that certain systems and machine implementations indeed can be somewhat finished, even if the I4.0 implementation as a whole is not. Thus, the following discussion about what do think about in the freezing stage can be applied both to finished implementations of systems and machines, as well as to a finished full implementation of I4.0. Again, Lewin also stated that the freezing stage require leaders to provide resources for coaching, training and reward systems to continue motivating the employees.

During the freezing stage, we stress the importance of two-way feedback, which we described in the previous section. Managers and shift-leaders need to arrange for regular one-to-one meetings with their employees, again discussing the employees’ personal development, as well as letting them express their opinions on how the systems and machines are running, how management is handling the new I4.0 environment and whether there is room for improvement in any aspect. As long as there is still change going on, these meetings should still be held often. When changes are dialed down, perhaps they can occur less often. However, it’s important that the employees don’t feel as if management doesn’t want to listen to them anymore. Maybe the manager can ask how it feels for the employee and whether she or he would agree to have a meeting every other week rather than every week. The manager should still stay available if the employee wants an additional meeting. These kinds of regular two-way feedback meetings we believe will keep the employees feeling involved. Aside from feedback, we believe that continuous encouragement is also vital for continued motivation among the employees.

Another important aspect during the freezing stage is continued education. To not forget newly acquired skills and knowledge, the organization should arrange recurring educational events, such as courses or lectures about I4.0 techniques. This to make sure that employees are updated according to the new techniques that are used in their manufacturing. It will likely also boost motivation, since employees feel like they’re learning, and like they can contribute to the organization with their newly acquired skills. This aspect is especially important since, as described earlier, I4.0 will likely not be complete, at least not for a while. The organization needs to keep their employees updated and educated about techniques that will come to be implemented in their
manufacturing environment, as to keep the change process moving forward. These courses and educations can advantageously integrate some gamification in the form of problem solving and rewards, as we described in the change stage section. The following figure (figure 5) shows the aspects that should be continuously reinforced during the freezing stage.

![Figure 5: Important aspects during the freezing stage](image)

Finally, an imperative aspect during the freezing stage is results. Management needs to communicate the results of the I4.0 implementation (efficiency etc.) so that employees see that their efforts have been rewarded. This will likely keep the employees motivated for further initiatives, as they see that they have made significant contributions to the organization. Our final suggestion – in the spirit of gamification – is celebrating success, where the entire organization, management and employees included, can enjoy their efforts and results, after a hopefully successful Industry 4.0 implementation.
7 Conclusions

In this study, we have investigated implementations of Industry 4.0 and how they can be facilitated. Early on, we realized that this kind of large-scaled technological change would be challenging in many ways. For this reason, we developed a focus on the employees’ and the organizational perspective, and formulated the following research question: in the employees’ as well as the organization’s perspective, how can an Industry 4.0 implementation be facilitated? Through a literature study combined with interviews with three companies within the Swedish manufacturing industry, we have developed some focus areas that we believe can help organizations with their I4.0 implementations.

Concluding, we consider the most important focus areas of change projects of this magnitude to be motivation, engagement and involvement. Employees constitute a major part of the organization, and if they are not engaged in the change project, the change will not happen. For employees to become engaged, they need to be motivated so that they want to take part in the change. Involving employees properly in the change process will also make them more motivated, since they will feel as if they are important to the organization. Motivation, engagement and involvement will contribute to the well-being of employees, as well as a higher chance of a successful change project for the organization. It will also lead to higher efficiency within the manufacturing environment.

Another important focus area, we conclude, is transparency; keeping the employees informed about what is going on. Management cannot simply say that a change will happen without telling the employees why it happens; the employees will see no reason to why they should make any effort towards this change. Keeping the employees well-informed allows them to develop an engagement and a motivation, which will drive the change forward.

Because Industry 4.0 is so technologically advanced, knowledge and education will also be significant focus areas during the change project. Regarding education, we suggest a lecture-workshop solution where employees are first educated on Industry 4.0, and then presented with a problem statement that they should solve in teams using Industry 4.0 techniques. A gamification approach could be to add a reward to this challenge. We also suggest, when new machines or systems are implemented, that certain employees have a responsibility over teaching the machines and systems to their coworkers as well as making sure that they are functioning well. To make an Industry 4.0 implementation work well, we also stress the importance of feedback. Feedback should be frequent, regular and two-way, meaning that the employee should be given feedback, but should also give feedback to her or his manager and to the organization itself.

Finally, we would like to say that Industry 4.0 is an extensive and large-scaled change, and therefore very complicated. However, if management makes a genuine effort to involve their employees, the organization has a great chance of conducting a successful Industry 4.0 implementation, where the entire organization with all its employees are on the same track and working towards the same goal.

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8 Recommendations for Future Research

During this study, we have identified some aspects and topics that could be studied further. These topics could perhaps be useful for our interview subject organizations, as well as for ourselves or other students in future studies.

In this study, we focused on gaining knowledge from literature, as well as including valuable practical information from three organizations to be able to provide more realistic solutions. An extension of this study could examine many more organizations – more than three – or focus on a certain industry within manufacturing and examine several industries within that industry. This approach could allow for more statistical and more generally applicable solutions.

Another interesting extension of this study would be to focus on a single organization and their I4.0 implementation. It would be possible to follow them through their progress and see what solutions would actually be applicable in practice. This could be conducted by implementing one or some of the solutions we provide in this study, testing them within the organization and evaluating whether it is useful, both in the perspective of the employees (well-being, motivation) as well as the organization itself (profit, efficiency etc.).

Continuing, we identify some limitations in our study when it comes to our suggested VR solution for machine simulation during the change stage. Within this study, there was not sufficient information about the production environment of the studied organizations to be able to draw a conclusion about whether this kind of solution would be possible. Therefore, an interesting topic would be to examine this kind of solution within a single organization – would it be profitable, would it increase efficiency, and would it be technically possible at this stage of the I4.0 implementation?

Yet another interesting topic to study would be, as described in the change stage, the implementation of a leaderboard within the production environment. Earlier, we discussed that it could be used to boost motivation and to increase efficiency, but that it might raise safety concerns and jeopardize employee well-being. It would be possible to examine this within a specific production environment, recording how these parameters (efficiency, motivation, safety, well-being) are affected by the leaderboard and evaluating whether this kind of solution would influence profitability – whether positively or negatively.
References


Google, n.d. Google Scholar. [Online] Available at: https://scholar.google.se


Kovar, J. et al., 2017. *Virtual reality in context of Industry 4.0 proposed projects at Brno University of Technology*. Prague, Czech Republic, Institute of Electrical and Electronics Engineers.


PwC, 2016. *Industry 4.0: Building the digital enterprise*, s.l.: PwC.


The Industry-Science Research Alliance; National Academy of Science and Engineering, 2013. Recommendations for implementing the strategic initiative INDUSTRIE 4.0, s.l.: Federal Ministry of Education and Research.


Appendix - Interview Questions

Semi-structured Questions

Technical Questions
- Do you utilize cloud computing?
- Do you utilize artificial intelligence/machine learning?
  - Do machines and/or sensors in your production collect data? How do they do that?
- Do you employ data analysis?
- Do you use AR or VR?
- How much potential do you see within these concepts for your own production and organization?
- How do you view cyber-security?
- Are your computerized systems integrated in any way? Do they have the ability to share information with each other and collect information from each other?
  - Vertical integration
  - Horizontal integration
- To what extent do you follow your product life cycle?
  - Do your products send information when they are in need of service or when they need to be disposed of?

Organization
- What is your organizational structure like (flat/hierarchal)?
- What specific organizational challenges do you see for your organization, when it comes to the implementation of the above concepts?
- How has the implementation of above concepts affected the roles of your employees within the organization?

Gamification
- How do you motivate your employees towards change?
- How difficult is it to motivate your employees at times of change?
- Do you see any kind of difference in need of acknowledgement, feedback and praise between different generations among your employees?
- Do you see any kind of difference in willingness to change between different generations among your employees?
- Do you know of the concept of gamification?
  - [If not, explain it.]
  - Do you implement any aspects of gamification within your organization?
    - Competitions, points, achievements, leaderboards...
Structured Questions

- To what extent have the above described concepts been implemented in your organization?
- To what extent do you think above described concepts will be implemented in your organization?
- How much do you think above described concepts will change the human’s role in your organization?
- Do what extent are your products individualized/customized?
- How much time do you think it will take for your organization to implement industry 4.0?
- How willing to change do you perceive your organization to be?
  - management
  - employees
- To what extent do you consider your organization to be leading in technology?