CHALMERS
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Gamification in a Workshop Environment

A Design for Evaluating the Effect of Gamification on Learning

Master's thesis in Learning and Leadership

Ulrika Holm

Victor Huke

Communication and Learning in Science
CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

With gamification being a growing field of study and practice, this study proposes an implementation of gamification in a workshop situation. Gamification is defined as the use of game design elements in non-game contexts. The field struggle with showing conclusive results. However, it has shown a potential to positively affect motivation and learning. This study implements 13 game-elements using the MDA framework, dividing elements into mechanics, dynamics and aesthetics, to create a workshop with a focus on the participants. The thesis also evaluates the game-elements in relation to existing literature and propose an experimental design for evaluating the effect of gamification on knowledge retention. A pretest of the gamified workshop was performed to ensure feasibility and the thesis suggest modifications to improve the situation. The implementation may affect motivation, engagement and learning positively. However, some literature indicates indifference of gamification, meaning that gamification provides no effect.

Keywords: gamification, learning, knowledge retention, education, workshop, game elements, MDA

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Ulrika Holm, Victor Huke, Gothenburg, May 2020

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Acronyms

MDA Mechanics, Dynamics, and Aesthetics. 2, 3, 6, 9, 11, 23, 26–28, 37, 48, 50–52, 57

SDT Self-determination theory. 12, 16, 53, 54

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Introduction

As market chains shift ever faster, the Swedish industry face new challenges. To stay competitive on global markets, Näringsdepartamentet (2015) has put fort a digitalization strategy for the Swedish industry. One of the main goals of this strategy is to secure and supply competence for the industry.

The project *Smarta Fabriker* has sprung from this goal and operates a learning environment for digitalization. In this environment, workshops are given to demonstrate how digitalization can be used to transform a manufacturing site towards a sustainable future. Within the project Smarta Fabriker, mini-factories have been constructed in order to show possibilities of digitalization to educate and inspire the industry. Further, the project Smarta Fabriker aims to inspire and motivate young people to pursue a career path within technology (Smarta Fabriker, 2020). With this in mind the project Smarta Fabriker is interested in learning how gamification can be used to transfer knowledge and create an interest for technology. The thesis, investigating gamification, is conducted within the sub-project *Production for Future*, which is a production line developed during the spring of 2020, displayed in figure 1.1.

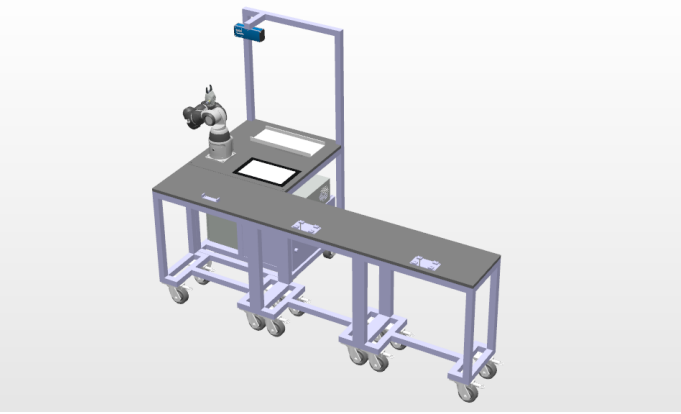

Figure 1.1: The production line within the project Production for Future.

1.1 Background

Defined by Deterding, Dixon, Khaled, and Nacke (2011), Gamification refers to the use of game-elements in non-game contexts. Existing research indicates that gamification has a positive effect on motivation in relation to the task it is applied to (Toda et al., 2019). It has a wide range of application possibilities and is considered a cross-disciplinary research field. A mapping study done by Albertazzi, Ferreira, and Forcellini (2019) classifies published research on gamification by field association. It shows that a majority of papers researching gamification stems from the field of education, training, and academia.

Due to the extensiveness of the term, gamification can be applied to different areas of education, e.g. at an organizational and classroom level. Through organizational systems game-elements can be used to structure and present courses. At the classroom level, the game-elements can be directly applied to the content provided in the learning situation. Another aspect that can differ is what is targeted by the gamification. It can be applied to either increase understanding of the learning content or to support behaviors that are necessary for an educational context, such as attendance.

Sailer, Hense, Mayr, and Mandl (2017) note that the motivational efficiency of gamification is uncertain due to unclear research strategies. Similarly, Cassel, Dicheva, Dichev, Guy, and Irwin (2019), note that scientific evidence regarding effects on student learning is insufficient. Dichev and Dicheva (2017) explain that even though a majority of empirical studies show positive results, the validity can be critiqued. Dichev and Dicheva (2017) point to the "need of a systematic program of experimental studies mapping game-elements to the learning and motivational specifics of individual (groups of) learners" (p.27). Dichev and Dicheva (2017) note that the questions for empirically evaluating gamification should clarify the settings by including the studied game-elements, the intended learners and the type of activity.

Game-elements are often divided into categories when used for gamification. Two commonly used methods divide the elements into three levels. One divides the elements into dynamics, mechanics, and components, whereas the other divides the elements into mechanics, dynamics, and aesthetics. The latter framework is presented by Hunicke, Leblanc, and Zubek (2004) and is called Mechanics, Dynamics, and Aesthetics (MDA). Bozkurt and Durak (2018) highlight the MDA framework as one of the lenses "offering the most benefit in gamification articles". Hunicke et al. (2004) highlight the possibility to create an experience-driven design when using the MDA framework. Therefore the MDA framework will be used to clarify the game-elements used in this thesis.

1.2 Purpose

This thesis presents a workshop using gamification by implementing game-elements in a non-digital setting. The workshop is designed for lower secondary school students and intends to provide a meaningful and inspiring learning environment for technology. The workshop design is based on existing literature within gamification and learning. To enable empirical evaluation of the gamification used in the workshop, an experimental design is presented. A pretest of the workshop, in the experimental setting, is conducted to ensure feasibility.

1.2.1 Research Questions

The research questions are:

RQ1: How can the MDA framework be applied to the new learning situation at Smarta Fabriker to create a gamified workshop?

RQ2: What possible effects can gamification have on learning in a workshop environment?

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Theory

Gamification is an expanding field of research. Dicheva, Dichev, Agre, and Angelova (2015) highlight the shared opinion on the potential of improving learning through gamification. Dichev and Dicheva (2017) state that games are known to elicit motivation and engagement. Dichev and Dicheva (2017) also state that motivation "is among the important predictors of student academic achievements" (p.2), making gamification attractive for education. This chapter firstly presents gamification and how it can be applied to learning situations. Secondly, some aspects of learning theory, followed by motivation theory are presented. Lastly, the term inclusion is clarified.

2.1 Gamification

According to Deterding et al. (2011), the term gamification occurs first in 2008, even though the concept is much older. For instance, the military has longtime utilized badges and ranks (Dicheva et al., 2015). However, it is not until around 2010 gamification has been widely adopted by areas such as business and education.

Deterding et al. (2011) defines gamification as the use of game design elements in non-game contexts. The author separates gamification from similar concepts such as serious games. Serious games are explained as complete games, that similarly to gamification could be used in situations with a purpose separate from entertainment, such as educational purposes (Deterding et al., 2011). However, gamification only implements parts of games, in contrast to the complete game, which is fully developed. Albertazzi et al. (2019) explains gamification "as a process of adding game design elements and creating gameful experiences, relying on particular game elements or experiences, instead of in the development of a game" (p. 192). What is categorized as game-elements is not unambiguous and Deterding et al. (2011) proposes game-elements to be treated as characteristic building blocks found in games. These building blocks need not be part of all games but should be part of most.

2.1.1 Game Design for Gamification

Even though gamification differs from complete games, some game design principles can be used to achieve gamification. Dicheva et al. (2015) note that game-elements can be categorized differently, where the MDA framework is one method for categorization. This framework originates from digital games and divides game-elements into mechanics, dynamics, and aesthetics. Hunicke et al. (2004) explain mechanics as the components of the game; dynamics as the behavior of the mechanics acting on the player; and aesthetics as the desirable emotional responses when the player interacts with the game. Hunicke et al. (2004) advise the designer to consider the perspective of the player, as well as the designer, to encourage experience-driven design. The perspective of the player starts by experiencing the aesthetics, through the dynamics, to the mechanics, whilst the designer's perspective is the revers, starting with the mechanics that will create the dynamics and aesthetics (Hunicke et al., 2004).

The mechanics are the control mechanisms and actions afforded to the player, Hunicke et al. (2004) explains. Mechanics could be the shuffling of a card game or directed bonuses in a game like Monopoly. It is the mechanics that support the gameplay dynamics.

In the MDA framework, the dynamics are placed in between the aesthetics and the mechanics, which illustrates the interaction between the elements. The dynamics aim at creating the desired aesthetics. Hunicke et al. (2004) illustrate this by the example of the aesthetic fellowship, which can be achieved by using teams for sharing information or direct the winning criteria to make it harder to reach alone.

Hunicke et al. (2004) note that the words "fun" and "gameplay" should be avoided when describing the aesthetics of the game. Instead, Hunicke et al. (2004) created a more directed taxonomy with examples of aesthetics:

- Sensation
- Fantasy
- Narrative
- Challenge
- Fellowship
- Discovery
- Expression
- Submission

Further, Hunicke et al. (2004) state that games often strive to evoke multiple aesthetics within the player.

2.1.2 Game-elements in Learning Contexts

Albertazzi et al. (2019) note that the majority of studies connected to gamification are within the fields of education, training and academia. Khaleel, Ashaari, Wook, and Ismail (2016) state that the main goal of gamification is to increase student engagement, motivation, and understanding by providing playful learning experiences. Similarly, Dichev and Dicheva (2017) explain gamification in education as "an approach for encouraging learners' motivation and engagement by incorporating game design principles in the learning environment" (p. 25). However, Dichev and Dicheva (2017) point to the challenge of implementing game design in education and that there is a lack of practical guidelines. Even though Dichev and Dicheva (2017) have identified an increasing number of studies claiming empirical evidence for gamification as effective in education, valid claims can not be made due to inconclusive or insufficient evidence. Palmquist and Jedel (in press) explain that there might be a contextual dependency on whether gamification results in success or not.

The study presented by Dichev and Dicheva (2017) put together empirical evidence of motivational effects and effectiveness of learning. The study selected 41 empirical studies and Dichev and Dicheva (2017) found that 12 presented positive evidence, 3 showed a negative effect, and 25 were inconclusive. Dichev and Dicheva (2017) states that

> Despite the growing body of studies, we found the level of understanding of how to promote engagement and learning by incorporating game design elements to be questionable. In parallel, a significant part of the empirical research was nonetheless reporting success stories and possibly contributing to the 'inflated expectations'. (p. 3)

The material reviewed by Dichev and Dicheva (2017) is within the educational and learning field, but differs in several aspects, including subject, level of education, and the number of implemented game-elements. The author reports a lack of justification for the selected game-elements. The most commonly used game-elements, Dichev and Dicheva (2017) list as points, badges, levels, leaderboards and progress bars. The most commonly used combination is noted as points, badges and leaderboards. Dichev and Dicheva (2017) give possible explanations for the regular use of points, badges and leaderboards, as being similar to existing assessment models and the easiest to implement. Dichev and Dicheva (2017) states that few implementations of deeper game-elements, such as challenge, narrative, role-play and choice, have been conducted. One question yet to answer is whether more game-elements yield better

results or not. Dichev and Dicheva (2017) also prompt that it is not yet known how to pick the right combination of game-elements. With few positive results, within a broad spectrum of education, the results are not possible to generalize.

Besides the potential positive effects of gamification, there are some identified negative effects. According to Dicheva et al. (2015), some game-elements can negatively affect intrinsic motivation. Further effects are identified by Toda, Valle, and Isotani (2018). The authors present four categories of negative affects found as a result of gamification: Indifference, Loss of Performance, Undesired Behavior, and Declining Effects. The Indifference category holds the issue of the gamification not effecting the participants in the study. This could be, not increasing learning or indifference towards the gamified system. Loss of Performance treats negative effects regarding the learning process of students, as a result of implementing gamification. The author points out the declining performance as a result of demotivating effects from a gamification implementation. Difficulties understanding the rules or that focus is put on game-mechanics rather than assessment are other conceivable complications. The issue of Undesired Behavior Toda et al. (2018) explained as gamification causing different effects than expected, often due to poor planning. The gradual loss of motivation and engagement when implementing gamification falls within what Toda et al. (2018) calls Declining Effects. Toda et al. (2018) differentiates Declining Effects from the Loss of Performance, yet this may also lead to a loss of performance. Besides the negative effects studied by Toda et al. (2018), another aspect to consider while implementing gamification is the novelty effect. Dichev and Dicheva (2017) explain that the positive effect may be a result of the novelty of the situation rather than the gamification itself.

Gamification often refers to an implementation in a digital platform (Bozkurt and Durak, 2018). However, gamification can be implemented without using digital media (Palmquist, 2018). Kutun and Schmidt (2018) presents a gamified scenario using 17 mechanics, e.g. clear goals, in the form of a board game. This implementation of gamification claims to improve learning motivation. Wu, Chen, Wang, and Hou (2018) also proposes a board game in the context of chemistry education, which states that the users reported positive experiences. However, this study did not study any behaviors.

Kusuma, Wigati, Utomo, and Putera Suryapranata (2018) point to the advantage of using several game-elements in a gamified application: “To intensify the effect of gamification, gamification designers need to mix and match various mechanics, as different combination of mechanics can give different effect to the player”(p. 391). Further, Kusuma et al. (2018) state that it would be preferable to apply several mechanics to reach all 8 types of aesthetics described by Hunicke et al. (2004), presented in section 2.1.1. When applying gamification to a learning context,

Palmquist (2018) explains that there are many possible game-elements to select from. Palmquist and Jedel (in press) state that

> There seem to exist no standardization on how different game elements are designed or how they function. In one study, badges could be interpreted as something different than in another study, which is problematic for identifying the effect of the game element. (p. 2)

Even though there exists no standardization, some collections of game-elements have been presented. Kusuma et al. (2018) present game-elements found in 33 articles, categorized into the MDA framework. The paper presents elements and descriptions to ease the implementation. The aesthetics that are found are the same as presented by Hunicke et al. (2004) in section 2.1.1.

The mechanics presented by Kusuma et al. (2018) are divided into four categories: player progression, tasks, game content, and additional features. The player progression includes points, level up systems, and achievements such as badges. The tasks include missions and mini-games, such as quizzes. Under game content, role-playing is found. Within the section additional features, Kusuma et al. (2018) placed e.g. background story, feedback, map, and characters. Kusuma et al. (2018) explains that

> Making students feel like they are in different world via role-playing game model is also recommended because by choosing the role they want, they subconsciously express themselves and will feel motivated to keep learning using the role they have chosen. (p. 391)

Some of the dynamics described by Kusuma et al. (2018) are

- Receive badges, achievement, or other rewards
- Role-playing
- Difficulty adjustment
- Turn–based
- Hints.

Kusuma et al. (2018) describe that the student with good scores can receive badges, achievement or other rewards to enhance motivation. Role-play is described as the opportunity for players to choose characters in the game. Difficulty adjustment refers to challenges being automatically adjusted to suit the player. Kusuma et al. (2018) describe Turn-based as turns including both time-limit and limited actions provided to the player. Hints Kusuma et al. (2018) explain as the game providing help to guide players within the situation.

Further examples of game-elements are found in the standardized taxonomy of game-elements for gamification in education, presented by Toda et al. (2019). The taxonomy consists of 21 game-elements with a description, examples of implementation, and a notation if the element is expected to affect engagement and/or motivation. Beyond providing possible elements for education and behaviors that might be effected, Toda et al. (2019) highlights that the elements are evaluated by experts. Table 2.1 presents 13 of the elements presented in the taxonomy, categorized according to possible behaviors affected, engagement, motivation, or both.

Table 2.1
13 of the game-elements from the taxonomy presented by Toda et al. (2019). The game-elements are categorized into possibly affected behavior. Parentheses show alternate terms.

Engagement	**Motivation**	**Engagement & Motivation**
Level	Cooperation (team-work)	Competition
Point		Imposed Choice
Progression	Narrative	Objectives
Sensation		Social pressure
Stats (Results)		Time-pressure.
Storytelling		

Toda et al. (2019) provides an explanation for each element. The ones with a possibility to affect engagement are levels, points, progression, sensation, stats, and storytelling. Toda et al. (2019) explain levels as hierarchical layers that enable gradual advance for the player. Points are described as a way of measuring performance. The game-element progression enables the player to follow their progress and place themselves in the game context. Sensation, Toda et al. (2019) explain as letting the players' senses create the experience, e.g. through sound stimulation. Visual information about outcomes provided to the player Toda et al. (2019) calls stats, but may also be referred to as results. Storytelling attends to the way the story within the game is told, Toda et al. (2019) clarify this by equating the story to a script. The game-elements that may affect motivation are cooperation and narrative. Cooperation is by Toda et al. (2019) explained as the collaboration towards a mutual goal, also called teamwork. A narrative refers to the order of events in a game, which integrates the players' actions.

To affect both motivation and engagement, Toda et al. (2019) propose the game-elements competition, imposed choice, objectives, social pressure, and time pressure. Competition suggests that the players compete against each other towards a shared goal. The imposed choice is incorporated by forcing the player to make decisions in order to advance. An objective is according to Toda et al. (2019) implemented to guide the players' actions and may also be called missions or quests. Toda et al. (2019) presents to types of pressure, social pressure induced by social interactions, and time-pressure which is pressure imposed by time.

In a qualitative study of game-elements, Aldemir, Celik, and Kaplan (2018) discuss game-elements in relation to aspects noted by students. Aldemir et al. (2018) classifies the game-elements into the three levels dynamics, mechanics and components, slightly different from the MDA framework. Challenge was one of the mechanics and narrative was one of the dynamics implemented. Aldemir et al. (2018) states that "According to the participants, challenges were necessary for a gamified learning environment", and student requested challenges presented in-class, e.g. role-playing challenges. The study recommends the use of challenges, however, some thoughts from students were highlighted. In the study, some challenges were described as repetitive and the reoccurring structure could be perceived as boring according to the students. The implementation by Aldemir et al. (2018) involved 'team-skills', which brought about several different reactions. Some students reported positive and some negative experiences toward team collaboration. The negative experiences were attributed to some participants that should have negatively affected the result. Competitive collaboration, according to Aldemir et al. (2018) are supported by most. However, some students would prefer emphasis being put on collaboration. The game-element narrative is also recommended for gamification in learning situations by Aldemir et al. (2018). According to Aldemir et al. (2018), the potential positive impact on motivation and learning outcomes were confirmed. Further, Aldemir et al. (2018) points to the importance of relevance in the narrative: "Considering that the possible number of target learners in a classroom can be many, a narrative relevant to the interests of the majority can be suggested."(p. 248)

The study by Khaleel et al presents game-elements for learning situations. The study presents game-elements, suggested by gamers and students, described as:

> The game elements to increase the fun and entertainment level are Points, Scoring System, and Stars. On the other hand, the game elements to increase the motivation for students to challenge each other are Badges, Top 10, and Leaderboard. Whilst game elements to improve the skills of gaming and learning are Result, Report, Dashboard, Percentages of Competency, Progress Bar, Stage, Level, Countdown, Profile Information, Pictures, and Avatars. (Khaleel et al., 2016, p.873)

Sailer et al. (2017) presents a study focusing on gamification and motivation, using the Self-determination theory (SDT), further explained in section 2.3.1. The study performed an experiment in a digital setting. Two different compositions of game-elements compared to the control setting, which used only points, were tested in the experiment. The game-elements that were used in the experiment were points, badges, leaderboards, performance graphs, meaningful stories, avatars, and teammates. One of the gamification configurations included badges, leaderboards, and performance graphs. The other configuration used avatars, a meaningful story, and teammates. The configurations were evaluated in relation to the needs presented by SDT, the needs for autonomy, competence, and relatedness. The first configuration showed a higher satisfaction of the need for competence, compared to both the control setting and the configuration using stories, avatars, and teammates. The second showed higher social relatedness compared to both the control setting and the configuration using points, leaderboards, and performance graphs.

2.2 Learning Theory

A longtime debate regarding knowledge and learning, what they are, and how they are achieved, has resulted in multiple learning theories. Different theories deal with learning from different perspectives. To support the design of the learning situation, a selection of learning theories are presented in the following section. The theories provide insight into how learning could be measured, as well as where and how learning takes place. Theories commonly mentioned within the field of gamification and within the context of workshop environments are selected.

2.2.1 Bloom's Revised Taxonomy

Krathwohl (2002) describes Bloom´s taxonomy as a model for categorizing expected learning goals concerning a set of instructions. The original taxonomy, which aimed to promote the education of higher thinking, was conceived in the mid-fifties. It presents six cognitive dimensions of learning: knowledge, comprehension, application, analysis, synthesis, and evaluation. All of the named dimensions, except application, had underlying knowledge categories that formed objectives to master before a student could reach a higher cognitive dimension.

However, the hierarchical structure of the taxonomy was met with criticism, and sceptics meant that students can operate at a higher dimension before fully mastering the prior. To address this criticism, co-authors D. Krathwohl and L. Anderson revised the taxonomy in 2001 by putting less emphasis on the hierarchical structure and by implementing a knowledge dimension. The new dimension specifies what type of subject matter is targeted for each learning objective. In contrast to the

original knowledge categories, the revision also includes metacognitive knowledge, which addresses self-knowledge and strategic thinking. Learning objectives created using the taxonomy should (a) specify the subject matter and (b) describe to which extent the student should be able to process the subject. Figure 2.1 presents Bloom´s revised taxonomy table. Learning objectives are categorized and placed in the table, relative to their process and knowledge dimension.

		The cognitive process dimension					
		1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
The knowledge dimension	A. Factual knowledge						
	B. Conceptual knowledge						
	C. Procedural knowledge						
	D. Metacognitive knowledge						

Figure 2.1: Depiction of an empty taxonomy table.

When creating a course or lesson, learning objectives are used (Felder and Brent, 1998). Learning objectives are statements of tasks that students are supposed to be able to achieve if they learn the content of the course or lesson. When an instructor puts the learner in focus "they formulate learning objectives and use them as cornerstones of course design, delivery, and assessment" (Felder and Brent, 1998, (p.22). Felder and Brent (1998) state that the learning objectives should be observable, meaning that they should be formulated so that the instructor could either see the task being performed or see the result of the task (Felder and Brent, 1998).

2.2.2 Behaviorism

Behaviorism is one of the fields focusing on learning as behavioral change. Phillips and Soltis (2014) highlight that accessibility to data and scientific methodology are major contributors to the conception of behaviorism. What is studied must be possible to replicate for the scientist, making the inside of the human mind unreachable. Instead, the available behaviors were studied. In general, behaviorism deals with changing and inducing behaviors. There are two branches within behaviorism, classical conditioning and, instrumental conditioning.

Classical conditioning takes advantage of a behavioral reflex as a result of a natural stimulus. It was found that a behavior connected to a natural stimulus could be evoked using conditional stimulus. By introducing the conditional stimulus in

conjunction with the natural stimulus in repetition, the behavioral reflex can be induced by the conditional stimulus alone.(Phillips and Soltis, 2014)

Within the other branch, instrumental conditioning, it was found that behavior could be strengthened or weakened using rewards or penalties. The reward given must not be given consistently. In fact, an arbitrary reward, compared to a consequent reward, causes the learned behavior to stay longer when the reward has defaulted. Followed by this theory, completely new behaviors can not be created. Behaviors can only be induced by a stimulus, strengthened, weakened, or constructed by already existing behaviors. (Phillips and Soltis, 2014)

2.2.3 Social Learning Theories

According to Phillips and Soltis (2014), the social learning theories acknowledge, in contrast to earlier theories, that learning takes place in social contexts. Social constructivism highlights that knowledge is socially determined. In all parts of society, there are knowledge and tools that are considered valuable for the learner, thus should be obtained by the learner.

John Dewey, according to Phillips and Soltis (2014), emphasizes that learning takes place when the learner is being involved in meaningful activities. By extension, most learning comes about in conversations with others. Further, Dewey stressed that school is a community and that collaborations among the students are desirable. The pupils must be engaged in meaningful activities and the most beneficial learning activities according to Dewey, are ordinary communication with others.

One application of social learning theory is the use of peer discussion. Smith et al. (2009) state that students' confidence, as well as correctness, usually increases after peer discussion. This is applicable to the case of having someone in the discussion previously knowing the correct answer, as well as the opposite situation, where the answer is unknown by all parts participating in the discussion.

2.2.4 Active Learning

Active learning is commonly defined as any instructional method that engages students in the learning process (Bonwell and Eison, 1991). Although homework and traditional exercises can be embraced by this definition, active learning mainly concerns what happens in the classroom. In contrast to being passive listeners while accumulating information, students should participate in meaningful activities that engage the mind (Bonwell and Eison, 1991). Engaging students in activities such as discussion, problem-solving, or experiential learning, forces them to process the information they are exposed to. Studies show for example that by incorporating peer discussions during lectures, students retain more knowledge for longer (P. Micheal,

2004). Active learning often engages the students through the higher cognitive processes of Bloom´s taxonomy.

J. Michael (2006) credits and explains the benefits of active learning to the theory of constructivism. Simply put, the students expand and re-configure their mental models of real-world concepts through exposure to them. While empirical studies support the benefits of active learning, P. Micheal (2004) points out that the variety of instructional methods that fall under the label of active learning can be misleading as their impact varies. Instead of using these instructional methods at face value, P. Micheal (2004) encourages deliberate adoption, "The activities must be designed around important learning outcomes and promote thoughtful engagement on the part of the student."(p.226)

2.2.5 Self-efficacy Theory

Self-efficacy theory emerges from cognitive psychology and the belief that motivation and learning are cognitive processes. In the self-efficacy theory, Bandura (1977) explains underlying mechanisms for behavioral change. Self-efficacy refers to the expectation of personal efficacy, and the theory is based on the premise of self-efficacy being affected by psychological procedures. Bandura (1977) proposes that there is a central processor of efficacy information. "That is, people process, weigh, and integrate diverse sources of information concerning their capability, and they regulate their choice behavior and effort expenditure accordingly" (Bandura,1977, p. 212).

Bandura (1977) differs *outcome expectation* from *efficacy expectation*. The first represents the belief of an outcome as a result of a behavior, whereas the second is the belief that one can successfully execute the behavior to attain the expected outcome. A person's efficacy expectation is consequently essential for the execution of a behavior.

Bandura (1977) presents different sources of information which can affect efficacy expectation. Among these, performance accomplishments and vicarious experience are found. Performance accomplishments are efficacy information based on personal mastery experience. Performance accomplishments are raised by success and lowered by failure, meaning the efficacy expectation can be affected similarly. However, occasional failure can strengthen persistence, if later overcome. Vicarious experience, that is watching others achieve something, can affect a person's self-efficacy by persuading "themselves that if others can do it, they should be able to achieve at least one improvement in performance" (Bandura,1977, p 196). This source of self-efficacy is less dependable than performance experience.

2.3 Motivation

Deci and Ryan (2000) state that it is commonly assumed, within motivational theory, that people initiate and persist in activities as a result of an expectancy that the behavior will lead to a certain outcome or goal. From this, the distinction between intrinsic and extrinsic motivation arose. Gagné and Deci (2005) explain intrinsic motivation as an interest in performing a behavior. On the contrary, extrinsic motivation implies that the behavior is performed because of the consequences followed by the behavior or activity.

2.3.1 Self-determination Theory

Gagné and Deci (2005) describe Self-determination theory (SDT), as an autonomy continuum. In SDT, the emphasis is placed on the distinction between autonomous motivation and controlled motivation. Additionally, both are placed in contrast to amotivation, a lack of intention and motivation. Amongst autonomous motivation, intrinsic motivation is found. In contrast, the controlled motivation Gagné and Deci (2005) explain causes a sense of having to involve in a behavior or activity. Extrinsic rewards call for this type of motivation.

The self-determination continuum range from amotivation, through extrinsic motivation, to intrinsic motivation. Extrinsic motivation is divided into four degrees: external regulation, introjected regulation, identified regulation, and integrated regulation. The complete scale is (1) non-regulation, (2) external regulation, (3), introjected regulation (4), identified regulation (5) integrated regulation, and (6) intrinsic regulation.

External regulation is when an uninteresting activity is "initiated or maintained by contingencies external to the person" (Gagné and Deci,2005, p. 334). The additional three dimensions, the processes of introjection, identification, and integration are summarized by the term internalization (Gagné and Deci, 2005). Gagné and Deci (2005) explain this process as making the regulation of a behavior internal, by absorbing values, attitudes, or regulatory structures. If a regulation is taken in, but not accepted, it is called introjected regulation. This type of regulation can be perceived as controlling the person. The identified regulation describes the regulatory process as coherent with self-selected goals and seems to reflect parts of the self. Integrated regulation, the form of extrinsic motivation closest to the intrinsic motivation, gives the impression that the behavior is part of the self. The behavior becomes central to personal identity.

SDT sees internalization as a natural process. To enable this process, Gagné and Deci (2005) explain that three basic psychological needs must be met, the needs for

competence, autonomy, and relatedness. If all needs are fulfilled in relation to a behavior, the person tends to internalize the behavior. The degree upon the satisfaction of the needs determines whether the internalization will achieve introjection, identification, or integration. (Gagné and Deci, 2005)

2.4 Inclusion

To address the term inclusion within an educational context, the Swedish school system strives to accommodate every student's needs, academical and social likewise (Jederlund, 2017). To achieve this, Jederlund (2017) points out that the school environment needs to consciously adapt to the ruling class settings. Nilholm and Alm (2010) mention difficulties of achieving educational and social inclusion.

Nilholm and Alm (2010) explain that the term inclusion has faced critique, raised by Mcleskey and Waldron (2007), due to the lack of an explicit definition. However, in the study "An inclusive classroom? A case study of inclusiveness, teacher strategies, and children's experiences", Nilholm and Alm (2010) provides an explicit definition of inclusion by dividing it into 3 parts. The first aspect deals with differences being viewed as ordinary. The second aspect is about whether all students are being part of the social community of the classroom. The third aspect attends to students being part of the learning community of the classroom. It is important to note that it is the experience and perception of the participants/pupils that are in focus.

3

Research Site

The research is conducted within the context of the project Production for Future within the project Smarta Fabriker. This chapter explains how workshops are normally organized by the project Smarta Fabriker. Additionally, the frames set by the project of Production for Future are presented.

3.1 The Project Smarta Fabriker

The project Smarta Fabriker is located in an open space for displaying technologies for digitalization within the industry. A smart factory, a collaborative assembly station, and a new demonstrator called Production for Future are found at the site. The project Smarta Fabriker transfers knowledge to a wide range of groups, amongst them school classes and groups from the industry. A visiting group participates in a workshop, during which factories and technologies are explained and displayed. The workshops are experience-based, and the participants get the opportunity to test the technologies at the site.

Even though the context of the project Smarta Fabriker is not necessarily a part of the educational system, the workshops function as educational lectures. When a school class is visiting Smarta Fabriker, the student perspective is from an educational perspective, making the learning situation similar to a classroom context. However, the instructors do not know the participants before the visit, which differs from a traditional classroom environment.

A visiting group can vary in size but is often divided into smaller groups of around eight people. Generally, the groups circulate between different stations that treat different topics. The participants often get an opportunity to interact with the technology at the site.

The information given on each topic is based on a script. The script describes what content should be shared in the workshops, and proposes questions that could be used to engage the visitors. The questions often have several answers, but at least one given in the script that can be presented to the group. The workshops are

held by teachers or interns. The interns are from an upper secondary school with a technical orientation.

3.2 Production for Future

The goal of the project Production for Future is to build a new demonstrator for digitalization within production. The demonstrator is a production line for a Lego model, consisting of three assembly stations and one collaborative robot module, visualized in figure 3.1. The robot module can be attached to either of the stations. One worker on each station is required to produce the products in the production line. The product is manually carried by the workers between stations.

There is material to build 12 products. The product can be customized into several versions. Order specifications follow the product to inform the worker on what to assemble. Instructions for each product variant are displayed by the tablets fixed to each work station.

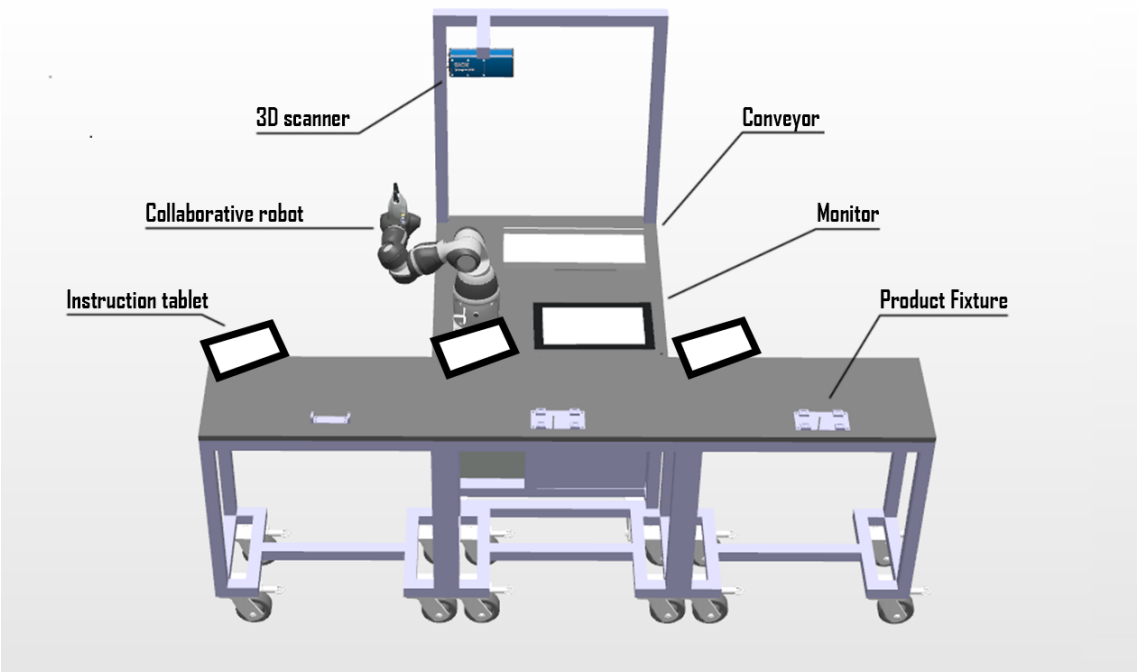


Figure 3.1: The production line at the site of the project Production for Future. The picture illustrates three assembly stations with instruction tablets and the collaborative robot module attached to the second assembly station. Connected to the collaborative robot module are a monitor, conveyor, and 3D-scanner.

3.2.1 Goals for the Workshop

To the project of Production for Future, the main goals for the workshop, with the target group of lower secondary school students, are to inspire participants to pursue a career within technology. Therefore, the workshop should provide knowledge as well as a fun experience. Additionally, the workshop must create a feeling of inclusion among the participants.

4

Methodology

To answer RQ1 a gamified workshop was designed using the MDA framework. To enable evaluation an experimental design was created. Due to visiting restrictions at the site during the Spring of 2020, the experiment could not be performed as planned. The evaluation process to answer RQ2 instead relies on literature within the field of gamification and a pretest of the gamified workshop and the experimental design.

This chapter firstly presents the design process for the gamified workshop. Secondly, the development process of the experimental design is described, and thirdly, follows a description of the performed pretest.

4.1 Workshop Design

Since no well-defined methodology for designing a gamified workshop was found, the methodology begun with two perspectives, (1) the learning perspective, and (2) the game perspective. To produce the learning content for the workshop, learning objectives were formulated. Simultaneously, the gamification process started with gathering game-elements before applying the MDA framework. The processes merged in the writing of the script. A visualization of the process is provided in figure 4.1. Although the processes are visualized and explained as separate, the processes influenced each other, to enable the merging of the parts. Below, the process of creating the learning objectives and the information flow are described, followed by the process of gamifying the workshop.

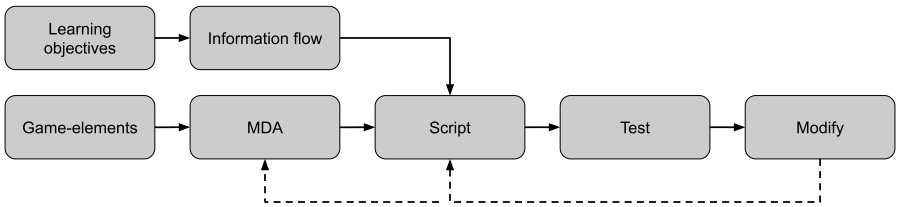


Figure 4.1: An illustration of the design process of the gamified workshop. Solid arrows show the overall flow and dashed arrows the main iterations. The design process started with (1) creating the content by defining learning objectives, and (2) choosing game-elements for the gamification.

4.1.1 Workshop Content

The content for the workshop was selected and created in collaboration with the project Production for Future. Since the production line is central to the project, the possibility for the visitors to use this was a necessary part of the workshop. Further, some constraints to the workshop were set early in the process to enable the workshop to be held during the usual visits, namely that the workshop should accommodate 5 participants within the time frame of 60 minutes.

Before the content could be created for the workshop, learning objectives were formulated. The learning objectives were produced in collaboration with the project Production for Future, resulting in six objectives, LO1-LO6, described below. In the early stages, there were more concepts and content, which were gradually reduced to the six concepts in the final workshop. The information that should be provided for the participants to reach the learning objectives were provided by the project Production for Future. The information was later adapted to the script. After the workshop, the participants should be able to

LO1. briefly describe the concept of flexible production,

LO2. briefly describe the concept of a bottleneck in production,

LO3. describe some aspects of what makes a robot collaborative,

LO4. identify what part of the vehicle is called chassis,

LO5. identify what part of the vehicle is called the body,

LO6. briefly describe what ergonomics means in a production setting.

When formulating the objectives, Bloom's revised taxonomy matrix, explained further in section 2.2.1, was used to classify the objectives. The matrix with the learning objectives included, can be found in figure 4.2. All learning objectives are placed under the cognitive processes remember and understand. This choice is based on the population chosen in this study and the evaluation process. The participants

do not necessarily have much prior knowledge within the subject of production and digitalization, making it difficult to aim for the more complex dimensions. Additionally, the participants should not have to put in to much time into evaluation of the learning objectives, thus it could negatively affect the overall impression of the workshop.

The knowledge dimension	The cognitive process dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge	LO5, LO4	LO3				
B. Conceptual knowledge	LO1, LO6	LO2				
C. Procedural knowledge						
D. Metacognitive knowledge						

Figure 4.2: The learning objectives, LO1-LO6, here presented in Bloom's revised taxonomy table. The figure shows were the learning objectives are in the knowledge and cognitive process dimensions.

The order of content was decided with the intention to create a coherent workshop. The workshop begins with presenting the learning objectives and general information about the workshop. Then the physical parts, such as the production line and the collaborative robot, are explained to further clarify the situation. An understanding of how the production line works is necessary to achieve the learning objectives and to be part of the building activity. Further, the robot is mentioned early to reduce any distractions due to the robot.

The building activities were incorporated to activate the participants, by applying or exploring the concepts treated in the workshop. The activity lets the participants operate the production line. The building activities are provided three times during the workshop, each with corresponding content. The number of activities was decided upon with the game-element rounds in mind. To fit the time-frame of 60 minutes three similar parts were formed. The first time, the activity should introduce the production setting and the concept of bottlenecks. Prior to the second build, flexible production is explained, and the building activity enables the concept to be applied to the experience. During the last build session the robot is incorporated. This is explained through the concepts of bottlenecks as well as ergonomics. The workshop ends with the learning objectives being repeated to clarify what was treated in the workshop. To enable meaningful thought processes, discussions were incorporated after each activity. According to active learning, section 2.2.4, peer discussions help the participants process the information.

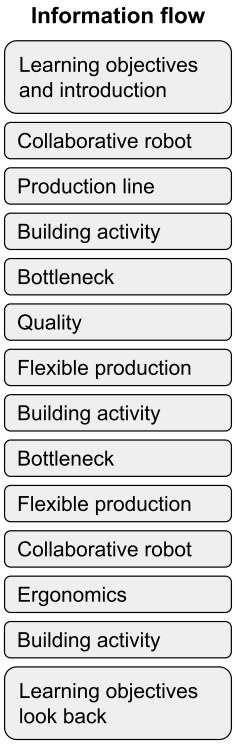


Figure 4.3: This is a visualization of the created information flow of the workshop, including main concepts and activities. Starting at the top, they are presented in the order they occur in the workshop.

4.1.2 Gamification Process

To produce a gamified workshop, the definition by Deterding et al. (2011), namely using game design elements, was used. To specify what is meant by game-elements, the framework MDA, explained in section 2.1.1, was used. Since Kusuma et al. (2018) recommend using combinations of game-element, a selection of game-elements was considered for the implementation. However, by implementing several game-elements, the gamified scenario comes closer to a complete game according to the definition of gamification. To not take on the complexity of creating a complete game, parts of the workshop were intentionally designed according to conventional learning methods. For example, no game-elements were applied to the discussions during the workshops.

Since most of the literature gives only a few examples of elements, e.g. the taxonomy by Toda et al. (2019) presented in section 2.1.2, a broader perspective was sought in the early process of gamifying the workshop. To do this, game-elements, as well as examples of games, were gathered using brainwriting. Wilson (2013) explains brainwriting as an ideation method preferably used in the early stages of the design cycle. The participants, during a specified time, write ideas related to a topic in this

case game-elements and games. The generated ideas were discussed, and duplicates were sorted out. Additional elements, close or similar to the ones found, were added in the second round of brainwriting. The ones possible to implement in a physical environment were singled out and kept for further investigation.

After gathering examples of game-elements, two simultaneous processes began, the elements were categorized into the MDA framework and implemented into the workshop. The implementation process aimed at merging the game-elements with the content and information flow of the workshop, whilst the categorization ensures that each aesthetic is represented by at least one mechanic and dynamic. When the game-elements were incorporated into the MDA framework and would fit with the information flow, in figure 4.3, a script was created. Some of the elements needed visual props, which were designed using Photoshop and content at the site.

Aesthetics

The soft goals for the workshop, set by the project Production for Future, presented in chapter 3, were taken into consideration in this part of the workshop design. The participants should (a), feel included, and (b), think that the workshop was a fun experience. Since Hunicke et al. (2004) propose that the perspective of the player to be considered, the aesthetics were decided from these goals. However, the term fun is not specific enough according to the MDA framework. Instead these goals were met by selecting the aesthetics narrative, fellowship, and challenge. Except being derived from the term fun, the aesthetic narrative was chosen as it goes well with the information flow of the workshop. Fellowship is interpreted to include the social aspect of feeling included, presented in section 2.4. Since problem-solving is part of working within technology, the aesthetic challenge was chosen. The other examples given by the MDA framework were excluded, for instance, due to a perceived complex implementation. To enable discovery, choices should be afforded to the player, making it more difficult to ensure the presence of the learning objectives. Expression and discovery call for choices and may work if the participants are willing to share their thoughts, which was considered uncertain in the chosen target group.

Mechanics and Dynamics

With the aesthetics set, the mechanics and dynamics were decided in alternating order. The mechanics were easier to merge with the content of the workshop, whilst the dynamics are directly linked to the aesthetics.

When it comes to the mechanics and dynamics corresponding to the aesthetic challenge, the dynamics were chosen first. Since different mechanics can correspond to different levels of challenge, the dynamic objective was chosen. By proposing a goal connected to the building activity, the workshop would have some challenging

moments, without causing a highly competitive atmosphere. When deciding upon to have an objective as a dynamic the three common gamification elements, points, badges, and leaderboards, were also excluded. They are commonly used to create a feeling of challenge or competition. In this implementation the competition aspect is uncertain, since this could be perceived as unpleasant. Aldemir et al. (2018) stated that some students would prefer the focus to be put on collaboration rather than competition, why the game-element objective, provided on a team level, was chosen. The objective provides the feeling of challenge without competition between students or groups of students. Additionally, the workshop is provided in a real-time context, which can make it difficult to ensure points being divided correctly, and that the right badges are created beforehand. Both aspects form the decision of not implementing the commonly used points, badges, or leaderboards to attain the chosen aesthetics.

The opposite order, mechanics before dynamics, was used when the game-element rounds were decided upon. This mechanic was decided upon early to enable several encounters with the production line. With the aesthetic narrative and the mechanic rounds, the dynamic was defined as progression. The rounds allowed for the testing of the first round a few times before the remaining game-elements were completely determined. After each test, simplifications and clarifications were made to the script, rules, and visual props. The workshop was tested on technical university students, upper secondary school students, and primary school students, displaying technical issues with the workshop.

All selected game-elements are presented and categorized into Mechanics, Dynamics, and Aesthetics in figure 4.4. The 13 game-elements are further described and summarized in chapter 5.

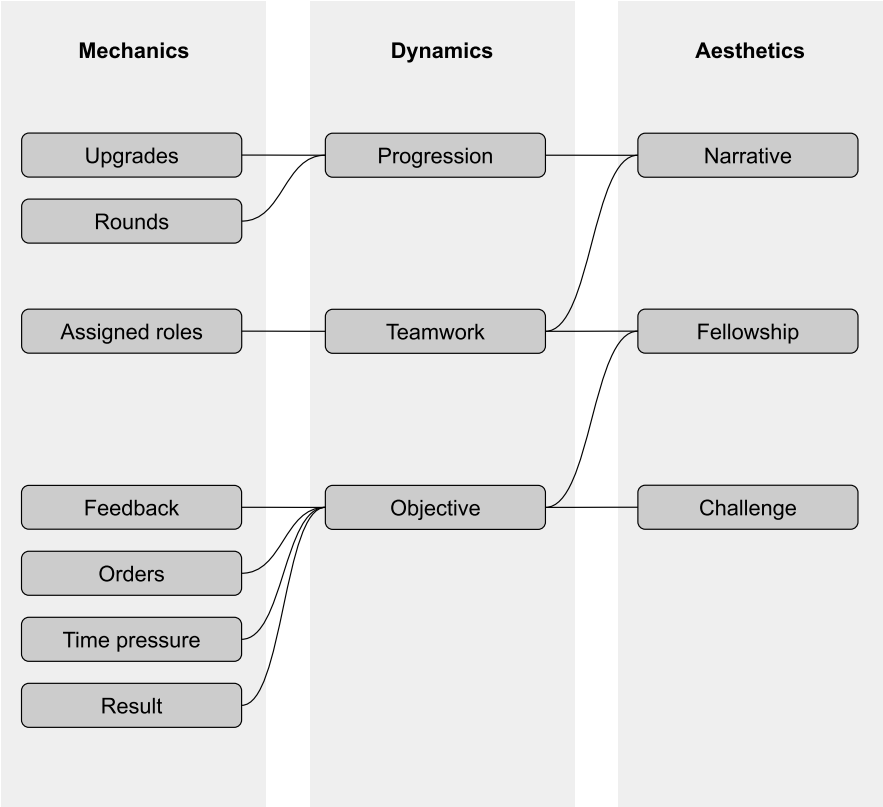


Figure 4.4: The chosen game-elements categorized into mechanics, dynamics, and aesthetics. The game-elements are linked to show how the mechanics support and relate to the dynamics and the dynamics of the aesthetics.

Design of Visual Props

The mechanics are incorporated into the workshop through a script. To give visual support to the workshop props were designed. The props were created to guide the player through the workshop situation and to strengthen the feeling of being part of a game situation. A game-board was created using a whiteboard, displaying both learning objectives and game aspects, such as the team, the rounds, the goals and the result of the building activity. To indicate success or failure, red and green thumbs, that could be applied to the board, were created. Further, order cards, role cards and upgrade cards were created to support the building activity and to emphasize the roles and change of the production line.

4.1.3 Evaluation of the Game-elements

When the game-elements were selected, the implementation of the workshop was described. To evaluate the gamification, literature was summarized in relation to each element. Most game-elements are represented by the same notation by some or several sources. Literature presenting game-elements with another notation than

the one in this configuration, but similar to the implementation, were included. Literature presenting game-elements with the same notation, but obviously different implementations were noted together with the stated difference.

4.2 Experimental Design

To investigate the possible effect gamification can have on learning, the following hypothesis (Ha) was arranged to specify what type of setting and what type of learning is studied in this experiment: *Gamification* in a workshop environment affects *knowledge retention* positively. An experimental design was set up to enable data collection during the workshops to gain insight on whether to discard or verify this hypothesis. Three questionnaires and two observation protocols were produced, for control a comparable workshop was designed by excluding the independent variable gamification. The population targeted for the experiment are lower secondary school students within the region of Gothenburg. The experiment design classifies as a quasi-experiment due to the fact that the randomisation of the participants is done within the groups visiting the site.

4.2.1 Variables

The variables set up for the study were, gamification, knowledge retained, motivation, and activity. Gamification was regarded as the independent variable which was manipulated to separate the control workshop from the experimental (gamified) workshop. The dependent variable was defined as knowledge retained and should be measured through questionnaires before and after the workshop. Learning as the process of retaining new knowledge in relation to a set of instructions (Krathwohl, 2002), was considered to have taken place if the knowledge is kept 2 weeks after the workshop. The two week time period was set to evaluate the learning over time. Activity and motivation were set up as explanatory variables as they both have correlations to gamification and learning. Table 4.1 summarizes the variables in the experimental design.

Table 4.1
All measured variables in the experimental design.

Independent variable	**Dependant variable**	**Explanatory variables**
Gamification implemented during workshop.	*Knowledge retained* two weeks after the workshop.	*Activity* during the workshop. *Motivation* during the workshop.

4.2.2 Data Collection

Even though the data collection could not be performed as planned, a design to measure and quantify the variables of the experiment was set up. It intends to collect data which can tell whether or not there is a correlation between the dependant and independent variable. It is supposed to be carried out through three questionnaires and two observation protocols. The same set of questionnaires and protocols should be used for both the control and experimental workshop. In addition to the experimental variables, the questionnaires contain questions regarding inclusion. Figure 4.5 represents the data collection layout for the experiment. The data is of a quantitative nature and is intended to be analysed through a statistical approach to examine its significance.

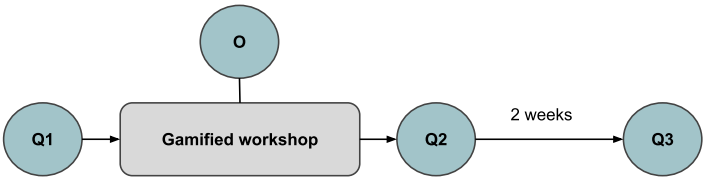


Figure 4.5: Layout of data collection

Questionnaires

Prior to the workshop, the participants answer the first questionnaire which tests their knowledge of the learning objectives. Further, they are asked to assess their own attitudes regarding motivation and class activity in technical education. After the workshop, the participants are yet again tested on their knowledge of the learning objectives and they are asked to assess their own attitudes regarding motivation and activity during the workshop. Two weeks after the workshop the participants are tested on their knowledge of the learning objectives to investigate how much of their knowledge is retained. The questionnaire forms can be found in appendix C, D and E

Observation protocol

The first observation protocol designed to monitor the progression of the workshop to assure that all parts of the information flow are present. This protocol was set up to be able to tell whether the results from a preformed workshop could be used or not. The second observation protocol was set up to monitor the verbal activity of the participants during the workshop. This observation protocol quantifies the number of questions asked and conversations held, initiated by the participants. It also contains a scale to evaluate the attention of the participants.

4.2.3 Control workshop

The control workshop was designed by excluding all game-elements from the gamified workshop. The information flow is structured in the same order for both workshops. In instances where a game-elements delivers additional information, this information is introduced by the instructor, this is the case for the game board, role and upgrade cards. The control workshop is considered as an active learning situation due to the group discussions and building experience. The participants are encouraged but not forced to take part in these activities. The complexity progression during the building activities are still present but, the narrative is not reinforced by the game-elements. The manuscript for control workshop is found in appendix B

4.3 Pretest

A team of four upper secondary school students were put together to participate in a pretest. The purpose of the pretest was to test the feasibility and identify improvements for the workshop- and experimental-design respectively. Since only four out of the five roles could be filled by the test group, the fifth role was held by the instructor. During the pretest, the entire gamified workshop was tested. The participants performed the two first questionnaires and the observation protocols were filed by one observer each. The observers were people active within the project Production for Future.

As the participants were familiar with the learning objectives prior to this pretest, no indication regarding the learning outcome could be drawn. After the pretest two Semi-structured group interviews were organised with the test group and observers to collect data on ideas and experiences that were not brought up by the questionnaires. An interview guide, found in appendix H was put together to initiate the interview. Remarks regarding the workshop and experiment made during the interviews were categorized and compiled. From these remarks, suggested modifications were produced to improve the workshop.

5

Results

This chapter firstly presents the workshops. Secondly, the implemented game-elements are explained and a summarized evaluation is provided based on literature. Lastly, the observations from the pretest and remarks from the following group interview are presented.

5.1 Workshops

The two workshops created are the gamified and the control workshop. Both follow the information flow presented in section 4.1.2. Similarly, both workshops are divided into 3 sections, which in turn follow the sequence (1) lecture, (2) building activity, and (3) discussion. An overview of the structures of the workshops, compared to the information flow is provided in figure 5.1. The lecture part mainly consists of information provided by the instructor. The building activity and discussions are providing opportunities for the participants to be active. The script for the gamified workshop is provided in appendix A. The script for the control workshop is found in appendix B.

For the gamified workshop, the three sections are referred to as rounds. Each round has the same structure as the control workshop. The content is presented via a game-board, also displaying the structure of the workshop. Early in the first round, the participants are assigned roles through role cards. The descriptions provided for each role are shared by the participants. Following parts are the same for all rounds:

- Cards introduce upgrades to the production line, and descriptive information tied to the card is presented by the instructor.
- Before the building activity, a goal is presented to the team. The goal is building four products, in four minutes.
- During the building activity, order cards gives the worker information on what to build. The cards are then put on the board to show the number of products produced during the activity.

- After the building activity, a success or fail indicator is displayed, both to evaluate the round and introduce the discussion phase.

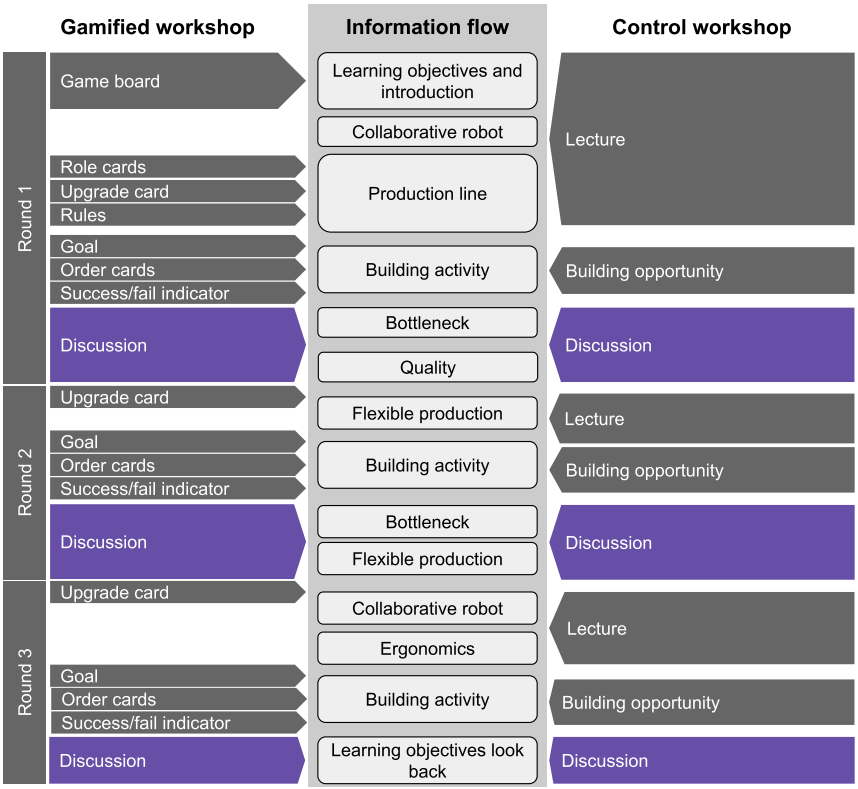


Figure 5.1: A comparison between the two workshops in relation to the information flow. The gamified workshop shows where the props created to implement the game-elements are explained in relation to the information flow. The control workshop consists of the forms lecture, building opportunity and discussion.

Material for the Gamified Workshop

The materials created for the workshop are a game-board, upgrade cards, role cards, order cards and success or fail indicators. The game-board is presented in figure 5.2. There are three upgrade cards, one for each round in the workshop, displayed in figure 5.3. One of the role cards and an order card are presented in figure 5.4. Descriptions of the roles are found in table 5.1, which presents the information provided to the participants. The indicators used after the building activity are a green or red thumb on a magnet, enabling the thumbs to be rotated when placed on the game-board.

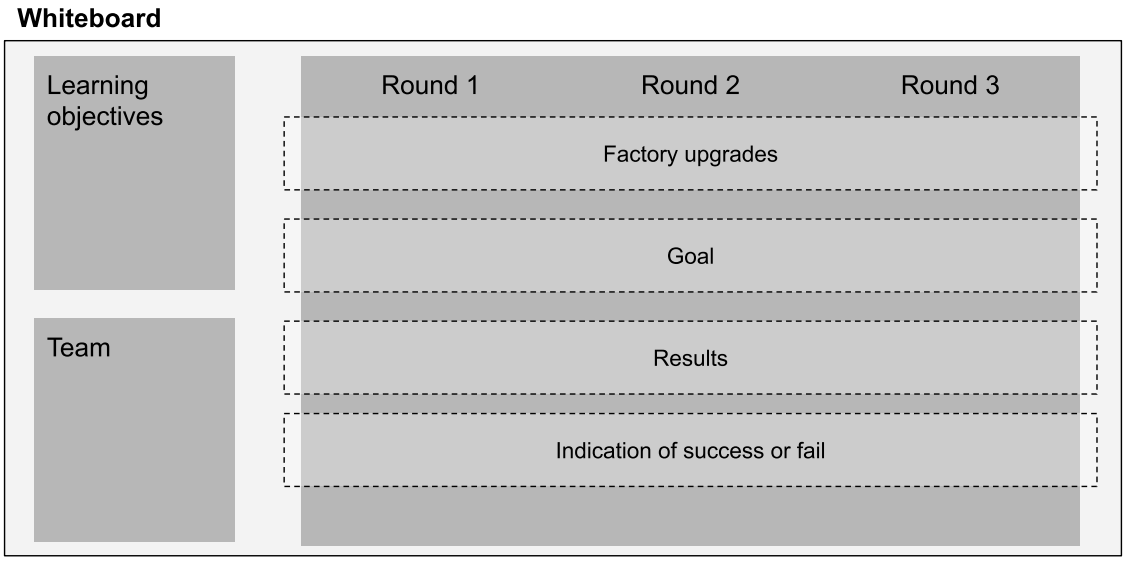
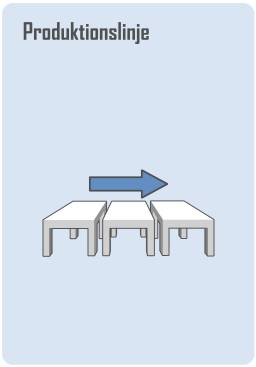
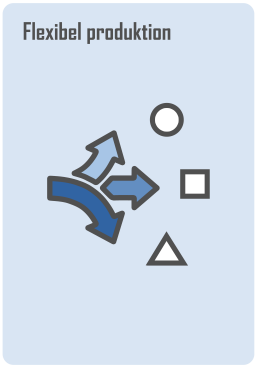


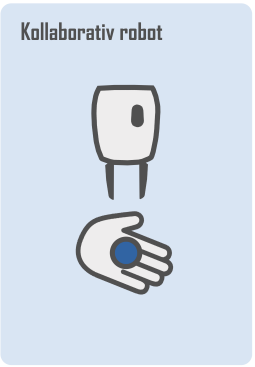
Figure 5.2: An illustration of the configuration of the game-board. To the left, the learning objectives were presented as a bulleted list and below the roles and the names of the participants were noted. The three rounds are presented next to each other. At the top, each round presents an upgrade card within the area noted Factory upgrades. Below follows the goal, the result and the indication of success or failure.



(a) *The production line* is the first card displaying the state of the production line during the first round.

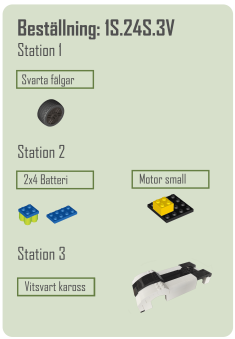


(b) *Flexible production* is the second card, allowing the production line to produce multiple varieties of the product in the same flow.



(c) *Collaborative robot* is the third and last upgrade card. After this card is presented, the collaborative robot is added to the production line, in this implementation, on the third station.

Figure 5.3: The upgrade cards designed for the workshop.



(a) This is an example of an order card. The card displays what material should be assembled on each station. The text within squares corresponds to the choices given on the instruction tablets.

(b) This is a role-card, the chassis assembler. Each card has a description and a picture connected to the role.

Figure 5.4: Examples of cards used in the workshop. (a) shows an order card, and (b) a role card.

Table 5.1

These are the five roles in the gamified workshop with a description. The information is given to the participants through cards displaying the role and the description.

Role	Description
Chassis assembler	This means that you, during production, mount wheels and attachment points at the chassis of the product. This is the first station in the production line.
Battery assembler	This means that you, during production, mount batteries and engine to the chassis. This is the second station in the production line.
Body assembler	This means that you, during production, mount the body and turntable to the product chassis. This is the third and last assembly station in the production line.
Production manager	As production manager, it is your responsibility to make sure the rules are followed and to count the number of products produced at the end of each round. You should also promote a good work environment by encouraging the personnel in the factory. If materials are dropped on the floor, you should pick it up and place in a specific container provided by the instructor, which the rest of the personnel are not allowed to do.
Materials manager	As materials manager, you separate the products that arrive at your station. The material is brought back to the stations at the end of each round to enable reuse.

5.2 Implemented Game-elements

The implemented gamification consists of 13 game-elements, visualized in the MDA framework in figure 4.4. A description for and a overview of the literature relating to each element are provided below in tables 5.2, 5.3 and 5.4.

Table 5.2
Implemented aesthetics.

No	Aesthetic	Implementation	Literature
1	Narrative	To give the participants the feeling of being part of a story, the content is presented to the participants as if they were workers in a factory. The factory goes through a development process for digitalization. The story perspective is given by the instructor, the narrator of this story.	Hunicke et al. (2004) presents narrative in the MDA framework as an aesthetic to implement fun in a game. The aesthetic is also found in educational implementations by Kusuma et al. (2018). According to the taxonomy provided by Toda et al. (2019), narrative has the possibility to affect the motivation of the participants. Toda et al. (2019) also presents the game-element storytelling which is explained as similar to a script. This implementation can be seen as similar to storytelling, however, more focus has been put on narrative, through ordering and creation of a coherent flow. Since focus has been put on creating a narrative it is evaluated as such. To be evaluated as storytelling, the implementation should be more focused on this and developed further. The implementation by Aldemir et al. (2018) recommend narrative, since it has potential to positively affect motivation and learning. **Positive to the potential of increasing motivation and learning**
2	Fellowship	To create a feeling of fellowship among the participants, the situation highlights teamwork in the factory. The participants need to work together to produce products.	Fellowship is an aesthetic presented in the MDA and found by Kusuma et al. (2018). However, it is not mentioned in the other studies reviewed. **No indication of effect.**
3	Challenge	The challenging feeling is promoted during the activity of building products in the production line to promote participation.	Challenge is one of the presented aesthetics to create fun, provided by Hunicke et al. (2004) in the MDA framework. Kusuma et al. (2018) also found challenge as an aesthetic in the educational context. Aldemir et al. (2018) presents challenge as necessary for gamification and it was met with positivity from students. **No indication of effect**

Table 5.3
Implemented dynamics.

No	Dynamics	Implementation	Literature
1	Progression	To get a progression, a story illustrating more difficult and complex problems for the production line is implemented. The production line is developing with the intent to solve the problems met, starting with the first card representing the production line in its simplest form.	Progression is found in the taxonomy presented by Toda et al. (2019), with the synonym map, stating the possibility to affect engagement. **Positive to the potential of increasing engagement**
2	Teamwork	Teamwork is mainly applied to the building activity in the workshop, but the participants are approached as a team in other parts as well. The factory will not produce products if the workers are not there and all perspectives are needed in the discussion. The teamwork is also needed to carry the narrative, since the improvements should be related to the input of the participants.	Teamwork is found in the taxonomy presented by Toda et al. (2019), stating the possibility to affect motivation. Teammates were in one of the game-element combinations in the study performed by Sailer et al. (2017) and showed increased social relatedness. **Positive to the potential of increasing motivation and social relatedness**
3	Objective	To create a challenge in the building activity, an objective is provided. By providing something to work towards in the activity the feeling of fellowship and community should be strengthened.	Objective is found in the taxonomy provided by Toda et al. (2019).Toda et al. (2019) states that the objective can affect engagement and motivation. **Positive to the potential of increasing engagement and motivation**

Table 5.4
Implemented mechanics.

No	Mechanics	Implementation	Literature
1	Upgrades	In this implementation, upgrades are used to evolve the production line, where the story takes place. The upgrades thereby support the progression of the production line and the narrative connected to the evolving factory. The upgrades are introduced through upgrade cards and complemented with information provided by the instructor.	**Not found in literature.**
2	Rounds	The rounds provides a repetitive order to the workshop and display the changes in the story. The same structure and rules applies to all rounds.	Kusuma et al. (2018) present the game-element turn-based which is similar to the implementation of rounds. The implementation differs from the game-element turn-based, since it only have one party. No literature on effect is found. **No indications of effect.**
3	Assigned roles	The participants are randomly assigned one out of five roles. This enables the participants to share different perspectives regarding the building activity. The roles are explained to the team by the team-members.	Role-play recommended by Kusuma et al. (2018), however, choice is noted as important which is not included in this implementation. Aldemir et al. (2018) states that the students call for e.g. role-playing challenges, which this could be explained as. **No indications of effect.**
4	Feedback	In this implementation, the mechanic feedback is provided after the building activity. The feedback is provided through a visual representation of success or fail, related to the objective.	The feedback implementation is not quite as other feedback implementations. However, the implementation has some similarities to achievements, such as points, but not as extensive as those systems. Since the implementation can neither be compared to the game-element feedback or badges, no indications can be discerned. **No indications of effect.**

No	Mechanics	Implementation	Literature
5	Orders	The objective for the building activity include the number of products that should be produced during the activity. The number of products are stated by the instructor and cards represent each order. The cards also provides information on what to build at each station.	**Not found in literature.**
6	Time-pressure	The time-pressure is set to define the objective further. The number of products should be built within a predefined time. The instructor keeps track of the time, which is not visually available for the participants during the activity.	Time-pressure is found in the taxonomy presented by Toda et al. (2019) and is predicted to have a possible effect on engagement and motivation. **Positive to the potential of increasing engagement and motivation**
7	Result	During the build, the assigned role production manager, are using the order-cards to visualise the progress. Each finished product is put on the board.	Toda et al. (2019) present the game-element stats, also called result, which might affect engagement. Khaleel et al. (2016) propose the game-element results for improving gaming and learning. Noteworthy about the implementation is that it is not as extensive as many digital implementations, which can provide more information to the player. However, the implementation is perceived to have a similar potential. **Positive to the potential of increasing engagement**

5.3 Pretest

The pretest was executed for the gamified workshop, due to its small scale and lack of control data, no conclusive trends or correlations can be stated from this data. In the second questionnaire, the most marked descriptions for the workshop were, exciting, fun and easy. Even though the test group were familiar with the learning objectives prior to the experiment, the average correct answers increased from 4.75 to 7 out of 7 questions in between the first and second questionnaire. Further, the test group did not assess their motivation to be higher during the workshop in comparison to a regular technology lecture. However, they expressed a higher degree of inclusion during the workshop. The data collected from the questionnaires are found in appendix K and L.

The observation protocol for verbal activity showed that all participants were verbally active at least once during the workshop. The observation protocol for the

script showed that the majority of the information was included. However, the order of the information were sometimes altered. The data collected through observations is presented in appendix I and J.

5.4 Group Interview

Some quotes from the interviews related to the most notable remarks are presented in tables 5.5 and 5.6. The remarks from the group interviews with suggested modifications to the workshop and experimental design are presented in tables 5.7 and 5.8.

Table 5.5

Translated quotes from the interview with the script observer (SO), activity observer (AO) and the workshop instructor (WI), related to a summary remark.

Remarks	**Quotes**
It is not possible for one observer to file both protocols at the same time.	SO: "We didn't fill in both, luckily, it wouldn't have been possible for me to fill in both." AO: "No I think it was hard enough as it was."
It was hard to keep track of the script order during the workshop.	WI: "It was difficult to keep track of the script with the complete document." SO: "[The instructor] did not quite describe the order cards when intended, [the instructor] changed the order of the distribution of roles and order cards." WI: "I did not see the distribution of roles in the script."
The discussions and respective script material worked well, however, a less experienced group might introduce challenges not experienced in the pretest.	WI: "[The participants] came up with good suggestions that I barely could relate to." AO: "I thought it was like a textbook example, the discussions and how [the instructor] led and repeated [the participants] suggestions." AO: "This group is confident in itself."

Table 5.6
Translated quotes from the interview with the participants (P1-P4) in the pretest and the instructor (I), related to a summary remark.

Remarks	**Quotes**
The instructions for quality check at the third assembly station were not adequate, and therefore not performed as intended.	P3: "My instructions were not complete, i could not tell what was the front or back of the product." P2: "It is very easy for the person doing the quality check to just skip past some steps and continue"
Tablet instructions for one product variant of the second station of were incorrect	P2: "My instructions were incorrect, if you follow them for the large engine and the large battery, everything does not fit"
There is a misconception of which part of the vehicle that the term chassis refers to.	P1: " I am not sure how related this is, however, the thing about what a chassis is could be useful to know early on. You could say something like: you think this is a Chassis but it is actually"
Adding product variants as a mean to introduce flexible production during the second round did not necessarily feel like an upgrade	P1: "The only reason we were faster the second round was because we were getting used to the building tasks. Flexible production did not really do anything"
The goal were not perceived as an important aspect of the workshop by the participants.	P3: "I do not think it matters if you reach the goal or not, what matters is that you feel an improvement between the rounds"
The goal increased the motivation for some of the participants.	P4: "The first round was [motivating], even though it did not go very well" P2: "It feels like you should be able to produce four products in four minutes, I want to achieve that"
The success/fail indicators increased the motivation of the participants.	I: "When you received the fail indicator, were you more motivated to succeed in the next round?" P2: "Yes" P3: "Well I was"

Remarks	**Quotes**
Using the collaborative robot during the last round did not improve the production speed significantly.	P3: "If you are gonna do this workshop again i think its a good idea to make sure the robot actually is faster than a human at preforming the task" P2: "It is probably hard to make upgrades with the robot because the tasks are so simple, one could make the manual task harder instead "
Information about the learning objectives were introduced bit by bit which makes it hard to put together.	P3: "I think it would have been better to introduce the concepts when they are added to the production line, for example, when flexible production is added to the production line [the instructor] explains it" P2: "You could introduce the learning objectives at the start and say that these concepts will be explained later so that the participants are familiar with the concepts at least"

Table 5.7
Remarks made by the observers and instructor after the pretest and suggested modifications for the workshop and experiment

Topic	Remarks	Suggested modification
Protocol	It is not possible for one observer to file both protocols at the same time.	Assign at least one observer per protocol.
Script	It was hard to keep track of the script order during the workshop.	(1) Create cards with keywords that follow the informational flow, or (2) illustrate the workshop progression further on the game board (whiteboard) and add sections for rules and taking notes during the discussions.
Discussions	The discussions and respective script material worked well, however, a less experienced group might introduce challenges not experienced in the pretest.	No modification.

Table 5.8
Remarks made by the test group after the pretest and suggested modifications for the workshop and experiment

Topic	Remarks	Suggested modification
Instruction	The instructions for quality check at the third assembly station were not adequate, and therefore not performed as intended.	Overhaul the quality check for assembly station three.
Instruction	Tablet instructions for one product variant of the second station of were incorrect	Correct building instruction.
Information	There is a misconception of which part of the vehicle that the term chassis refers to.	Bring up this common misconception during the introduction phase when the product is disassembled.
Game Element	Adding product variants as a mean to introduce flexible production during the second round did not necessarily feel like an upgrade	(1) Consider other upgrades, or (2) highlight that only one product variant is produced during the first round
Game Element	The goal were not perceived as an important aspect of the workshop by the participants.	No modification.
Game Element	The goal increased the motivation for some of the participants.	No modification.
Game Elements	The success/fail indicators increased the motivation of the participants.	No modification
Game Element	Using the collaborative robot during the last round did not improve the production speed significantly.	Make sure that the implemented robot sequence has a relatable/visible improvement to the production line.
Information	Information about the learning objectives were introduced bit by bit which makes it hard to put together.	Add a section for taking notes on the game board, write notes for the introduced concepts.

6

Discussion

This chapter firstly provides discussions concerning the field of gamification. Secondly, the configuration and suggested modifications of the workshop are treated. Thirdly, a discussion about the implemented game-elements and other possible elements are held. Fourth, the experimental design is discussed, and lastly, some suggestions for further research within the field of gamification are presented.

6.1 The Field of Gamification

Gamification being a cross disciplinary field is notable in the research, which shows many different insights. Even within educational contexts, gamification differs between the implementations. The focus of the implementations vary between learning and other behaviors. Research on the effect of gamification is mixed with evaluations of practical systems. Additionally, there are few guidelines of how to implement gamification, both when it comes to which and how many game-elements should be implemented. The many differences between studies, both in definitions, implementation and purpose, makes it difficult to find related information for creating a gamified design. The literature used in this study consists of mapping as well as some specific studies. The specific studies provide different insights and contexts to support the overall view of the mapping studies. Focus is put on studies that are transparent with the game-elements used and with a focus separate beside points, badges and leaderboards. Therefore, the review is not complete but tries to capture possible and relevant aspects of gamification.

As a result of the field being incoherent, positive findings on effect are difficult to generalize. There are also many inconclusive results, which shows uncertainty of the possible positive effects of gamification. Dichev and Dicheva (2017) propose clear research questions for evaluating the effect of gamification. The experimental framework attempts to present this type of question, and the workshop is designed to fit into the experimental framework. In addition to the need for clearly formulated questions, the level of the implementation studied should be clarified. It can be difficult to read whether it is a course or lecture being gamified in existing studies.

When gamification is evaluated to have positive effect on motivation or learning it is often unclear what it is compared to. When it comes to courses it is often digital or blended learning, including both online and in class learning. The extent of the gamification is also unclear. Therefore this implementation focused on presenting clear frames including time and similar activities. Since the other workshops at the site have active elements, the gamification implementation is compared to an active situation. To compare gamification to a situation not implementing the activities and the encounter with the robot, could effect the outcome more than the implemented gamification.

Beyond the difficulty of navigating within the field of gamification, a first glance at the studies presented within the field, indicate a quite certain outlook on the positive effect on motivation and learning. Further investigation shows the lack of results that validate the positive effects. Rather than a positive effect, there is a potential of positive effect, which not yet has been validated. In this study, a critical perspective was sought to not amplify the potentials that are not validated. However, a proper empirical evaluation has not yet been conducted, which is necessary to draw any conclusions regarding the effect of this implementation. It should be noted that the extended belief of the potential may affect the implementations. Another aspect that might effect the field is that much time can be spent on a gamified design, which can create a desire to amplify the results. This can both be generalizing indications that are not generalizable and reinforcements provided by the instructors during the implementations, even though not intentional. During this implementation, the discussion about both potential positive and negative effects have been present to avoid the potential bias.

As stated above, Dichev and Dicheva (2017) note the importance of specific questions, yet the questions of this thesis take on a broader nature. This thesis tries to answer the first research question, *RQ1: How can the MDA framework be applied to the new learning situation at Smarta Fabriker to create a gamified workshop?*, by providing a transparent design process. Since there is a contextual dependency within the field, insight into the process can reveal how and why game-element are implemented. This is beneficial in an evaluation of the implementation and may give an answer to the follow-up question, why an implementation did or did not work. Transparency can also push the field towards a common design method. The methods found are either associated with a complete course or only refers to the method of MDA, without explaining how it was applied.

The second research question, *RQ2: What possible effects can gamification have on learning in a workshop environment?,* is also broader than proposed by Dichev and Dicheva (2017). This to include the experimental framework even though it could not be performed and to evaluate possible effects. Even though some literature

proposes a potentially positive effect of gamification, the contextual dependency and difference between studies, make the evaluation process uncertain. The sources are within the field of gamification, but as stated above, the field is incoherent and the generalizability is questionable.

It is notable that this implementation of gamification differs from what seems to be the most common use in two ways. Firstly this implementation is analogue in contrast to the common digital implementations. Secondly, the learning situation is one isolated occasion, in contrast to the implementation of a complete course. The choice of implementing analogue gamification is a result of the situation. By providing analogue gamification, the visitors need not to be prepared or download any application to participate. Additionally, the production line was under development during the design process, making an analogue implementation a more dependable option. By doing so, more focus could be put into the design process rather than choosing an appropriate platform.

Regarding the situation of implementation, it is not so common to apply gamification on one separate occasion. Dichev and Dicheva (2017) argues that validity could be questioned by referring to the novelty effect. In this case, the novelty effect is considered present in both the gamified workshop and the control workshop developed for the experiment. For study visits or isolated workshops, the novelty effect may not be a disadvantage. If there is a greater learning in the gamified workshop in contrast to the control workshop, it can be beneficial to use gamification for isolated learning situations. However, it should be noted that it can not be directly transferred to complete courses.

6.2 Workshop configuration

The gamified workshop was successfully executed during the pretest. The implemented game-elements blend naturally with the informational progression of the workshop which gives a structure to the workshop. To further improve upon the workshop design, suggested modification was developed out of the remarks made during the group interviews.

For example, to aid the instructor following the script it was suggested that the gameboard could be further curated inline with the informational flow. This can be done by adding new sections to the gameboard that correspond with the progression. A section for taking notes of important concepts that are brought up during the discussions and instructions.

A misconception concerning the term chassis was brought to light during the workshop. Some of the participants thought the term referred to the body of the vehicle instead of the undercarriage or framework. The misconception is suspected to stem

from the use in computer hardware, where the term refers to both the outer shell and load-bearing framework. This misconception should be addressed when the product is introduced and separated during the workshop.

The robot sequence introduced during the third round of the workshop ran as intended, however, it did not successfully display relatable benefits of using a collaborative robot because of two reasons. Firstly, the equivalent task of performing the quality check manually, took less time to preform than intended. This due to inadequate instructions where steps could be skipped. Secondly, the ergonomic advantages are not obvious in a setting where Lego blocks are assembled. To address this issue, the instructions for the manual quality check should be overhauled, possibly by adding a system to report on key steps in the quality check to increase redundancy, this could remove the issue where the participants skip steps to save time.

Further, the project Smarta Fabriker should consider developing robot sequences that solve other tasks in the production line. Adding new upgrades with different complexities can enable adjustment of the learning content. This falls outside of the experiment scope since adding new upgrades would introduce new concepts. However, it opens new possibilities to tailor the workshop to a specific population.

The test group expressed that the goal for each round was perceived as unimportant, yet, that it provided motivation in form of something to strive for. This might seem counter intuitive, however, it is an expression of different attitudes, where the aesthetic challenge, speaks to some participants and not others. More test need to take place in order to tell how the goal affect the participants, although this indicates that the goal is implemented in a desirable way where it adds motivation to some and is not discouraging to others.

6.3 Game-elements in Learning

The implementation provided in this thesis has started with the perspective of the participants and the decision of the three aesthetics. The MDA framework was mainly used to ensure that the intention of the chosen game-elements is thoroughly implemented to increase the likeliness of a successful implementation. It is important to note that not all game-elements were considered and many were deselected as they are more suitable in a digital implementation, such as direct feedback or individualizing the learning experience. Since there are still no unambiguous definitions of different game-elements for gamification in education, the choice is based on the elements that the research group could gather and perceived as possible to implement. The method explains the conscious deselection, however, the unconscious deselection is still hidden. A more extensive taxonomy of game-elements,

divided into categories following the MDA framework, could provide further insight by showing the elements not selected in the process.

The final workshop have 13 implemented game-elements. The number of game-elements was a result of the iterations in the design process. Early in the process, more elements were implemented, however, elements were removed to reduce the complexity of the implementation. The final workshop is perceived to provide a suitable level of complexity, however, it needs to be tested for the specific target group of lower secondary school students.

The number of aesthetic was decided upon within the research group. Kusuma et al. (2018) argues for the use of many aesthetics in an implementation, meanwhile Dichev and Dicheva (2017) state that more elements can not be concluded as more effective. The argument stating that the providing of several aesthetics can appeal to different people did guide the process. However, more game-elements can also increase the complexity of the gamification. A more complex situation can increase the risk of creating a situation which is hard to understand from a participant perspective. The rules might become too complex, causing the content and learning to be overlooked. This concern limited the number of aesthetics. Several aesthetics were implemented, but with an awareness of the complexity problem. What is perceived as comprehensible is not obvious, why several simplifications were made during the design process. The simplifications were often a response to the performed tests during the design process.

Toda et al. (2018) found some negative effects of gamification, divided into the categories indifference, loss of performance, undesired behavior, and declining effects. These are not considered for specific game-elements, but are found in complete implementations. Since this implementation has not been empirically evaluated, these negative effects can not be neglected. Toda et al. (2018) propose that there might be an indifference, which in this implementation would falsify the hypothesis, Ha, in the experiment. An eventual loss of performance would be shown by higher performance by the control groups. In this implementation, undesired behavior could be a strongly competitive behavior among the participants or participants focusing more on the game-elements than the content or the field of technology. Since one workshop is conducted during a short time period, the declining of effects may not be as extensive as it could be in a longer course. However, the participants may perceive the workshop as too repetitive, which was brought about in the study by Aldemir et al. (2018).

An overview of the presented game-elements in tables 5.4, 5.3, and 5.2 shows that the literature taken into consideration propose that six of the elements indicated the possibility to affect motivation, engagement or learning, five of the elements were found in the literature but the effect was not, and two were not found in

literature at all. Further, it is noted that both of the elements that were not found in literature are mechanics, and thereby the ones closest to this specific context. It is seen that the aesthetics are less connected to the context which might make it easier to generalize, however, they are dependent on the more specific dynamics and mechanics, which affect whether the implementation is successful or not. Since there is an interplay between the categories in the MDA framework, it could be beneficial to look at the networks branching out from each aesthetic. From this, it can be seen that all three parts have some potential positive effect. Perhaps these clusters are one way of comparing implementations rather than evaluating every game-element, which are considered contextually dependent.

In the pretest the group showed some indication of an increase of the feeling of inclusion, compared to an ordinary lesson in school. This is interpreted as the implementation of the game-elements connected to the aesthetic fellowship was successful and suited the group. However, this does not mean that it would suit other groups. There are indications from the study provided by Aldemir et al. (2018), that some students requested team-work. This is promising, but no reported results have been noted regarding lower secondary school students.

The aesthetic challenge is performed through the dynamic objective. From the pretest some level of competition was perceived, however not within the team. How others react to the same implementation is uncertain. Other groups might amplify the competition aspect, without all team members necessarily being positively tuned to the competition aspect, which is not desired. A strong presence of competition might even cause the group to blame each other for failure. This could create a negative feelings among the participants, which would oppose the goal for the project of Smarta Fabriker.

As an alternative to the current implementation of the aesthetic challenge, an implementation using the mechanics points, badges and leaderboards were considered, since this is the most common implementation of gamification. Such an implementation could also provide the simplest implementation. However, the conclusion was that this would neither benefit the participants nor the field of gamification. The implementations of points badges and leaderboards are similar to the behavioristic learning approaches since both foci on reward systems to enhance behaviors. However, behavioristic learning approaches, being a well-known learning theory, are not applied in education during most lectures. If points are the best method for learning and motivation, should it not be a more common practice? Since learning is a complex process, and seems to be different on an individual level, what behaviors should be reinforced to enhance learning is not crystal clear. Points could be provided to increase the number of questions asked. An increased number of question is not a promise of increased learning. Other behaviors that can be rewarded are

the number of completed tasks or perhaps attempts, however, the argument is the same, the relation to learning is not clear. The question of what should be rewarded remains.

Another aspect of using reward systems, or systems providing ground for comparison, is the well being of the users. This type of measurement could provide clarity of what is considered important in a context. Perhaps, it would clarify the learning content and an eventual assessment. However, this type of system could probably affect users negatively as well. Measuring during learning might cause the participants to feel controlled, or connect learning with the rewards and therefore loose intrinsic motivation. Another aspect to consider is the more consistent use of points, badges and leaderboards. What will be the effect on students, or users of gamified learning situations, when points, badges and leaderboards are a rule rather than an exception? A constant measuring could create undesired feelings, such as stress, or create extensive competition among peers. These aspects should be considered thoroughly before implementing points, badges and leaderboards.

Rewards, being an external motivational factor, falls under external regulation in SDT. External regulation is the external motivation with the lowest degree of autonomy. SDT pose the internalization process as a natural process if the needs for competence, autonomy and relatedness are fulfilled. Internalization strengthens internal processes for regulation, and are successively integrated to be more in line with inner values. In this context, an internalization would be the more beneficial regulation, since a long term interest is sought by the project of Production for Future. An internalization could support an interest in technology. Perhaps this would also contribute to the learning process, both within and without of the workshop. However, the relation between this type of motivation and learning is neither clear.

If internalization is sought by the workshop, the three needs should be fulfilled. In the workshop, the participants are given the opportunity to contribute information which could fill the need to feel competent. The need for autonomy could be felt in the activity, since the instructor does not interfere in the activity. However, autonomy is limited in other parts of the workshop. Other game-elements that provide more autonomy were considered, e.g. the aesthetics expression or choice as a dynamic. Choice was considered for the narrative, to provide an opportunity for the participants to influence the upgrades. However, such an implementation would be difficult to compare to a workshop without gamification. The need for relatedness can be filled as the social aspect is present in the workshop. The assigned roles are incorporated partly to make it easier to take part in both the building activity and to provide unique perspectives in the discussions. This implementation creates a platform with the intention of facilitate ordinary conversations among the participants, which according to social learning theory is where learning takes place.

Beyond creating a situation that supports the needs presented inSelf-determination theory, Self-efficacy can give further insight to the process of engaging in a behavior. In this implementation, self-efficacy theory are applied to the feedback implementation, which takes the form of red or green indications. Self-efficacy points to performance accomplishments being one source of efficacy information. By providing an experience of success, the situation is hoped to support the participants in seeing themselves performing behaviors that are common within the field of technology. This to possibly see technology as a possible career. According to self-efficacy theory, failure does necessarily negatively effect self-efficacy. However, the failure should be overcomed by success. The implementation is designed to provide at least one indication of success. The intention is to provide it to the building activity. However, during the pretest the instructor gave the group a green indication with the motivation of detailed discussions, since all three rounds resulted with an indication of failure. This opportunity should be included in the script to ensure positive feedback.

6.4 Experiment

To evaluate the implemented gamification without inflating result, an equivalent control workshop is required. This workshop was designed by excluding all game-elements from the existing experimental workshop. This approach assures to some degree that the participants engage in similar processes and with the same information. However, as the game-elements are built into the workshop, removing them can affect the workshop drastically, therefore a trade off between removing the elements and retaining similarities occur. For example, the control workshop is structured in three sections which is a remnant of the game-element rounds. One could argue that this element is still present however, it is not reinforced by its connected elements, upgrades and narrative. The resulting control workshop is believed to be equivalent to the experimental workshop without implementing any game-elements, it also categorizes as a workshop environment because it incorporates discussions and practical work.

Even though the workshops are designed as active learning situations and engage the participants in cognitive processes of the higher order, the experiment is designed to study learning through the fundamental cognitive process of remembering factual and conceptual knowledge. This was a conscious decision to eliminate unfair advantages as the higher cognitive processes generally require some degree of base knowledge to master, they also take more time and are harder to evaluate in questionnaires.

As the test group were familiar with the learning objectives prior to the pretest, the questionnaire testing this knowledge was set up as short text answer questions. This resulted in an unwanted situation where the first questionnaire added stress to the participants as they dedicated themselves to answer the questions correctly. This resulted in a prolonged questionnaire session, which is not desirable as too much time spent in evaluation can negatively affect the overall impression of the workshop. For the intended population, it is highly recommended that the test take the form of multiple-choice questions to avoid such scenarios.

Unfortunately, a complete data-set could not be gathered from the pretest alone. However, in a scenario where the experiment is executed in its whole, the data collected regarding the dependant variable, is intended to be analysed through a statistical independent t-test where the average scores of the two groups are compared to tell whether or not there is a probable correlation between gamification and knowledge retention.

The explanatory variables motivation and activity are studied to gain knowledge of why a certain result occurs. An increase in motivation could imply that the participants are more willing to engage with the content. As active learning suggests an increased activity would force the participants to process the informational content further. However, it is unclear whether an increase in motivation and activity leads to a situation where more knowledge is retained, it is therefore of interest to study these variables to see how they correlate with knowledge retention.

In the first questionnaire, the participants are asked to assess their own motivation during a regular technology lecture, this is done to benchmark their motivation in a related scenario. In the ideal case, the randomization of the participants lead to an equal assessment between the two groups, this would open the possibility to see how the two workshops affect motivation individually, the same goes for activity.

Inclusion is studied to verify if the purpose of creating an inclusive workshop is served or not. As Nilholm and Alm (2010) mention, it is hard to encompass every aspect of inclusion. However, by implementing roles with assigned tasks the gamified workshop tries to provoke active behaviors in participants that would otherwise take a passive approach in a lecture setting. These behaviors hope to induce a greater feeling of inclusion by activating all participants in the social and learning community.

6.5 Further research

According to the arguments above, the recommendation is to not focus on the implementation of reward systems such as points, badges and leaderboards. Instead, focus should be on deeper game-elements, such as the ones in this implementation of gamification. Therefore, the suggested modifications, presented in tables 5.8 and 5.7, should be implemented and then the experiment could be performed. If the workshop is used without the experimental evaluation, a critical approach towards the actual effect is important as well as caution when using the thumbs or other rewards.

If the experiment is performed, the study can be followed by modifying the workshop to provide further insight into the specific elements. The recommendation is to exclude one or two of the aesthetics, with connected dynamics and mechanics. By repeating different combinations, the chains, and perhaps individual elements, can be evaluated.

When knowledge retention has been evaluated it would be interesting to investigate more complex dimensions of the cognitive process dimensions, presented in Bloom's revised taxonomy described in section 2.2.1. Instead of evaluating the learning through a questionnaire, an assignment where the reasoning is in focus could be provided at the end of the workshop. Such an assignment could be reasoning about possible effects of adding buffers between the stations. However, this would call for additional checks on how used the participants are to performing such tasks. This to highlight differences between prior knowledge.

In this thesis, the effect of gamification on learning is in focus. Inclusion is taken into consideration in the design of the workshop and in the questionnaires. However, to evaluate the effect gamification has on inclusion, the questionnaires should be supplemented by qualitative data collections, e.g. interviews. Since inclusion is a commonly used term, this relation would be of interest for future research within gamification.

Indifference or negative performance are perceived to be commonly attributed to a poor implementation or a specific context. This rather than focusing on the evaluation of the effect of gamification, as an indifference or negative performance should provide the possibility to falsify the effects of gamification. This raises the question of what would distinguish the results of an inadequate implementation from a successful implementation with negative effects. Such insight could be important for the field to be able to separate poor implementations from valuable results and thereby strengthen the credibility.

7

Conclusion

It is clear that there are many possible game-elements for the given context. The MDA framework was helpful to ensure a thoughtful design with the participants in focus. This thesis proposes one implementation of gamification, using 13 game-elements to attain the aesthetics narrative, fellowship and challenge. The implementation is specific to the context, however, the method shows how such an implementation can be performed in other contexts.

Further, the thesis proposes possible outcomes as improved learning, motivation and engagement. However, negative effects such as undesired behaviors could be present. The situation could also be perceived as to complex for the target group. The gamified workshop could show no effect compared to the control workshop. Since the studies within the field of gamification not yet are generalizable, the actual outcome must be evaluated. To get insight into the effects on learning, the workshop needs to be performed and evaluated, advantageously using the proposed experimental design. This would benefit both the actual implementation and the field of gamification as there are few comparisons between gamification and other active learning situations.

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A

Script for Gamified Workshop

Aktivitet (activity)	**Informations-flöde** (Information flow)	**Manus** (Script)
Föreläsning (Lecture)	Lärandemål och introduktion (Learning objectives and introduction)	**Runda 1** **Introduktion** Det här är production for future, det är en produktionslina där vi kan demonstrera nya metoder för produktion. Den består av 3 arbetsbord och en robot. Idag ska ni få känna på hur det kan vara att jobba i en sån här miljö. Ni skall bygga den här legomodellen som efterliknar VERA, volvos kommande autonoma transportlösning. Har ni några frågor så är det bara att avbryta. Vi kommer köra 3 rundor där vi bygger och mellan dem diskuterar vi tankar och idéer med målet att förbättra och utveckla produktionslinan. När ni är här på linan är det viktigt att ni jobbar tillsammans för att klara alla beställningar. Under workshopen kommer vi stöta på lite begrepp som vi vill att ni tar med er härifrån - Flexibel produktion - Flaskhals - Kollaborativ robot - Ergonomi - Kvalitet
	Kollaborativ-robot (Collaborative robot)	Roboten som ni ser här en är en kollaborativa robot vilket betyder att den kan arbeta tillsammans med operatören. Till exempel genom att avlasta vid tunga lyft eller att den jobbar med en produkt samtidigt som en montör. Som ni ser är roboten inte inburad. Det som skiljer sig från en vanlig robot är att den rör sig försiktigt och är programmerad att stanna om den stöter i något, exempelvis människan den samarbetar med.
	Produktionslina (Production line)	Om vi tar och tittar på produkten, den består av ett par delar, om vi plockar isär den har vi. - karossen - Batteri och motor - Chassit **Utdelning av roller och regler** Innan vi kör igång skall ni få dra era rollkort så ni vet vilka uppgifter ni har.. - Dra rollkort - Vi kör laget runt med att läsa upp era rollbeskrivningar, vi börjar med... - Skriv namn upp på tavlan allt eftersom rollerna läses upp Så här ser ett beställningskort ut. Det beskriver vilken variant som skall byggas, dvs, vilka delar som tillkommer vid varje bord. kortet ska skickas med produkten genom linan. Bygg-instruktioner för VERA ser ni på läsplattorna på arbetsborden.

		Prata om kortet “linje produktion”. Såhär ser det ofta ut: produkten rör sig framåt, mellan olika stationer. På varje station utförs vissa saker, exempelvis hjul sätts på på produkten. Det är i en sådan produktion vi kommer börja. *Deltagarna ställer sig vid arbetsstationerna.* Första rundans mål är att bygga 4 Bilar på 4 minuter - beställningskorten ligger på första arbetsbordet och följer som sagt med produkten genom linan Regler ● Produkten får inte flyttas till nästa bord förrän det finns plats på fixturen på bordet framför ● Material som faller på golvet läggs i uppsamlingslådan ● Montörer får ej förbereda delar innan beställningen har kommit till bordet ● Driftledaren sätter upp beställningskort för färdiga bilar på tavlan **Mål** Okej, kommer ni ihåg målet? 4 bilar på 4 min. Då kör vi.
Byggaktivitet (Building activity)	Byggaktivitet (Building activity)	**Bygga** *mål 4 bilar på 4 min*
Diskussion (Discussion)	Flaskhals (Bottle neck)	**Diskussion** *Gå till tavlan.* (**fråga**) Hur kändes det? (**fråga**) Lyckades vi nå målet? varför/varför inte? *Kolla på hur många produkter som producerades.* *Bestäm gemensamt med gruppen om de får grön eller röd tumme.* *Led in på flaskhals, utifrån vad deltagarna har sagt.* Använd tavla: Prata om en flaska som vi häller ut vätska från, vad är det som bromsar? - flaskhalsen. På samma sätt är det i vår produktionslinje. Den uppgift som tar längst tid gör att totaltiden blir längre. Stationerna runt omkring får vänta på produkten eller att skicka den vidare. (**fråga**) Vilken station var flaskhalsen? Diskutera 2 och 3 som ni står. (**Uppföljning på fråga**) Kvalitetssäkringen tog lång tid. (Om inte för att det tar tid att lära sig instruktioner) (**fråga)** Annan sak som tog lång tid, montera isär produkten. Varför gör vi det? (**Uppföljning på fråga**) Återanvända legobitarna. I en produktion som levererar produkter till kund är det viktigt att fundera på vilka delar av produkten som kan återanvändas (förklara) eller återvinnas (materialet).
	Kvalitet (Quality)	(**fråga**) Burken vi presenterade i början, här hamnade/hamnade inte något material. Varför vill vi lägga det tappade material här och inte montera dem i produkten? (**Uppföljning på fråga**) Säkerhet och kvalitet. Vi vill skapa en högkvalitativ produkt, som kunden kan lita på. Om vi tappar delar så är det inte säkert att de fungerar som de ska och därför kan de inte monteras in direkt i produkten. (**Uppföljning på fråga)** digitalisering kan hjälpa oss med detta Så nu har vi prata om lite olika delar kvalitet, återanvändning (hållbarhet) och flaskhalsar. Vi drar ett uppgraderingskort
Föreläsning (Lecture)	Flexibel produktion (Flexible production)	**Runda 2** **Fabrikens uppdatering - Flexibel produktion** Vi fick uppgraderingen Flexibel produktion. Detta innebär att vi blir bättre på att anpassa oss efter vad kunden vill ha.

		Den här rundan kommer vi bygga olika varianter av produkten. En kund vill att transportlösningen skall kunna åka längre och behöver därför större batteri. En annan vill ha en grå kaross istället för en vit. Att kunna hantera olika produktvarianter i en och samma produktionslina är en aspekt av flexibel produktion. Ni kan även se att det finns monterade hjul på alla bord. (**Info**) Ja då kan man ju fråga sig varför dom finns där? (**Info**) Detta är en aspekt av flexibel produktion, det gör det till exempel möjligt att snabbt ställa om eller fabriken efter behov. *Deltagarna ställer sig vid arbetsstationerna.* *Ev repetera regler* ● Produkten får inte flyttas till nästa bord förrän det finns plats på fixturen på bordet framför ● Montörer får ej förbereda delar innan beställningen har kommit till bordet **Mål** Precis som innan skall vi producera 4 produkter på 4 min, men det kommer olika varianter den här gången. Då kör vi.
Byggaktivitet (Building activity)	Byggaktivitet (Building activity)	**Bygga** *4 produkter på 4 min*
Diskussion (Discussion)	Flaskhals (Bottle neck)	**Diskussion** *Gå till tavlan.* (**fråga**) Hur kändes det den här gången? *Kolla på hur många produkter som producerades.* *Bestäm gemensamt med gruppen om de får grön eller röd tumme.* (**fråga)** Vi pratade om flaskhalsar innan, uppstod den på ett annat ställe nu när ni har blivit lite varma i kläderna? Var det lättare att se när ni hade fått träna en runda? (**Uppföljning på fråga**) Kom fram till att kvalitetssäkringen tog lång tid. Men nämn även att batterierna kan ta ganska lång tid.
	Flexibel produktion (Flexible production)	(**fråga)** Ni fick testa att bygga två olika produkter i en och samma produktionslina. Vad finns det för vinst av att kunna tillverka olika grejer i samma lina (**Uppföljning på fråga**) *Förslag:* ● Man kan anpassa sin produktion efter efterfrågan ● Mindre lager ● Mindre onödiga produkter (ekologisk hållbarhet) ● Där går snabbare att ställa om produktionslinan till för en annan produktion. ● Det går snabbare att ställa om till en ny produkt
Föreläsning (Lecture)	Kollaborativ robot (Collaborative robot)	**Runda 2** **Fabriks uppdatering - kollaborativ robot** *Dra ett nytt kort* - Kollaborativ robot (på bord 3) - den får hjälpa till med kvalitetssäkringen. Den kollaborativa roboten passar bra i en flexibel produktionslina eftersom den kan samarbeta med montören. Precis som montörerna behöver roboten också kunna hantera olika produktvarianter vilket man gör genom programmering. Som ni ser har även bordet för den kollaborativa roboten hjul vilket gör det möjligt att flytta den till den stationen som behöver den mest.
	Ergonomi (Ergonomics)	Innan har vi ju pratat om flaskhalsar vilken roboten skulle kunna hjälpa till med, men det skulle även kunna vara att avlasta en montör ergonomiskt. Ergonomi är läran om hur arbetsredskap och arbetsmiljö påverkar människan. I detta fallet så kan det innebära att roboten hjälper till vid svåra(påfrestande) uppgifter för att montören inte ska skada sig.

		Uppgiften är kanske inte svår att genomföra en gång med om man gör en uppgift om och om igen finns det en risk att man skadar sig. Ett exempel kan vara tunga lyft såsom att montera hjul. Vi tar och tittar på vad roboten kan göra. *Demonstrera med den kollaborativa robotens uppgifter. Start/Stop. Demonstrera **en** station.* *Deltagarna ställer sig vid arbetsstationerna.* **Mål**: Nu skall vi bygga sista rundan. Samma regler som innan. Målet är 4 bilar på 4 minuter (eventuellt 5 om de har klarat det innan). Då kör vi
Byggaktivitet (Building activity)	Byggaktivitet (Building activity)	**Bygga** *4 produkter på 4 min*
Diskussion (Discussion)	Återblick på lärandemål (Learning objectives look back)	**Diskussion** *Gå till tavlan.* (**fråga**)Hur gick det? *Kolla på hur många produkter som producerades.* *Bestäm gemensamt med gruppen om de får grön eller röd tumme.* *Repetera begreppen med hjälp av deltagarna:* ○ Ergonomi ■ Har ni några förslag på var roboten kan hjälpa till för att förbättra ergonomin? ○ Flaskhals ○ Flexibel produktion ○ Kvalitet ○ Kollaborativ robot ■ Hur var det att bygga tillsammans med roboten? ■ Var hade ni velat ställa roboten för att bygga snabbare? (ta bort en flaskhals) Jag tycker att ni har varit jätteduktiga!

B

Script for Control Workshop

Aktivitet (activity)	**Informationsflöde** (Information flow)	**Manus** (Script)
Föreläsning (Lecture)	Lärandemål och introduktion (Learning objectives and introduction)	Det här är production for future, som är en produktionslina där vi kan demonstrera nya metoder för produktion. Den består av 3 arbetsbord och en robot. Idag kommer ni få testa att bygga produkter i den här fabriken och vi kommer att diskutera lite olika områden kring produktion. Produkten som byggs är den här legomodellen som efterliknar VERA, volvos kommande autonoma transportlösning. Om ni har några frågor så är det helt okej att avbryta. Och ni får gärna svara rakt ut på frågor. En viktig sak för att det ska fungera är att vi samarbetar för att alla ska få möjlighet att vara med och prata och ställa frågor. Under workshopen kommer vi stöta på lite begrepp som jag vill att ni tar med er härifrån - Kollaborativ robot - Flaskhals - Flexibel produktion - Ergonomi - Kvalitet
	Kollaborativ robot (Collaborative robot)	Nu tar vi och tittar på produktionslinan. Produktionslinan består av tre arbetsbord och en kollaborativ robot. Den kollaborativa roboten, är en robot som j kan arbeta tillsammans med operatören. Till exempel genom att avlasta vid tunga lyft eller att den jobbar med en produkt samtidigt som en montör. Som ni ser är roboten inte inburad. Det som skiljer sig från en vanlig robot är att den rör sig försiktigt och är programmerad att stanna om den stöter i något, exempelvis människan den samarbetar med.
	Produktionslina (Production line)	Om vi tar och tittar på produkten, den består av ett par delar, om vi plockar isär den har vi. - karossen - Batteri och motor - Chassit **Produktionslinjens montörer** Fråga vad deltagarna heter och skriv upp namn på tavlan. Som jag nämnde innan finns det 3 arbetsstationer, och till dessa finns det tre olika montörer. Chassimontör, batterimontör samt en karossmontör. Vi går och tittar på fabriken. *Vi ställer oss vid den första stationen.* Här står den första montören, chassimontören. Denna monterar hjul och fästpunkter på chassit. (**visa stationen)** På stationen finns instruktioner i en läsplatta som visar hur monteringen går till. Och även här finns instruktioner i läsplattan. *Vi går vidare till den andra stationen,* Här jobbar batterimontören. Här monteras batterier och motor fast på lastbilen. (**visa stationen)**

		Gå till sista stationen. På den sista stationen står karossmontören och här monteras karossen och vändskivan fast på lastbilen. Vändskivan sitter här och det är här man fäster lastbilens trailer/last. (**visa station)** Eftersom att det här är sista stationen i produktionslinan så behövs även en kvalitetskontroll. Andra viktiga roller i produktion kan vara någon som ansvarar föt och leder produktionen för att se till att det går som det ska. Det är också viktigt att tänka på vad som händer med materialet innan, under och efter produktion.
Byggaktivitet (Building activity)	Byggaktivitet (Building activity)	**Bygga** Är det någon som vill testa att bygga? Det kommer finnas fler möjligheter att testa. Vem vill vara var? *Placera ut eleverna. Om det är fler än tre som vill så byt efter ca 2 bilar på första och andra stationen. Fråga eleverna hur det går under tiden. De som inte bygger kan plocka isär bilarna.* Om inte någon plockar isär bilarna så gör detta tillsammans.
Diskussion (Discussion)	Flaskhals (Bottle neck)	**Diskussion** *Gå till tavlan.* (**fråga**) Hur kändes det? *(om möjligt koppla till deras känslor/svar)* I produktion så brukar man prata om flaskhalsar. Tänk er en flaska som vi häller ut vätska från, vad är det som bromsar? Jo flaskhalsen. På samma sätt är det i vår produktionslinje. Den uppgift som tar längst tid gör att totaltiden blir längre. Stationerna runt omkring får vänta på produkten eller att skicka den vidare. (**fråga**) Gick det att upptäcka någon flaskhals nu när vi byggde? (**Uppföljning på fråga**) (**1**) Om ingen upplevde något: Eftersom det var första gången så kan det vara svårt att märka och instruktionerna tar lite tid. (**2**) Om någon gav ett förslag förutom batterier, upprepa förslaget och fortsätt lägg efteråt till om batterier. (**3**) Om batteriförslag upprepa eller lägg till enligt nedan **Tillägg:** Om man producerar många kan det vara så att det tar lång tid att montera batterier - många små delar. (**fråga**) Under tiden vi byggde/eller efter, plockade vi isär produkten. Varför gjorde vi det? (**Uppföljning på fråga**) Återanvända legobitarna. I en produktion som levererar produkter till kund är det viktigt att fundera på vilka delar av produkten som kan delar återanvändas eller återvinnas (materialet).
	Kvalitet (Quality)	(**fråga**) Om material tappas på golvet, så ska man inte föra in det direkt i produktion igen. Varför tror ni att det är så? (**Uppföljning på fråga**) Säkerhet och kvalitet. Vi vill skapa en högkvalitativ produkt, som kunden kan lita på. Om vi tappar delar så är det inte säkert att de fungerar som de ska och därför kan de inte monteras in direkt i produkten. (**Uppföljning på fråga)** digitalisering kan hjälpa oss med detta Så nu har vi prata om lite olika delar kvalitet, återanvändning (hållbarhet) och flaskhalsar. Vi går vidare till att prata om olika varianter

Föreläsning (Lecture)	Flexibel produktion (Flexible production)	**Flexibel produktion - 5 min (Diskussionsyta)** Nu producerade ni endast en produktvariant. Om vi tänker oss att den här produkten produceras till riktiga kunder, så vill kunderna kanske ha olika färger på sina lastbilar. Eller så behöver de kunna köra olika långt för att kunna leverera sina produkter på ett smidigt sätt, vilket gör att de behöver olika stora batterier. På varje station finns minst två varianter. Att kunna hantera olika produktvarianter i en och samma produktionslina är en aspekt av flexibel produktion. Flexibel produktion handlar både om att kunna anpassa produktionslinan efter de produkter som efterfrågas, hantera varianter, och att kunna ställa om fabriken fysiskt. ● För att kunna flytta om i fabriken har arbetsborden hjul. Vilket även roboten har. Detta gör att det snabbt går att ställa om eller förflytta fabriken om det behövs. Den här fabriken kan exempelvis tas med till andra ställen om vi vill visa upp den.
Byggaktivitet (Building activity)	Byggaktivitet (Building activity)	**Bygga - 5 min** Nu testar vi att bygga olika varianter efter varandra, ni kan välja att bygga olika varianter nu. Vilka vill bygga den här gången? *Placera ut eleverna. Om det är fler än tre som vill så byt efter ca 2 bilar på första och andra stationen. Fråga eleverna hur det går under tiden. De som inte bygger kan plocka isär bilarna.* *Uppmana deltagarna att bygga andra varianter.*
Diskussion (Discussion)	Flaskhals (Bottle neck)	**Diskussion** *Gå till tavlan* (**fråga**) Hur kändes det den här gången? (**fråga**) Vi pratade om flaskhalsar innan, upplevde ni någon flaskhals den här gången? Nämn att kvalitetssäkringen tog lång tid. Men nämn även att batterierna kan ta ganska lång tid.
	Flexibel produktion (Flexible production)	Ni fick testa att bygga två olika produkter i en och samma produktionslina. Vad finns det för vinst av att kunna tillverka olika grejer i samma lina ● Man kan anpassa sin produktion efter efterfrågan ● Mindre lager ● Mindre onödiga produkter (ekologisk hållbarhet) ● Där går snabbare att ställa om produktionslinan till för en annan produktion. ● Det går snabbare att ställa om till en ny produkt (**fråga**) Innan nämnde jag flexibel produktion. Om vi nu skall införa en robot i produktionslinan, men fortfarande vill ha en flexibel produktion, vad behöver roboten ha för funktioner? (**diskussion i par/3 grupp**) (**Uppföljning på fråga**) ● kollaborativ robot (utan bur och som kan samarbeta), ● på hjul, ● klara olika varianter (veta vilken motor, eller vilket batteri som skall monteras) ● veta vilken station den står på
Föreläsning (Lecture)	Kollaborativ robot	Den kollaborativa roboten passar bra i en flexibel produktionslina eftersom den kan samarbeta med montören. Precis som montörerna behöver roboten också kunna hantera olika produktvarianter vilket man gör genom programmering. Som ni ser har även bordet

	(Collaborative robot)	för den kollaborativa roboten hjul vilket gör det möjligt att flytta den till den stationen som behöver den mest.
	Ergonomics	Innan har vi ju pratat om flaskhalsar vilken roboten skulle kunna hjälpa till med, men det skulle även kunna vara att avlasta en montör ergonomiskt. Ergonomi är läran om hur arbetsredskap och arbetsmiljö påverkar människan. I detta fallet så kan det innebära att roboten hjälper till vid svåra(påfrestande) uppgifter för att montören inte ska skada sig. Uppgiften är kanske inte svår att genomföra en gång med om man gör en uppgift om och om igen finns det en risk att man skadar sig. Ett exempel kan vara tunga lyft såsom att montera hjul. Vi tar och tittar på vad roboten kan göra. *Demonstrera med den kollaborativa robotens uppgifter. Start/Stop. Demonstrera **en** station.*
Building activity	Building activity	**5 min bygga** Nu ska vi testa att bygga med tillsammans med roboten. Roboten står på bord 3. Vilka vill bygga den här gången? *Placera ut eleverna. Om det är fler än tre som vill så byt efter ca 2 bilar på första och andra stationen. Fråga eleverna hur det går under tiden. De som inte bygger kan plocka isär bilarna.*
Diskussion (Discussion)	Återblick på lärandemål (Learning objectives look back)	**Diskussion** (**fråga**) Hur var det att bygga tillsammans med roboten? *Repetera begreppen med hjälp av deltagarna:* ○ Ergonomi ■ Har ni några förslag på var roboten kan hjälpa till för att förbättra ergonomin? ○ Flaskhals ○ Flexibel produktion ○ Kvalitet ○ Kollaborativ robot Kul att ni ville vara med och bygga och diskutera!

C

Questionnaire 1

Område	Fråga	Svar
Motivation	Teknikämnet är mitt	Minst omtyckta ämne — 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ — Favorit-ämne
	Hur motiverad är du under en vanlig tekniklektion?	Lite — 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ — Mycket
Inkludering	Under en vanlig tekniklektion brukar jag känna	Att jag inte är en del av gruppen — 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ — Att jag är en del av gruppen
	Under en vanlig tekniklektion brukar jag känna	Att gruppen inte lyssnar på vad jag har att säga — 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ — Att gruppen lyssnar på vad jag har att säga
	Under en vanlig tekniklektion brukar jag känna	Att jag inte tillför något till lektionen — 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ — Att jag tillför något till lektionen
Begrepp 1	Vad kallas läran om att anpassa arbete till människan för att förebygga risker för ohälsa och olycksfall.	*Kortsvar*
	Vad kallas den typ av robot som kan jobba tillsammans med en människa på ett säkert sätt?	*Kortsvar*
	Vilket begrepp används inom produktion för att beskriva en tidskrävande uppgift som begränsar flödet i ett produktionssystem?	*Kortsvar*
	Begreppet _____ produktion, beskriver en fabrik som kan hantera många produktvarianter och har stationer på hjul.	*Kortsvar*
	Vad kallas bottenplattan på ett fordon?	*Kortsvar*
Begrepp 2	_____ är ett begrepp som beskriver en fabrik som kan hantera många produktvarianter och har stationer på hjul.	☐ Production for future ☐ Flexibel produktion ☐ Snabb produktion ☐ Hållbar produktion ☐ Ergonimisk produktion ☐ Vet ej
	Människa och robot kan i produktion samverka för att minska påfrestningar på montörens kropp. Den här typen av förbättring benämns som förbättring av _____.	☐ Ergonomi ☐ Kondition ☐ Geologi ☐ Fonetik ☐ Etik ☐ Vet ej

D

Questionnaire 2

Område	Fråga	Svar
Motivation	Under workshopen lärde jag mig	Inget 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ Mycket
	Jag tyckte att workshopen var...	☐ Spännande ☐ Intressant ☐ Kul ☐ Lärorik ☐ Tråkig ☐ Obekväm ☐ Läskig ☐ Svår ☐ Lätt ☐ Relevant ☐ Långtråkig ☐ Enformig
	Hur motiverad var du under workshopen?	Lite 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ Mycket
Inkludering	Under workshopen kände jag mig...	Inte som en del av gruppen 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ Som en del av gruppen
	Under workshopen kände jag...	Att gruppen inte lyssnade på vad jag hade att säga 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ Att gruppen lyssnade på vad jag hade att säga
	Under workshopen kände jag...	Att jag inte tillför något till workshopen 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ Att jag tillför något till workshopen
Aktivitet	Under workshopen...	☐ hade jag velat vara mer aktiv ☐ hade jag velat vara mindre aktiv ☐ var jag så aktiv som jag ville.
	Under workshopen var delaktig för att...	☐ jag ville ☐ jag var tvungen ☐ någon annan förväntade sig att jag skulle vara delaktig ☐ situationen gjorde att jag behövde vara delaktig ☐ det var kul att vara delaktig ☐ om jag inte hade varit med hade det blivit sämre för gruppen ☐ Jag var inte delaktig.
Begrepp 1	Vad kallas läran om att anpassa arbete till människan för att förebygga risker för ohälsa och olycksfall.	*Kortsvar*
	Vad kallas den typ av robot som kan jobba tillsammans med en människa på ett säkert sätt?	*Kortsvar*
	Vilket begrepp används inom produktion för att beskriva en tidskrävande uppgift som begränsar flödet i ett produktionssystem?	*Kortsvar*
	Begreppet _____ produktion, beskriver en fabrik som kan hantera många produktvarianter och har stationer på hjul.	*Kortsvar*
	Vad kallas bottenplattan på produkten VERA?	*Kortsvar*
Begrepp 2	_____ är ett begrepp som beskriver en fabrik som kan hantera många produktvarianter och har stationer på hjul.	☐ Production for future ☐ Flexibel produktion ☐ Snabb produktion ☐ Hållbar produktion ☐ Ergonimisk produktion ☐ Vet ej
	Människa och robot kan i produktion samverka för att minska påfrestningar på montörens kropp. Den här typen av förbättring benämns som förbättring av _____.	☐ Ergonomi ☐ Kondition ☐ Geologi ☐ Fonetik ☐ Etik ☐ Vet ej

E

Questionnaire 3

Område	Fråga	Svar
Begrepp 1	Vad kallas läran om att anpassa arbete till människan för att förebygga risker för ohälsa och olycksfall.	*Kortsvar*
	Vad kallas den typ av robot som kan jobba tillsammans med en människa på ett säkert sätt?	*Kortsvar*
	Vilket begrepp används inom produktion för att beskriva en tidskrävande uppgift som begränsar flödet i ett produktionssystem?	*Kortsvar*
	Begreppet _____ produktion, beskriver en fabrik som kan hantera många produktvarianter och har stationer på hjul.	*Kortsvar*
	Vad kallas bottenplattan på produkten VERA?	*Kortsvar*
Begrepp 2	_____ är ett begrepp som beskriver en fabrik som kan hantera många produktvarianter och har stationer på hjul.	☐ Production for future ☐ Flexibel produktion ☐ Snabb produktion ☐ Hållbar produktion ☐ Ergonimisk produktion ☐ Vet ej
	Människa och robot kan i produktion samverka för att minska påfrestningar på montörens kropp. Den här typen av förbättring benämns som förbättring av _____.	☐ Ergonomi ☐ Kondition ☐ Geologi ☐ Fonetik ☐ Etik ☐ Vet ej

F

Observation protocol of Verbal Activity

Observation	Utfall		
Antal frågor			
varav frågor om instruktioner			
varav frågor på innehåll			
andra frågor			
- person 1	Ja	nej	
- person 2	Ja	nej	
- person 3	Ja	nej	
- person 4	Ja	nej	
- person 5	Ja	nej	
Samtal			
Samtal mellan elev-ledare			
- person 1	Ja	nej	
- person 2	Ja	nej	
- person 3	Ja	nej	
- person 4	Ja	nej	
- person 5	Ja	nej	
Levande diskussion			
Uppmärksamhet	lätt att få	neutral	svår att få
- Runda 1	1	2	3
- Runda 2	1	2	3
- Runda 3	1	2	3
Deltagare passiv			

G

Observation protocol for Script

Observationsprotokoll för gamifierad Workshop									
Starttid [min]	**Del**	**Information/aktivitet**	**ja**	**nej**				**svar av vem, deltagare/ledare**	**kommentar**
	förberedelser	Deltagarkoder ges ut	☐	☐					
		Frågeformulär-länk ges ut	☐	☐					
		Deltagare klara med frågor	☐	☐					
	del 1	Produktion for future presenteras	☐	☐					
		Vera presenteras	☐	☐					
		Deltagare uppmanas att ställa frågor	☐	☐					
		Genomgång av dagordning (3 rundor..)	☐	☐					
		Påpekar att samarbete är viktigt	☐	☐					
		Presenterar begreppslista	☐	☐					
		Kollaborativ robot presenteras	☐	☐					
		- tillsammans med operatör	☐	☐					
		- ej inburad	☐	☐					
		Plocka isär produkt	☐	☐					
		- kaross	☐	☐					
		- batteri och motor	☐	☐					
		- chassi	☐	☐					
		Rollutdelning							
		- deltagarna läser upp rollkort	☐	☐					
		- workshopledare (victor) skriver upp namn	☐	☐					
		Beställningskorten förklaras	☐	☐					
		- kortet följer med produkten mellan stationerna	☐	☐					
		- ledaren sätter upp dessa på tavlan efter färdig produkt	☐	☐					
		Bygginstruktioner finner ni på arbetsstationerna	☐	☐					
		Uppgraderingskort 1, "linjeproduktion", förklaras	☐	☐					
		Deltagare ställer sig vid arbetsstationer	☐	☐					
		Rundans mål presenteras	☐	☐					
		Regler presenteras							
		- förflyttning	☐	☐					
		- materiallåda	☐	☐					
		- ej förbereda	☐	☐					
		- beställningskort	☐	☐					
		Repetera mål	☐	☐					

		produktion körs/ bygger/spelar	☐	☐	positiv	neutral	negativ		
		Ledare inställning under produktion			☐	☐	☐		
		Förflyttning av grupp till tavla	☐	☐					
		Diskussion inleds	☐	☐	EPA	Direkt	Öppen		
		(fråga) Hur kändes det?	☐	☐	☐	☐	☐		
		(fråga) Lyckades vi nå målet? varför/varför inte?	☐	☐	☐	☐	☐		
		Begreppet flaskhals presenteras	☐	☐					
		(fråga) Vilken station var flaskhalsen?	☐	☐	☐	☐	☐		
		(fråga) ...montera isär produkten. Varför gör vi det?	☐	☐	☐	☐	☐		
		Återanvända legobitarna.	☐	☐					
		(fråga) tappat material inte i produktion, varför?	☐	☐	☐	☐	☐		
		Säkerhet och kvalitet.	☐	☐					
		digitalisering kan hjälpa oss med detta	☐	☐					
	Del 2	Dra uppgraderingskort	☐	☐					
		Flexibel produktion	☐	☐					
		- varianter	☐	☐					
		- omställningsbar	☐	☐					
		Deltagare ställer sig vid arbetsstationer	☐	☐					
		Mål presenteras	☐	☐					
		produktion körs/ bygger/spelar	☐	☐	positiv	neutral	negativ		
		Ledare inställning under produktion			☐	☐	☐		
		Förflyttning av grupp till tavla	☐	☐					
		Diskussion inleds	☐	☐	EPA	Direkt	Öppen		
		(fråga) flaskhals på nytt ställe?	☐	☐	☐	☐	☐		
		(fråga) vinst av att kunna producera olika variationer?	☐	☐	☐	☐	☐		
		Man kan anpassa sin produktion efter efterfrågan	☐	☐					
		Mindre lager	☐	☐					
		Mindre onödiga produkter (ekologisk hållbarhet)	☐	☐					
		Där går snabbare att ställa om produktionslinan till för en annan produktion.	☐	☐					
		Det går snabbare att ställa om till en ny produkt	☐	☐					
		Annat	☐	☐					
	Del 3	Dra uppgraderingskort	☐	☐					
		Kollaborativ robot	☐	☐					
		- på arbetsbord 3 / karossmontering	☐	☐					
		- kvalitetssäkring	☐	☐					

		Funktioner hos kollaborativ robot							
		- kan programmeras för att kunna hantera produktvarianter	☐	☐					
		- kan förflyttas / hjul	☐	☐					
		Förklara ergonomi	☐	☐					
		demonstration av station 3	☐	☐					
		Deltagare ställer sig vid arbetsstationer	☐	☐					
		Mål presenteras	☐	☐					
		produktion körs/ bygger/spelar	☐	☐	positiv	neutral	negativ		
		Ledare inställning under produktion			☐	☐	☐		
		Förflyttning av grupp till tavla	☐	☐					
		Diskussion inleds	☐	☐	EPA	Direkt	Öppen		
		hur gick det?	☐	☐	☐	☐	☐		
		Begrepp nämns:							
		Ergonomi	☐	☐					
		(fråga) Har ni några förslag på var roboten kan hjälpa till för att förbättra ergonomin?	☐	☐	☐	☐	☐		
		Flaskhals	☐	☐					
		Flexibel produktion	☐	☐					
		Kvalitet	☐	☐					
		Kollaborativ robot	☐	☐					
		(fråga) hur var det att bygga tillsammans med robote	☐	☐	☐	☐	☐		
		(fråga) var hade ni velat ställa roboten för att bygga snabbare?	☐	☐	☐	☐	☐		
	Avslut	Jag tycker att ni har varit jätteduktiga!	☐	☐					

H

Interview guide

Frågor till observatörer och instruktör

- Gick det att fylla i båda protokollen?
- Hur gick det att hålla sig till manus?
- Hur gick det att styra diskussionen utifrån deltagarnas svar i relation till det tänkta innehållet.

Frågor till deltagare

Frågeformulär:

- Var något som var som otydligt?
- Fick du visa den kunskap du lärt dig i frågeformuläret?
- Har ni några förbättringsförslag?

Workshop:

- Var det något ni upplevde som otydligt i instruktionerna?
- Var det något som var svårt att förstå under workshoppen?
- Hur kännes det att ha ett mål under varje runda?
  - Påverkade det ert fokus? Hur isåfall?
  - Var det motiverande?
- Hur kändes det när tummarna sattes upp på tavlan?
  - Motiverande?
  - Omotiverande?
- Har ni några förbättringsförslag?

I

Observation Protocol Data Verbal Activity

Observation	Utfall		
Antal frågor			
varav frågor om instruktioner	**2**		
varav frågor på innehåll			
andra frågor			
- person 1 **P******	Ja	nej	
- person 2 **E******	Ja	nej	
- person 3 **M******	Ja **2**	nej	
- person 4 **E******	Ja	nej	
~~- person 5~~	Ja	nej	
Samtal			
Samtal mellan elev-ledare			
- person 1 **P******	Ja **4**	nej	
- person 2 **E******	Ja **5**	nej	
- person 3 **M******	Ja **5**	nej	
- person 4 **E******	Ja **9**	nej	
~~- person 5~~	Ja	nej	
Levande diskussion	**2**		
Uppmärksamhet	lätt att få	neutral	svår att få
- Runda 1	1 **X**	2	3
- Runda 2	1 **X**	2	3
- Runda 3	1 **X**	2	3
Deltagare passiv	**1**		

J

Observation Protocol Data Script

Observationsprotokoll för gamifierad Workshop									
Starttid [min]	**Del**	**Information/aktivitet**	**ja**	**nej**				**svar av vem, deltagare/ledare**	**kommentar**
00:00	förberedelser	Deltagarkoder ges ut	☑	☐					
		Frågeformulär-länk ges ut	☑	☐					
		Deltagare klara med frågor	☑	☐					
07:30	del 1	Produktion for future presenteras	☑	☐					
		Vera presenteras	☑	☐					men senare
		Deltagare uppmanas att ställa frågor	☑	☐					
		Genomgång av dagordning (3 rundor..)	☑	☐					
		Påpekar att samarbete är viktigt	☑	☐					
		Presenterar begreppslista	☑	☐					
		Kollaborativ robot presenteras	☑	☐					
		- tillsammans med operatör	☑	☐					
		- ej inburad	☑	☐					
		Plocka isär produkt	☑	☐					Här presenterades mera
		- kaross	☑	☐					
		- batteri och motor	☑	☐					
		- chassi	☑	☐					Vad är chassit? "Bilen"
		Rollutdelning							
		- deltagarna läser upp rollkort	☑	☐					
		- workshopledare (victor) skriver upp namn	☑	☐					
		Beställningskorten förklaras	☑	☐					
		- kortet följer med produkten mellan stationerna	☐	☐					Inte nu
		- ledaren sätter upp dessa på tavlan efter färdig produkt	☐	☐					inte nu - presenterade i roll utdelningen
		Bygginstruktioner finner ni på arbetsstationerna	☑	☐					
		Uppgraderingskort 1, "linjeproduktion", förklaras	☑	☐					
		Deltagare ställer sig vid arbetsstationer	☐	☐					Gjordes istället regel repitition
		Rundans mål presenteras	☑	☐					
		Regler presenteras							
		- förflyttning	☑	☐					
		- materiallåda	☑	☐					
		- ej förbereda	☑	☐					
		- beställningskort	☐	☑					
		Repetera mål	☐	☑					

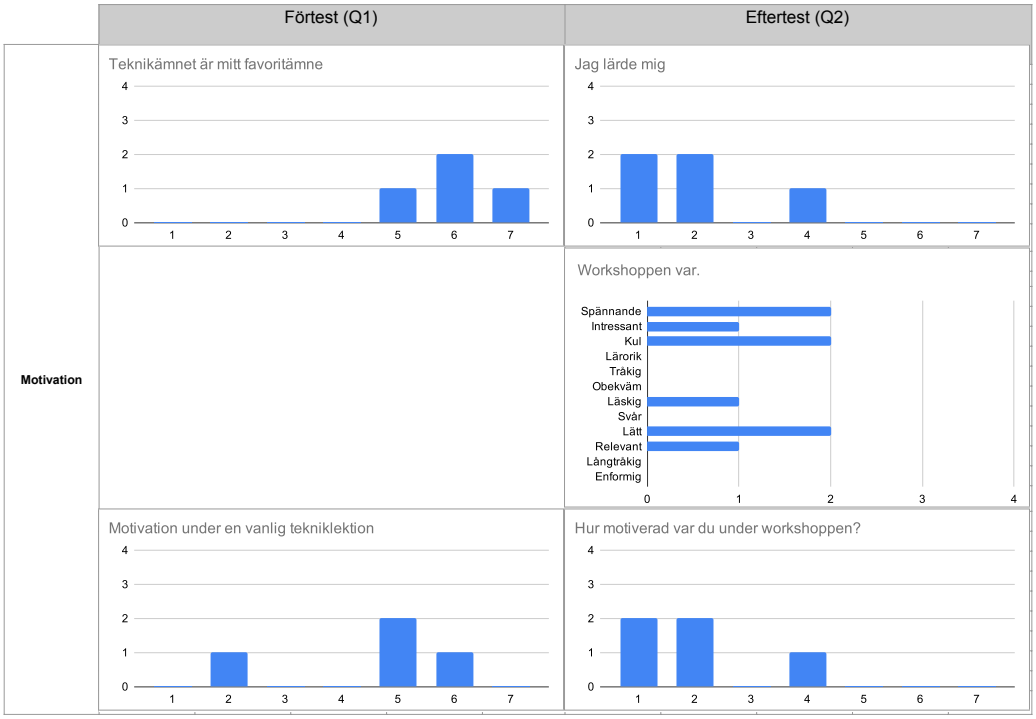
		produktion körs/ bygger/spelar	☐	☑	positiv	neutral	negativ		Mycket snack under produktion
		Ledare inställning under produktion			☐	☑	☐		
		Förflyttning av grupp till tavla	☑	☐					
		Diskussion inleds	☑	☐	EPA	Direkt	Öppen		
		(fråga) Hur kändes det?	☐	☐	☐	☐	☑		
		(fråga) Lyckades vi nå målet? varför/varför inte?	☐	☐	☐	☐	☐		Behövdes inte
		Begreppet flaskhals presenteras	☑	☐					Låångsammaste arbetsuppgiften
		(fråga) Vilken station var flaskhalsen?	☑	☐	☐	☐	☑	"vet ej"	fail
		(fråga) ...montera isär produkten. Varför gör vi det?	☐	☑	☐	☐	☐		
		Återanvända legobitarna.	☐	☑					
		(fråga) tappat material inte i produktion, varför?	☑	☐	☐	☐	☑	"Kul att ha"	
		Säkerhet och kvalitet.	☑	☐					
		digitalisering kan hjälpa oss med detta	☐	☐					vet ej
27:30	Del 2	Dra uppgraderingskort	☑	☐					
		Flexibel produktion	☑	☐					"typ" av produkt
		- varianter	☐	☐					inte ordet omställningsbar
		- omställningsbar	☑	☐					genomföra
		Deltagare ställer sig vid arbetsstationer	☑	☐					
		Mål presenteras	☑	☐					
		produktion körs/ bygger/spelar	☑	☐	positiv	neutral	negativ		
		Ledare inställning under produktion			☑	☐	☐		"Galant" lik
		Förflyttning av grupp till tavla	☑	☐					
		Diskussion inleds	☑	☐	EPA	Direkt	Öppen		
		(fråga) flaskhals på nytt ställe?	☑	☐	☐	☐	☑		"Korrekt"
		(fråga) vinst av att kunna producera olika variationer?	☑	☐	☐	☐	☑		
		Man kan anpassa sin produktion efter efterfrågan	☑	☐				d	
		Mindre lager	☑	☐					
		Mindre onödiga produkter (ekologisk hållbarhet)	☐	☐					
		Där går snabbare att ställa om produktionslinan till för en annan produktion.	☐	☐					
		Det går snabbare att ställa om till en ny produkt	☐	☐					
		Annat	☑	☐					mer av marknader
39:00	Del 3	Dra uppgraderingskort	☑	☐					
		Kollaborativ robot	☑	☐					
		- på arbetsbord 3 / karossmontering	☐	☑					
		- kvalitetssäkring	☐	☑					

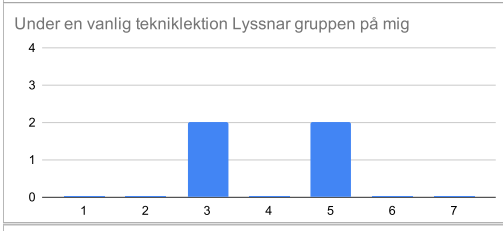
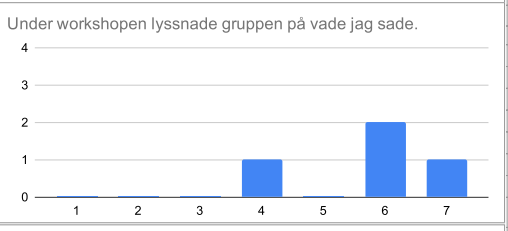
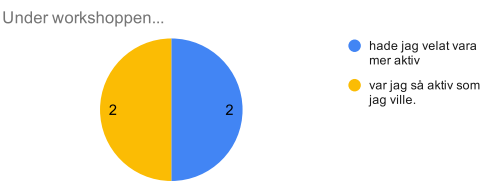
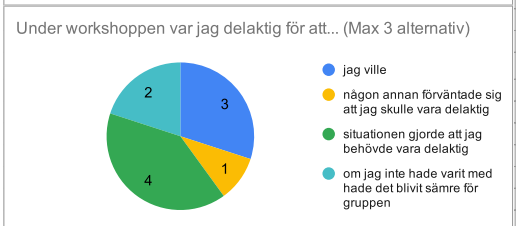
		Funktioner hos kollaborativ robot							
		- kan programmeras för att kunna hantera produktvarianter	☐	☑					
		- kan förflyttas / hjul	☑	☐					
		Förklara ergonomi	☑	☐					Exemplifierar ef definition
		demonstration av station 3	☑	☐					chassi / Kaross
		Deltagare ställer sig vid arbetsstationer	☑	☐					
		Mål presenteras	☑	☐					
		produktion körs/ bygger/spelar	☑	☐	positiv	neutral	negativ		
		Ledare inställning under produktion			☐	☑	☐		"Vi måste bli klar med sista"
		Förflyttning av grupp till tavla	☑	☐					
		Diskussion inleds	☑	☐	EPA	Direkt	Öppen		
		hur gick det?	☑	☐	☐	☐	☑	långsammare	svarade innan frågan ställdes
		Begrepp nämns:							
		Ergonomi	☑	☐					
		(fråga) Har ni några förslag på var roboten kan hjälpa till för att förbättra ergonomin?	☑	☐	☐	☐	☑		
		Flaskhals	☑	☐					
		Flexibel produktion	☑	☐					
		Kvalitet	☑	☐					
		Kollaborativ robot	☑	☐					
		(fråga) hur var det att bygga tillsammans med robote	☑	☐	☐	☐	☑	Kul, men mer tid	Digitalt, kolla hållbar.
		(fråga) var hade ni velat ställa roboten för att bygga snabbare?	☑	☐	☐	☐	☑		st. 2 för att kunna göra 2 arbetsuppgifter samtidigt
55:40	Avslut	Jag tycker att ni har varit jätteduktiga!	☑	☐					

Övriga kommentarer	- Gav en annan uppgift till driftledare under sisita rundan
	- Det uppstod frågor kring instruktionerna på läsplattorna (fel aktiga på ett ställe bla.)
	- Kanske längre tid sista rundan
	- Mycket vänte tid

K

Questionnaire Data Explanatory Variables



Inkludering		
		
		
Aktivitet		
		

L

Questionnaire Data Knowledge Variable

	Förtest (Q1)			Eftertest (Q2)		
	# Svar	# Korrekta svar	Medlv.	# Svar	# Korrekta svar	Medlv.
Begrepp 1	4	4	1	4	4	1
	4	3	0,75	4	4	1
	4	4	1	4	4	1
	4	0	0	4	4	1
	4	1	0,25	4	4	1
Begrepp 2	4	3	0,75	4	4	1
	4	4	1	4	4	1
Summa	28	19	4,75	28	28	7