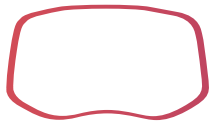# Concept Design for a Virtual Training Simulation with Game Elements

Ruben van Dijk
s1492349

Bachelor Assignment Industrial Design
University of Twente

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Bachelor Assignment Industrial Design

Author: Ruben van Dijk
                                 s1492349
                                 r.vandijk@student.utwente.nl

Institution: University of Twente
                                 Faculty of Engineering Technology

Client: Serious VR
                                 M. H. Tromplaan 52
                                 7513 AB Enschede, Overijssel, The Netherlands

UT supervisor: Alberto Martinetti
Supervisor client: Marjo Nieuwenhuijse

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Preface

This report of a bachelor assignment describes the process in which a design for a serious game is made. It is done for Serious VR, a starting company providing training simulations for production companies. The game has been built after researching virtual realities, serious games and trainings. This is used to create concepts.
I want to thank Marjo Nieuwenhuijse and Ton Kuper for sharing their passion for their new company with me. They gave me the possibility to throw myself into the virtual world and get to know the increasing number of possibilities there are for virtual reality. It was inspiring to see a company being built up and promoted and opened my eyes for entrepreneurship. Next to that I want to thank my supervisor from the University of Twente, Alberto Martinetti, for the support during my assignment to make this assignment work out the way it did.

Due to confidentiality, large parts of the report have been made confidential. In the analysis, confidential information has been used and this was used in the continuation of the report. This explains why the idea generation, concepts and the final concept have been shortened in this report.
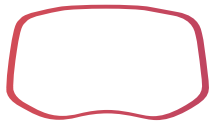
Summary

In this report a design is made to train new employees in a production company using virtual reality. This assignment is for the company Serious VR in Enschede. This company offers virtual reality trainings for employees along the production line. They develop the training simulation and offer the product. Within this project a concept design is made for a virtual training simulation game which transfers the knowledge of the machines from the old employees to the new employees. To improve the transfer of information, game elements are added.

Firstly the possibilities of virtual reality and other kinds of virtual reality have been researched in this report. From there, there is searched for the best possibility to transmit the information through one of these possibilities. Virtual reality proved to be the most logical solution to apply in a training game, since the employees learn to work in the same environment, without them making mistakes with bad consequences. Next to research of virtual reality, serious gaming has been researched. Here simulation proved to be the best for a training for the same reason why virtual reality worked best.

Next to the research about virtual reality and gaming, there is a research about how trainings are performed now and how people learn the most effective way. To make learning the most effective, the model of Kolb is used. Within this the following steps are defined: Do, Review, Learn and Apply. These steps have to be present and optimised. The elements of the ARCS model (Attention, Relevence, Confidence, Satisfaction) help to keep the player motivated and stimulate the learning.

During the idea generation, different ideas have been made to fill in the game elements with which a game is built. Also there have been ideas forged to fill in the ARCS model. This lead to three concepts which have been developed further. These three concepts focus on different aspects in the learning process.

Afterwards, the best parts of the concepts have been used to create a new concept. This concept has been told by explaining the full process. The most fragments from Kolb's learning process have been optimised, so the employees are trained the best way. Eventually the advice is to test the concept design with new employees in a client company. This is a fast way to find mistakes. This will not be done in the frame of this report. Besides that, the advice is to evaluate the concept with a professional trainer to point out the best parts. Serious VR will use the ideas that came out of this design in the creation of a training simulation for production companies.

Samenvatting

In dit verslag wordt een ontwerp gemaakt om nieuwe werknemers in een productiebedrijf te trainen met behulp van virtual reality. Deze opdracht is voor het bedrijf Serious VR in Enschede. Dit bedrijf biedt virtual reality trainingen aan voor werknemers langs de productielijn. Het ontwikkelt de training simulatie en biedt het product aan. Binnen dit project wordt een concept gemaakt voor een virtueel training simulatie spel waarbij de informatie over de machines van de oude werknemers wordt overgebracht naar de nieuwe werknemers. Om de informatie overdracht te verbeteren worden spelelementen toegevoegd. Eerst is er in dit project onderzoek gedaan naar de mogelijkheden van virtual reality en andere soorten virtual reality. Daaruit is gezocht naar de beste mogelijkheid om informatie over te brengen via een van deze mogelijkheden. Daarbij blijkt virtual reality het meest logisch te zijn om toe te passen bij een trainingsgame, zodat de werknemers leren werken in de omgeving, zonder dat ze fouten maken die ernstige gevolgen hebben. Naast onderzoek naar virtual reality is ook serious gaming onderzocht. Hierbij bleek dat een simulatie het beste werkt voor een training om dezelfde reden als waarvoor virtual reality het beste werkte. Naast onderzoek over virtual reality en gaming, is er ook onderzocht hoe trainingen nu worden uitgevoerd en hoe mensen het meest effectief leren. Om het leren het meest effectief te maken, wordt het model van Kolb gebruikt. Hierin zijn de stappen: Doen, Controleren, Leren en Toepassen. Deze stappen moeten present zijn en worden geoptimaliseerd. De game elementen die hierbij van waarde zijn, zijn Vrijheid en Controle voor de speler, Uitdaging tijdens het spelen en Verrassingen voor meer uitdaging. Daarbij werkten de elementen van het ARCS model (Attentie, Relevantie, Zelfvertrouwen, Voldoening) om de speler te blijven motiveren en het leren te stimuleren.

Tijdens de ideegeneratie zijn verschillende ideeën bedacht om de spelelementen in te vullen waaruit een spel bestaat. Ook zijn er ideeën verzonnen om het ARCS model in te vullen. Dit leidde tot drie concepten die verder uitgewerkt zijn. Deze concepten focussen op verschillende aspecten van het leerproces.

Hierna zijn de beste onderdelen uit de concepten gehaald en is daarmee een nieuw concept gemaakt. Bij dit concept is het volledige proces beschreven. De meeste onderdelen van het leerproces van Kolb zijn hierin geoptimaliseerd, zodat de nieuwe werknemers het beste worden ingewerkt. Uiteindelijk is geadviseerd om het ontwerp te testen met nieuwe werknemers in het bedrijf. Daarbij kunnen snel fouten gevonden worden. Dit zal niet meer in het kader van dit verslag worden uitgevoerd. Daarnaast is het advies voor de test dit ontwerp te bespreken met een professionele trainer om de beste punten aan te wijzen. Serious VR zal de ideeën die uit dit verslag gekomen zijn, gebruiken bij het ontwerpen van een trainingssimulatie in productiebedrijven.
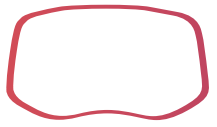
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1. Introduction

The client for this bachelor assignment is Serious VR, a company that aims to train employees in production companies by training them in a virtual environment to get them ready for the job. The following chapter will explain the assignment from Serious VR and how the assignment will be dealt with.

1.1 Problem

The coming years, many experienced machine operators retire due to the ageing problem in the Netherlands and this will create a shortage of experienced employees in the field. [1] To keep the experience in the company, it is important that the new personnel is trained and prepared to handle the unpredictable scenarios that cause failures in the machine and production line.

Actor Analysis
Serious VR

Serious VR is a company that trains machine operators in a virtual environment to learn non-automatable processes by combining serious gaming, blended learning, virtual reality and augmented reality. Serious VR is the company that is designing the virtual learning environment for the new personnel. They sell this product to the companies, to educate new personnel in the virtual space. Serious VR has ties with C4Real, which gives Serious VR the expertise to create virtual environments and use augmented reality. They have the expertise to create a game and a virtual environment that can be used for the distributed product. Serious VR is the company that produces and sells this training simulation.

Production companies

The production companies that Serious VR is designing for, are the customers of Serious VR. They aim for companies like Vredestein, where products are manufactured. Due to the ageing problem in the Netherlands, the experienced employees are retiring in the coming years. This means that the experience they have, is lost for the company. The learning environment would educate the new personnel with the knowledge the experienced employees left behind. The production companies have the knowledge about the machines and production lines and want a way to distribute this knowledge.

Experienced machine operators

The experienced employees that retire have knowledge and skills about the production machines in the companies. The experienced personnel knows the ins and outs of the machines or production line and knows what to do when an error occurs. This knowledge is valuable for the production companies. When the new employees are well-educated, the old employees can leave the company without loss of knowledge. This knowledge has to be put in the virtual learning environment.

New personnel

The new personnel has no knowledge about the production machines yet. These employees require training to use them and get to know what to do when errors occur. These are the main users of the product as the virtual environment is designed to educate them.

Project Framework

Due to the ageing problem in the Netherlands, a great deal of experienced employees are retiring. For production companies this means that they are increasingly losing the expertise they have. This loss of expertise could result in lower production speed and even production stoppages due to errors and human mistakes. The lack of experience results in situations in which the new personnel does not yet have the proper knowledge to handle the situation. Serious VR wants

to fill the knowledge gap by training the new personnel using the knowledge of the experienced employees. For this knowledge transfer there are two steps: get the knowledge out of the experienced employees and put the knowledge in the new employees.

Serious VR wants to create a virtual place in which new personnel can freely be trained and mistakes are made without consequences. Serious VR thinks the training is improved and quicker when the training takes place in a virtual environment, because the trainees can practice in a different reality which is a mirror of the production line or machine itself. In this virtual environment, the training takes place in a game, which educates the players. Serious VR uses the game elements to motivate the new personnel and decrease the time needed for education.

In this bachelor assignment the second step of the knowledge transmission is analysed. The focus will be on the transmission of knowledge on the new employees and the game elements that contribute to the distribution of knowledge.

1.2 Plan of Approach
Research purpose
Serious VR wants to have the second step of the knowledge transmission, putting the knowledge of the experienced employees in the new employees, researched. The knowledge is transmitted through a serious game in a virtual environment. Within this step are two stages. One is that the knowledge and the scenarios of the experienced employees have to be put in the game. The other is that the knowledge in the game is distributed to the new employees.

The goal is to find the most efficient way to translate the scenarios into a virtual environment and to find the most efficient way to educate the new employees.

This is researched by analysing ways to translate a scenario into the virtual environment. Then the process of learning will be analysed to see which way of education suits the target group of LBO and MBO level employees best. The results will be translated into gaming elements in a virtual environment and this will be tested to see whether the education works. Eventually this will result in a plan for a simulation training with game elements for the translation of knowledge to new employees. These steps will be executed within three months.

Goals and Deliverables
The goal of the project is to find the most efficient way to translate the scenarios into a virtual environment and to find the most efficient way to educate the new employees. At the end of the bachelor assignment a plan for translating the knowledge will be delivered and a concept for a serious game that has the best way of providing knowledge. This concept will contain the gaming elements that are implemented in the game and an explanation of the way the game is played. The plan for translating the knowledge will tell how the information and scenarios are translated into the game with which the new employee learns best.

1.3 Method

1.3.1 Analysis Virtuality and Serious Games
- What kinds of Virtuality are there?
- How is Virtuality used in the manufacturing environment already?
- What virtuality devices are there?
- What is a Serious Game?
- How are serious games used already?
- How is a virtual environment created?
- First decisions on how to implement virtuality in training.

1.3.2 Training analysis
- What do training programmes look like now?
- How do people take in information the most efficient?
- How much revision is needed to make people remember the longest?
- How can game elements contribute to learning?
- What is the training Serious VR focusses at?

1.3.3 Idea Generation
- Possible ways to implement the game elements.
- Possible ways to transfer knowledge

1.3.4 Concepts
- Description of three possible concepts
- How do the concepts suit the training needed?
- Which concept is the most suitable for the training?

1.3.5 Final Concept
- A walkthrough on the gameplay in the final concept
- How does the final concept meet the ARCS model?

1.3.6 Conclusion and Recommendations
- A conclusion on how the final concept worked
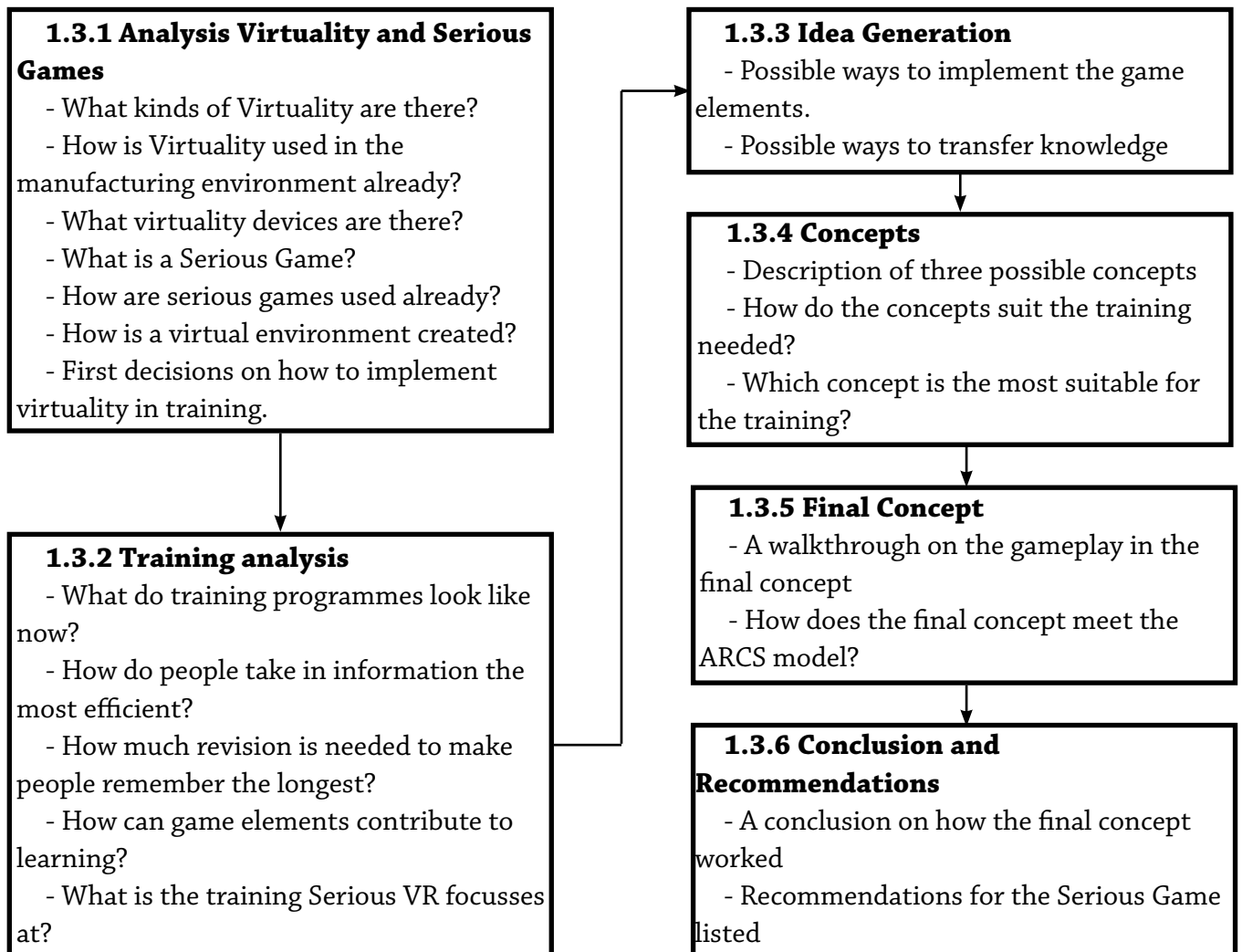- Recommendations for the Serious Game listed

Fig 01 | Figure showing a flow chart in which the method is explained

1.4 Definition list

The new employee = a new employee with LBO or MBO level education that has to be trained

The retiring employee = the employee that has all the knowledge about the machines and is leaving the company.

The target group = the companies who need a way to transfer their knowledge to the new employees

The knowledge to transfer = knowledge and skills about regular usage of the machines in production companies and when uncommon errors occur

Serious game = a game through which the knowledge is distributed to the new employee

Virtuality = the different kinds of a seperate reality. Virtual Reality, Augmented Reality and Mixed Reality under one name

VR technology = technology used to create a virtual depiction of the reality in the company

Virtual environment = the environment in the production company simulated in a virtual environment. This environment is where the training takes place

The final users of the product = the new personnel that has to be trained to use the machines

1.5 Abbreviation list

VR = Virtual Reality
AR = Augmented Reality
MR = Mixed Reality
VE = Virtual Environment

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2. Virtuality and Serious Games

There are different types of virtuality: virtual reality, augmented reality and mixed reality. Virtual reality can fully immerse the user, whereas augmented reality transports virtual aspects in the real world. This chapter will look at these different uses, how they are already used in manufacturing and how virtual worlds are built. Next to that, serious games will be analyzed, from the definition of a game to how serious games improve learning.

2.1 Virtuality

Virtuality is the umbrella term used in this report for Virtual Reality, Augmented Reality and Mixed Reality. All create a virtual environment, but they differ in how much immersion they allow the user. All do make use of virtual elements in an environment.

Virtual Reality

Virtual Reality (VR) is a depiction of a world that allows the user the feeling of presence in that world and in which he can interact with objects and people in that world. It is a virtual environment (VE) created to simulate this world that people have come up with. The ability to interact in this virtual environment makes the user a part of that world and he becomes immersed in it. [2]

An important part of a realistic VE is to create the feeling of presence. Presence can be perceived by the user when the environment is realistic enough, when it allows the user to have the feeling he is completely present and his actions change the environment. According to Steuer, presence can be created by providing the user with interactivity and the vividness of the virtual environment. These are important to provide the user with presence.

There are different types of virtual environments which differ mostly in how immersive they are. The least immersive is the world in which the user is not simulated, but merely transported through words. In these *text-based virtual realities*, the user is writing his own world and this world can be shared. In this environment multiple users can take part and a forum can be built to contribute in it. In these worlds only text is used to describe the actions and the world around it. An example of this text-based

reality is the game *Colossal Cave Adventure* designed by Will Crowther [3].

Virtual realities in which the user is fully transported to the VE, *(immersive) virtual reality*, are the most immersive. Here the user sees around him only the virtual reality and the user's interactions all have influences in that reality. This virtual reality can be seen all around the user by wearing a head-mounted display. When the user then looks around, the VE turns as well. This way the user can view the world all around him as if he were present in this world. This is less the case with *on-screen VR*, since the user has to turn the camera by for example pressing a button. The actions are displayed in this world, but not literally.

An example of this immersive virtual reality is for example the training simulation in the army RE-liON is working on [4]. The user is wearing a *Blacksuit* and is completely equipped with sensors, so the movements are literally translated into the game. VR glasses are placed in from of the eyes to show the user what is happening in the virtual world in which his movements are simulated. Even the gun contains sensors to allow the user to shoot in the game and simulate the aim of the user. This way the user is fully transported into the virtual world and all movements are simulated.

Augmented Reality

Augmented Reality (AR) is the addition of virtual elements in the real world. Although it is not virtual reality, it does provide the user with virtual elements in the world, so it adds useful information to the world. The VE is here a layer over the real world. Here images and options are added to the world to include more information in the world. The user is not transported to another virtual reality, but adds the layer by using VR

glasses or another camera. This way digital information about the world around you can be shown as if it were there.

Augmented Reality has been explored by Google when they were working on *Google Glass*. With this glass, they added digital information to the real world. With Google Glass, the user is able to scan locations he is looking at to see what the location is, advertisements can be scanned and immediately results can be found on the internet to get more information and movies can be watched any time. The glasses also gave the user possibilities like watching a movie and filming the environment at all times. These options made the Glass also an alternative for a camera or smartphone. [5]

Mixed Reality

There is also a combination of VR and AR which is called *Mixed Reality* (MR), which combines the advantages of both kinds of virtual environments. In this type, objects and complete virtual environments are shown in the world around you. The user acts in the real world, but interaction is possible in the virtual objects that are presented through the virtual world. The user is here wearing a head-mounted display too, but the difference between this one and the Virtual Reality display is that the real world is still shown with the addition of the virtual elements. It goes further than Augmented Reality, because there is more physical interaction possible with the virtual objects. [6]

An example of this Mixed Reality is the new Minecraft game that is planned to release in 2016 [7]. Minecraft is working on a new version of the game where the created world in Minecraft is transported on a table. Through a HoloLens the Minecraft world is displayed and you can move the world

around and interact in it. You even see the interaction other players in the world have and see their avatars moving around.

2.2 Virtuality in the manufacturing industry

The manufacturing industry has a lot to gain from virtual reality. There are multiple implementations of virtuality used for training, manuals or engineering. Listed below are a few examples of applications.

EYESIM

EYESIM creates an immersive VE of a power plant in which the user is placed. The user is depicted in this environment as a player of a game. The simulation is still an on-screen virtual environment. In this simulation, errors occur and the player has to fix the errors accordingly, so the error is fixed and the power plant can continue working. In the virtual environment, possibilities for interaction are lit up to attract the player's attention. This shows the player what his possibilities are to fix the problem in the virtual reality. The interactions are in this game not visualised, only the possibility to interact. The player does have the feeling he is the character in the game. [8]

COMOS

COMOS Walkinside looks like the EYESIM simulation, because they both create a VE in which the user is walking around. Both are on-screen virtual realities in which the environment is built like reality. The difference is that COMOS added the mission element to train the user. The user has got a few tasks listed on screen which he has to accomplish. If these objectives are completed before the time runs out, an additional objective is accomplished. The use of listed actions makes the training

something through which you follow an instruction guide and does not allow the player to find out how it works on their own. They do have the possibility to make wrong choices though. The actions that are done are simulated by the sim. This differs from EYESIM, where you do not see the character you are and the actions are not shown. COMOS does allow the player to work together with his colleagues. [9]

ESI

IC.IDO is the 3D Immersive Product Experience developed by ESI. This creates realistic virtual depictions of objects and the user can interact with these objects. Because of this technology, there is less need for prototypes, since the prototypes can be made virtually and the parts can virtually be assembled to see whether it will work or fit. This reduces the time needed to create a prototype and a lot of information about the feasibility is gained. To use this technology, the user wears glasses which follow the gaze of the user and a remote which is used for the interaction with the environment. [10]

EquipCodes

Augmented Reality is applied in the maintenance application of *EquipCodes*. A tablet is used to look at an object and on the screen of the tablet a depiction of the product is shown with information about the product and what actions should be done to fix it. This technology really helps during the maintenance and shows the user what has to be done and in which order. It does not necessarily train the user, but it equips the user with the knowledge that he needs for the action. The interactivity with the virtual environment is very low, since there is not really a VE created. [11]

These are just a few examples of VR used in the manufacturing industry. In figure 02 the examples have been ordered from virtual reality to augmented reality. Serious VR aims to be on the left side of this chart. These examples show how it can be used differently for training and as a support while working at the assembly, reparation or production. Augmented reality and virtual reality are both used for the training, but virtual reality has only been used on-screen. There is space for virtual reality to be used for training.
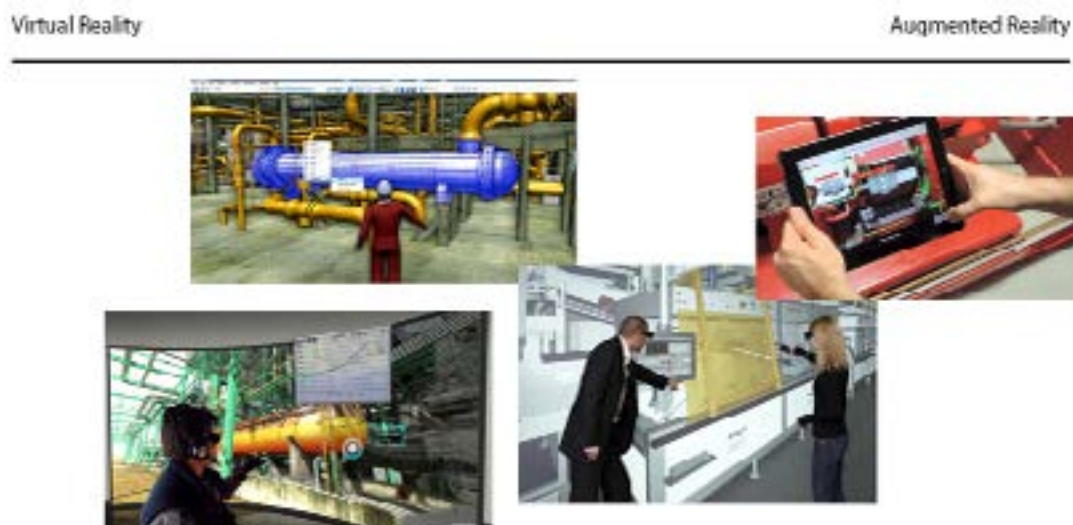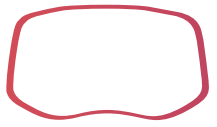

Fig 02 | The virtuality uses in manufacturing industry placed along the virtual reality - augmented reality line. From left to right: EYESIM, COMOS, ESI and EquipCodes.

Why is Virtual Reality useful?

Virtual Reality can become very useful when used as a tool for training. It has the ability to be used to transport people in an environment and give the impression of being there. VR is very effective in gaining experience and creating situation awareness. The added aspect of VR is that the user can train in the environment, while not being there. To achieve this, the user has to feel present in the VE. Situation awareness is defined by "(I) experiencing the plant and its units, (II) comprehending their meaning and purpose and (III) learning how to project the current status in the near future." [12]. Using VR, people are looking at the environment before even working in the real factory and they get to know the place and its possibilities before working there. This way, employees are already familiar in the environment and they do not have to discover it, which makes working more efficient from the start. It also raises their confidence, since they already have experience in the factory [13]. In this study, 100% of the users felt an increase in confidence and 55% even felt a strong increase.

The employees get to know the factory this way but also gain more understanding of the consequences their action have. By trying out possibilities, they see the consequences their actions have. Furthermore, the trainee can increase their skills without decreasing the production or damaging the real environment. This also increases their understanding about the machines and gives them insight in their actions [12]. By gaining this knowledge about the maintenance, it is better understood and can be done more accurately, which decreases the incidents in the factory. Also the safety in the factory becomes better organised, since in the virtual environment danger to the human safety can be depicted, which teaches the employee about his own safety, without real danger being present. This is good for the company, since less errors result in higher production and increased safety results in less employees at home due to accidents. And human errors are one of the most common causes of incidents, accidents or dangerous situation [12].

The understanding of faults educates the employees about the faults, but also how to recognise the faults in the future. This is the main task of a VR training, because this is one of the unique things VR training can offer. This creates knowledge the users can use to reduce the risk of the fault in the future, because, when they see a sign, they can interpret it as a signal that something could go wrong.

Getting to know the environment, learning what actions mean in this environment and understanding what is happening before actions are needed, are unique experiences that can be trained before the employee is even in the real environment by using VR training. This knowledge can be taught to the employees the conventional way, but learning by experiencing and doing is much more effective. [14] And this learning can be done while working in the real environment already, but by teaching the new employees in a separate environment, faults can be made and this has no impact on the real environment.

2.3 Virtuality Headsets

As VR becomes more present in the world and the use of virtual reality becomes more apparent, the market for VR headsets becomes larger. There are now multiple VR glasses on the market or soon being implemented. Below are the most important ones listed. They are divided in headsets, which are devices that transport the user to a VR environment, mobile headsets, which can only be used by attaching a mobile phone to it, and augmented headsets, which show the real world with virtual elements.

Headsets

Fig 03 | HTC Vive

Fig 04 | Oculus Rift

HTC Vive [15]

The *HTC Vive*, by HTC and Steam, is a very immersive headset and it tracks the user very well. Not only the movement of the head is followed, but also the position in the chamber is followed by the position trackers that are placed in the room. The HTC Vive also has two controllers with it that allow actions to be done and tracks the movement of the hands. The refresh rate of the HTC Vive is 90 Hz, which is enough to extinguish motion sickness. A disadvantage of the HTC Vive is that the headset always has to be connected to a computer and the sensors have to be placed in the room, but the successful room tracking makes up for it.

Oculus Rift [16]

The *Oculus Rift* started as a Kickstarter and it was at the base of the enthusiasm for VR headsets. The Oculus provides the user with positional tracking and therefore the possibility to move around. It is also connected to a computer and late 2016 controllers for the Oculus are coming on the market. The refresh rate is 90 Hz, which makes it as good as the HTC Vive. The connection to the PC makes the vividness of the game very high. The Oculus works with two screens, one for each eye, which are slightly different to create depth.
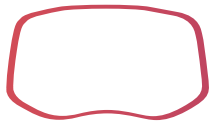
Fig 05 | Playstation VR

Fig 06 | FOVE VR

PlayStation VR [17]

Sony will release the *PlayStation VR* at the end of 2016. It is connected to a PlayStation and also provides two controllers to let the user interact in the game. The sound system of this VR headset will be better than others, so it could provide more vividness to the world. To do away with motion sickness, the refresh rate of the PlayStation VR is 120Hz which provides a very lively image. The connection to a PlayStation 4 instead of a PC makes it necessary for this headset to provide this refresh rate. The positional tracking is made possible by the 9 LED's on the headset.

FOVE VR [18]

The *FOVE VR* headset is unique to the headsets, because it has eye-tracking implemented. An infra-red sensor tracks the eye movement and makes the image the eye looks at more realistic than what is around it. This makes the eyesight in the FOVE also more realistic and it claims to be coming with positional tracking as well. FOVE is not yet on the market.

Mobile Headsets

Fig 07 | Samsung Gear VR

Samsung Gear VR [19]

The *Samsung Gear VR* is a headset in which the Samsung Galaxy is placed. It is merely a case for the mobile phone. Because this headset is powered by the Samsung Galaxy mobile phone and not a PC, the quality of the screen is only as good as the Samsung Galaxy. The advantage is that it is a cheap alternative for the expensive VR headsets. Another good thing about the headset is that it has buttons on the sides to adjust sound and brightness.

Fig 08 | Google Cardboard

Google Cardboard [20]

Google bought a very cheap alternative for VR headsets on the market with their *Google Cardboard*. The Cardboard is a foldable VR headset made of cardboard and can even be made yourself. It basically only contains a mobile phone and has two holes in it to look at. The screen is split in two, slightly different images to make the 3D experience. Unlike the Gear VR, the Cardboard does not provide any other functions. The mobile phone already has the technology to make rotational tracking possible. The most important advantage of the Google Cardboard is the price.

Fig 10 | Headsets along a virtual reality- augmented reality line. From top to bottom: Samsung Gear VR, Google Cardboard, PlayStation VR, HTC Vive, Ocuclus Rift, FOVE VR and Microsoft HoloLens.

Augmented Headsets

Fig 09 | Microsoft HoloLens

Microsoft HoloLens [21]

The *Microsoft HoloLens* is developed by Microsoft and currently only available for developers in the United States for $3000. The HoloLens creates new possibilities in the real world, like a new TV screen, interactive Skype and games. The difference is that the feeling of presence does not really have to be created, since you are interacting in the real world and there are only extras added. These extras are placed in a way that they could be realistic in the world around you. The HoloLens recognises hand commands. The unique thing about the HoloLens is that it is a fully independent Windows 10 PC and there is no connection to a PC needed.

In figure 10 the different headsets are shown in a chart and they are measured to see how they position themselves on the line between virtual reality and augmented reality.

At the start of this chapter, examples of virtual trainings in the manufacturing industry have been shown. These virtual trainings look already a lot like games. In the following part, the definition of a game will be described and what a serious game is, a game with which someone is trained.

2.4 Serious Games

Games designed to improve an aspect of learning are called serious games. This is an application of games and simulations to a non-entertainment domain. This way the game is mainly used for another purpose than entertainment, since it also educates players. To fulfil this educational and entertaining part of a serious game, the game designer always has to keep the result of the game in mind. The main focus of a serious game is education, but since play is an important aspect in learning and developing yourself, this is included to improve the education. And this inclusion is the difference with a game, which does not add an intent to learn something to use in real life.

A game is not so different from learning, say Salen and Zimmerman [22]. They mention that a game is like a logically designed and meaningful play, which is very much like learning. Meaningful play is what they say happens when the interaction between actions and consequences is implemented in the complete game. This shows the player the results of their actions and teaches the player that actions are not without consequences. The study of Mary Jo Dondlinger shows that games do motivate players to spend time on mastering the skill that is being trained [23]. For some learning outcomes, adding design elements even seems necessary to reach the desired education.

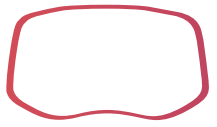### What kind of serious games are there?

Edugames or *edutainment* are games that try to send knowledge through a ludic game style. A small game is made and during the game, ludic information is transported to the player that teaches about the topic of the game. Often these games have an arcade-like feeling around it. An example of an edugame is *EcoQuest*, this is a point-and-click game in which the child Adam meets sick animals, who tell him about what happened to them due to littering people. The player gets to know things about the animals and about the effects littering have on the environment. [25] [26] [27]

Advergames

Advergames are created around a movie or product that is being advertised in the game. This is done by creating a game with for example the main character of the movie as the playable character of the game or showing the characters in the setting of the game. A product can be used as the prize in the game, which makes the product look as something worth winning. An example of this type of game is *America's Army*. This game is a shooter game in which the player is a character in the US army. The player does not only get to know the army and be triggered by that, the US government also recruits some of the best players in its army. This makes the game far more than a tactical shooter. Besides teaching the players about the army, there could even be other real-life consequences.

Activism games

Activism games or *Political games* are games which bring understanding about a current problem and activate people to take action. By showing the person what is happening in

real life nowadays, the player takes a critical look on the solutions that are implemented today or at his own regard towards the problem. Nowadays a good topic in the activism game would be a refugee camp just outside of Syria. By creating a game about this, the fear and current organisation in the camp can be shown, which might change the way citizens look at incoming refugees in their home country.

Edumarket games

Edumarket games have as their main focus to distribute the message of a certain company and to convince the player the company is doing great work. This makes edumarket games a combination of, for example, advergames and edutainment. Lots of aspects are added in this game to show the meaning of the company and what is stands for. An example of this game is *Food Force* in which the player runs the organisation United Nation in 6 mini-games. The goal of this game is to tell the people about what the UN does and to let them know it is important. This makes the UN a more respectable and understandable company.

In a *simulation game*, the real environment is mimicked very precise. This way players can train in the situation that is being simulated and the player gets to know the situation and understand its meaning. An example is *Flight Simulator*, where the player is flying a plane and learns how to take off, fly and land all in just a simulation. In this game there is a lot of freedom, like in the real world, and there is no clear objective stated.

Some of the serious game categories listed above do not have added value when it happens in an immersive virtual environment. Advergames could gain value because the immersion can make people even more excited about for example the

main character of the movie. America's Army is an example of the game, which could make people even more excited about the army when it was an immersive virtual reality experience. Activism games could create more understanding about the environment and increasing the empathy for what is happening, when it is an immersive game. The training and simulation games do gain value when a virtual environment is added. This allows the users to really experience the place and get used to it, while it can be made attractive by implementing a game in this environment. [28] In figure 11 the applications are shown to see whether the application of virtual reality is useful in the type of serious game.

2.5 Creating a virtual environment

The virtual environment that is created for a training simulation has to represent the real working environment. This can be created in a CAD program to illustrate the world in a 3D way. This environment is better when it is built as a high-realism environment [30]. The users have a better feeling of being present in the world. Using high-realism does require a stronger PC to run it properly though. To make up for the high-realism interaction environment, the background can be made less realistic. The user does not have to interact with this, he just has to feel present in the world. High-realistic products in the world were preferred by the users in the research of Thalen, because those products provided more feedback and the users knew better what the product was and how it should work

and what interactions were possible. In this research, users were arranging a print shop using virtual reality. A difficult part of this is to add behaviour in the world.

As in Thalen's research, the retiring employees could here help in the design of the game. When in the world, they could demonstrate the interactions and these can be saved. However, the research also mentioned that it is difficult to implement behaviour while being in a virtual environment. Stefan Wagner has created a virtual environment in which he can change the environment as well while playing the game. [31] But this idea required the player to understand the programming language, because that is what is used to change the world. This is not suitable for the retiring employees. They should just give their knowledge and a programmer can then put
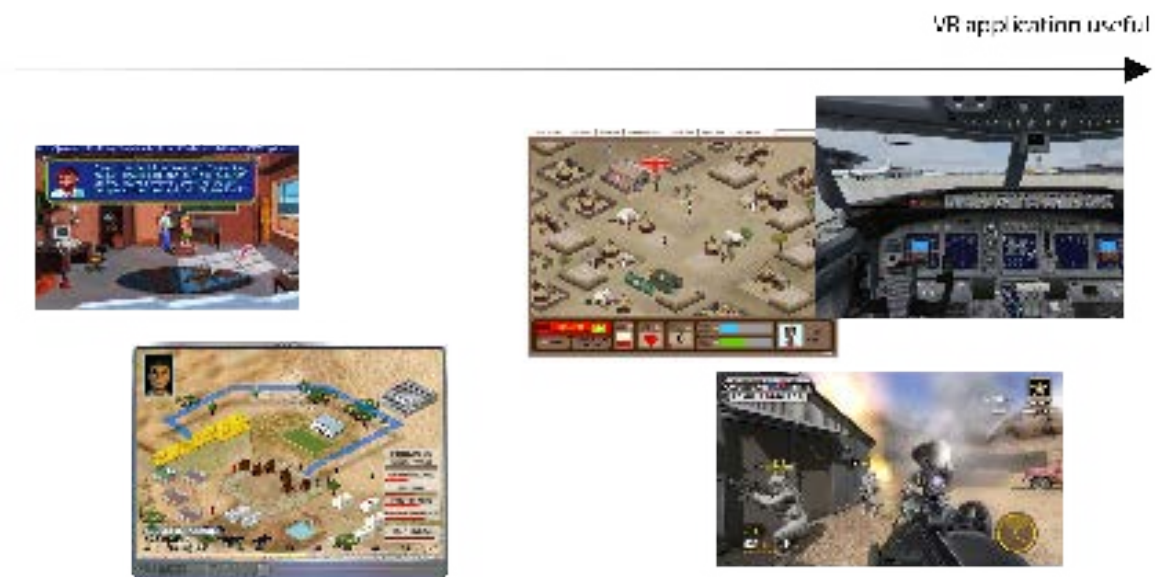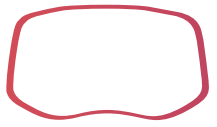

Fig 11 | The serious games mentioned ordered along a line of VR usefulness. From left to right: Edu-game (EcoQuest), Edumarket game (Food Force), Activism game (Darfur is Dying), Advergame (America's Army) and Simulation game (Flight Simulator).

this information in a game.

To make a virtual environment for a training simulation, 3D objects have to be implemented, which have a mass, are realistic, moveable or adjustable and have interaction possibilities. These are the core of the training, since the trainee has to learn to use these objects and how to control them. This is the biggest part of the virtual environment, the creation of the objects in the environment. The objects need to be built realistic, so that the user learns the ins and outs of the object. And to make this happen, the object also needs to have all interaction possibilities the real object has. All moveable parts in the object, have to be translated into the virtual world. Constraints have to be added, to make the adjustments as realistic as possible. This requires a lot of insight in the object, so the object has to be studied carefully before rebuilding it. Sometimes there is already a 3D visualisation available of the product, which would make the creation of the virtual environment a lot easier.

Next to the object, there are other things that have to be added in the virtual world. Tools can be added, so the trainee knows what tools are needed to perform his actions. In reality he then knows what tools are needed, to get the required result. Also sound, surroundings of the workplace in the environment, other employees. These things help to make the space realistic and give the user an idea of what to expect in the environment. The surroundings could be less realistic, because they are not what the focus is on, but to add them would be a good addition.

And an additional aspect of the virtual reality simulation could be the results of actions. When the trainee executes an

action, the results of this action could be simulated. This gives the trainee more insight in what reactions can be triggered and how he can prevent this in other situations. It makes sure the trainee is trained to be an expert.

2.6 First outline Serious VR Game

Virtuality choice

Virtual Reality or Augmented Reality

For a training programme there should be looked at both virtual reality and augmented reality. Both allow the player to learn working with the machines. However, there is a big difference between them. Augmented reality focuses more on guiding the user. The user wears his augmented reality glasses and sees the normal world and is guided in this world by for example arrows. The user follows the instructions given by the glasses and then completes his job. Virtual reality can also give the user instructions to let him complete a job, even though this does not happen in the real world. But in the case of VR, the user learns how to do the job and still has to do this in the real world. AR makes sure the job is immediately completed, VR needs more time to be effective in the company.

Even though AR gives immediate results, this is not necessarily the better solution. The user is guided by AR, but can also become dependent on it. This does not teach the user how to work with the product, but only follows its instructions. This means AR can hinder the user to become an expert, because he has no understanding about what he does. VR gives this expertise. In a virtual environment, the user can make all the mistakes and has full control over his actions, within the limitations of the VE. By making mistakes and seeing the results of them, more understanding of the environment is created. Though the training takes more time, the user knows what he does when he has finished his training.
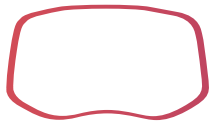
Also the employee is challenged when working in the company after a VR training. The employee tries to use the knowledge he has acquired and implement it. When AR is used in the field, the employee has no challenge when working and is just following orders. He could also become bored when doing this and this results in a less productive employee. So for Serious VR, virtual reality is more suitable.

The VR device

The VR training of Serious VR should use the HTC Vive. The quality of the graphics of the Vive is just less than the quality of the Oculus Rift. But the quality of the images is not the most important aspect of a training, so therefore this can be a little less. This is because in Thalen's research, it was not the most important to have the highest realism, just high enough to create the feeling of being present. The quality the Vive has is still very high. And the Vive makes up for this with its very good positional tracking. Positional tracking is an important part of the training, because the training should be done like it is done in the real world. Because the machines are big, it is important that movement is well tracked. Above that the hand movements also have to be tracked precisely. The Oculus does the tracking now still without controllers, which makes the coordination more natural, but the tracking with the controllers of the Vive more accurate. Also the controller might not allow the user to do the handling like it would be done in the real world, but the gross movement is shown and the user already knows how to grip a handle or hold a screwdriver. Therefore there will not be much education lost when using controllers.

When using the HTC Vive and Oculus Rift, there is also a difference in realistic manoeuvring. When trying to grab something that is far away, it feels unnatural

in the Oculus, like you have to move too far to finally reach something. The movements seem to be restricted when doing them. This feels more natural in the Vive, where the actions feel more similar to actions taken in the real world. This also makes the Vive more suitable, since in the training there is a lot of interactions needed and these have to feel realistic for the user, to also create a feeling of presence in the user.

The PlayStation VR has an even higher refresh rate at 120 Hz, where the Vive has it at 90 Hz, which makes the view even more vivid. As mentioned with the Oculus, the view does not have to be very vivid, but the tracking of the movements is more important. Therefore the Vive is more useful. The FOVE also has this problem and does not even provide positional tracking.

The mobile headsets are by far not as useful in professional use as the Vive and Oculus. These devices are useful when used by consumers who want to experience VR for a cheap price. They do not provide positional tracking, only rotational tracking. And above that, movements cannot be mirrored in the virtual world, because there is no hand tracking to follow the movements. The mobile headsets are not useful for this training simulation.

The augmented headset Microsoft HoloLens is useful when the user needs to be guided. But the training here should train the users to work in the company, without having to guide them all the time.

Even though the devices mentioned here are working with controllers to track the movements and interactions of the hands, the training will not lose its purpose. The training is focussing on the trainees' knowledge about the machines and how to interact with it, but for this purpose, the

complete translation of hand movements is not necessary. It does contribute to the immersive feeling in the simulation. There is a possibility to switch to this in the future, when this is cheaper and better worked out. Manus VR is already working on such a glove to support the HTC Vive [32]. Gest is also creating a device that tracks hand movements and translates these into actions [33].

Virtual Reality test

During a test with people who were trying out the Samsung VR, a few troubles came up. This test was during the event The Future of High Tech and people had the chance to try out the Samsung VR and look around in the virtual environment. They donned a Samsung VR glasses and a headset to fully immerse in the virtual experience. The users could look around 360 degrees, but there was no possibility to move around. In the virtual environment, the players were starting outside an elevator. After the intro talk, they moved inside and the elevator went up. The walls disappeared and the user saw three different environments on three different floors, respectively, grasslands with a farm, the inside of a futuristic apartment and a harbour. In these environments, diagrams appeared all around to explain what was could be improved inside the area.

The users knew immediately how to put the device on their head. Sometimes they put on their headphones first, but overall, they put the glasses on first. During the session, the people were standing and moved their head around. Because they wore headphones and glasses, they were fully transmitted into the virtual environment. Some people did not realise they could completely turn and kept their head still. It shows how important

it is to explain what the possibilities are, so the user experiences it fully. Besides that, there were some people who wandered off, not because they thought they could walk, but because they went off track while turning around. Overall most people put a hand on the table, to orient themselves. Because the environment is shifting and the user himself is standing still, this lead to some people feeling like they were moving as well.

The difficulty with the balance is already mostly gone in the HTC Vive. The main reason is that the movements of the user are mirrored in the virtual world, so when the user is moving in the real world, he is also moving in the virtual world. The trouble with the people who did not know what they could expect and that they could move around, can also easily be done away with by giving sufficient information before the simulation starts.

After the session, most people were surprised by how well it looked and the possibilities there were already with virtual reality. They were enthusiastic and wanted to see more of it. After hearing that the amount of possibilities is growing, they were surprised to hear how much interaction is already possible with for example the Oculus Rift and the HTC Vive. However, the users who already had more experience with virtual environments and had tried the Oculus, were less impressed by the session. They expected more improvements since the last time they tried it. This session was done with the Samsung VR, so the main trouble was the amount of pixels they saw in the screen.

3

3. Training Analysis

People learn the best by doing while they are learning, especially when they have to learn a skill. By doing and receiving feedback on how they did, they learn to improve themselves and apply this knowledge to do better the next time. In this chapter the most effective learning process will be investigated and what additions of game elements contribute to the learning process. In the end, a programme of requirements will be made.

3.1 How people learn

There are different types of learning that are present. [34] There is learning to do on the one hand, just mimicking what you are told and not understanding why the actions are needed. And on the opposite there is learning to understand, knowing what to do on which moment and being able to predict what the consequences are. For these different types of learning, there are different styles to achieve this. Learning to do can be easily achieved compared to learning to understand. For that you only need to mimic what you see and it is not important what the reactions are. To learn to understand, there is more time needed, because there is also more knowledge that needs to be gained. The process to gain knowledge is an interaction between the teacher and the learner using a teaching-learning process. This interaction in a certain environment leads to an outcome.

Learning can be achieved through an active approach in which the student actively tries to gain knowledge by actively reflect and do, instead of passive learning and only reading to understand. The active approach is more in line with the learning to understand. The user tries and afterwards sees the results. This is in contrast to passive learning, which gives hardly opportunity for fully realising what effects the actions have.

Learning to understand takes more time to accomplish. This is also shown in the case study by Truscott. [35] The students wrote a text and the text of one group revised and they were allowed to write it again. After the revision, these students made less mistakes than the time before. However, when both groups had to write a text again a few weeks later, they made the same amount of mistakes again. This shows that the first time, the students were just mimicking the things they had seen, which resulted in less mistakes. But the knowledge was not gained with an active approach by reviewing what has happened, which resulted in these students only learning something for the short-term.

The view on learning by Kolb's figure shows that learning is a very active approach. [34] In this learning cycle, there are four stages. Do, review, learn and apply. After the application of the knowledge, the knowledge can be used in the real life, but when it is used, the student does again and can then review what is happening too. The active approach is also supported by looking at the tips and tricks [29] [30]. These are mostly tips that focus on doing and reviewing what you have to do and why you have to do it. There is also focus on making the student aware of the importance to learn. This changes the orientation in learning, which makes the learning a positive pattern. [34] On the contrary, a negative learning attitude can be gained by only learning because a student wants to pass a test.

The importance of looking and analysing what you are about to learn and creating awareness, becomes clear in the hacks that help you memorise things quickly. [36]

Kolb's figure shows the four stages of the learning cycle: Do, Review, Learn and Apply. Within these stages there are 4 different types of students, namely Activists, Reflectors, Theorists and Pragmatists. This is shown in Tab 01. Activists are very open to new challenges, are eager to involve themselves into them and have a creative functional approach to problems, like brainstorming. Reflectors are usually standing back more to see what is happening when actions are taken and try to gain

different insights in what effects the actions have. Theorists analyse what has happened and they use theories and facts to come up with a solution. Lastly, pragmatists try out ideas to see whether the solution is working by applying whatever solution there is to see if it works. Their approach is a more trial and error approach. These four roles are different roles and a student mostly has a few of these roles in him/her. The best student takes on all these roles to come up with a solution.

This active approach by Kolb makes sure the student learns and ultimately understands. By doing, reviewing and theorising what is happening, the student is getting knowledge about the effects his actions have.

The teachers' perspective to learning also plays a role. When the teacher only wants to transmit knowledge to the student, the student gets the knowledge in a straight-forward way, but it does not invite the student to understand what he learns. The teachers should teach with the goal to change a students' idea about the topic. This will give more depth to the education.

Unlearning is a difficult part of learning where the student has to learn not to do something. Unlearning can be a long process, as the person already has an integrated idea in his mind on what he should do. To unlearn something, the idea of the action should change, the habit of the action should be taken out of the system. Trying to unlearn habits, can make the student feel unnatural, since he has to change the actions that defined him. Therefore, this should be done early in the process, so habits are not yet formed and the student is still learning to form his own identity in the place he is taught to fit in.

For a learner to take information in, it is the most useful for them to take it in small and easy bits. By starting with the basics and upgrade the basics by making the information more challenging. By asking to do tasks that the user mostly knows and implementing small parts that the player has to learn, he can increase the knowledge he knows and does not feel like he does not know anything. This way the student also knows the context of the knowledge he gains and where this can be used. [37]

3.2 How people learn most effective

To see whether the learning is effective, it is necessary to see what the goals of the learning is. Questions like "What should it be effective for?" and "When should it be effective?" should be asked. These questions shape the context in which the learning should be successful. In Watkins' article [34], there are four themes of learning cycles that promote effective learning. These themes are Active learning, Collaborative learning, Learner responsibility and Learning about learning.

- Active learning exists of an interaction between the student and material and persons, by active reflection, enquiry and sense-making. The reflection part is important, because otherwise there would be less learning to understand. Students rate research, group work, practical work and discussions as twice as effective as copying, answering questions and dictation.

- Collaborative learning results in a better understanding by working together in groups. These groups are trying to gain an understanding and help each other gaining knowledge. This is done by explaining what

you think and by looking at the problems together from different points of view.

-    In learning responsibility, the students are aware of their role in their learning. They know why what they learn is important and this makes them more engaged. The responsibility increases how much they like the learning and the motivation and effort they put in it.

-    Finally, learning to learn is when the student looks at what knowledge they gain and in which way they gained it. The learning becomes more reflective and strategic and there is more improvement in the way they learn, which results in more effective and personalised learning next time.

These elements or themes can be used in the learning cycle on their own, but if the learning becomes the most optimal, then all elements are present. This results in the most effective learning to understand and results in an education for an expert.

3.3 Young and Adult Learners

There are a few crucial differences in learning styles between a young person and an adult. Adults want to have more power when they are learning. They want to have a say in what they are taught and in what way they learn this information. A reason for this could be that they have life experience already and have learned things before. Therefore, they have an idea what works for them and what knowledge they lack in the world. Young people have this goal oriented learning less. They see learning more as a process in which they are told what to do. They need to be disciplined by a teacher, whereas an adult disciplines himself. They
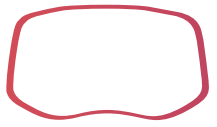
want to have fun during learning, so they keep motivated. Since young learners also do not see the goal they are working on as clear, they need motivation to stay focused and learn.

Both young and adult become motivated when they know the information they receive is relevant in the real world. Knowing that they can use the information in the future and being taught in the environment where they can use this knowledge, increases their motivation. And building further on that, they both learn best through experimenting with the knowledge they gain and using this in the environment. Also group activities stimulate the learning, since the learners are forced to think about the information they receive and how it is suitable for them.

In this report, the focus will be on young employees. In the most production companies, experienced personnel works already for a longer time there. They occasionally need training as well, but to limit the focus in this report, the focus will be on young employees. These need to learn everything, from the basics to the understanding, so the training has to cover all this.

3.4 Design of Training Programmes

There is a training programme for risk assessment and fire prevention. [38] They call a few strengths of the training: The content is relevant, they were specifically developed for that context, there is general information and a possibility to adjust this to the site and they take little time from the employees. They use a combination of videos and safety talks to train the employees. The videos are shown in large groups and then

the groups are divided to do the safety talk in smaller groups. Showing an instruction video is a passive way of distributing information and they try to make up for this by doing the safety talks, where they ask questions to the group, which forces the group to participate actively.

Tooling U-SME creates trainings for how to behave and what to do on the job. [39] They have a few samples to show what kind of trainings they offer. There are differences in freedom and storytelling and the game methods differ. The first sample is a storytelling training, where the player is asked questions about what decisions he should make during his job. The questions are replies to a certain situation he has to deal with at work. After choosing a reply, the player gets feedback on whether he made a right choice. The second sample is a training in a production company as shown in figure 12. There is a tutorial on lubricants, a certain topic the trainee still has to learn about. The player is given an avatar, a new employee in the factory and receives his training in the factory. The trainee now sees the work floor, while he is asked questions about the topic he now has to learn about. There is more freedom in this sample, since the player can move around to answer questions about different machines. The last sample gives the player full freedom. The player can use all the buttons on an interface. In the sample it is not clear what the player has to do, but when a goal has been set, this could provide the player with a lot of new ideas. The feedback also is not sufficient now, since it only shows whether the player pressed the right button or not. There is no feedback on what happens when you press the button you just pressed.

The lack of freedom in the first simulation by Tooling U-SME, in which the player has to answer questions multiple-choice, is not a problem. The situation has been sketched properly, so the player knows what he has to do. The trainee has to think about the actions he has to take and is forced to think about this by choosing an answer. More freedom might lower the motivation of the trainee, since he has to think too carefully on how he reacts in the situation. Because the training is for such a specific situation, this training seems appropriate. The training about the topics, where the player is an avatar in the world, gives the player more freedom. Now the player can walk around and learn about the topic from all perspectives.

The Training Requirements document from OSHA shows what a new trainee has to know about. [40] OSHA is an agency that focusses on the legislation for safety on the job and provides training frames for safety. The topics in the document have been listed according to the type of factory it is for. The topics range from exit routes to toxic substances. This gives an overview on what a training programme has to include, besides training the new employee to do his job. These safety measures are secondary to the general training the employees receive, but have to be included to make the training sufficient and to teach the trainee about safety on the site. [41]

The training programmes are now a lot written trainings or interactive trainings in which questions are asked. The trainings are mostly inspired by tests, a way to show what you know and receiving feedback on that. As shown before in *2.2 Virtuality in the Manufacturing Industry*, there are training programmes which try to use more interactivity already. Those simulation

training programmes train people to do the general actions and can teach people what to do when a dangerous situation occurs.

3.6 Training on the work floor

Serious VR aims to provide training in production companies. In these companies, the new employees have to work with new machinery they have not seen before. To train them now, the new employee is put in a group that works with the machinery already. In this group, the new employee is taught what actions to do by his fellow employees, since they are experienced in the use of those machines already. By being told what to do and trying out the interactions, the trainee is taught what to do. The new employee is ready to work in the group after one week. Then he understands what his role is in the group and can work with them. However, an employee is an expert in the field after 4 more years. Then they have experienced everything and know how to react in every situation.

To help the workers, there is an instruction paper or booklet next to the machine. If anything is unclear, they can look at the instruction to see what needs to be done. However, this is merely a summary of the interactions that have to be done and in what order. There is no explanation on what the machine does and what the important parts of the machine are. These basic actions are also easily learned. This is also what the trainees learn first during their training. But learning what actions are the most efficient, making the right choices and seeing the problems in a machine, there is more experience needed. This also requires a more detailed virtual environment for the players. The problems have to be constructed in a way that the employee can recognise the problems also in the real world. These details are important for the training, because otherwise there is only a basic employee trained and not the start of an expert.

In the environment there are four types of scenarios which are to be trained:

-    Operational training. This is the training which consists of the basic
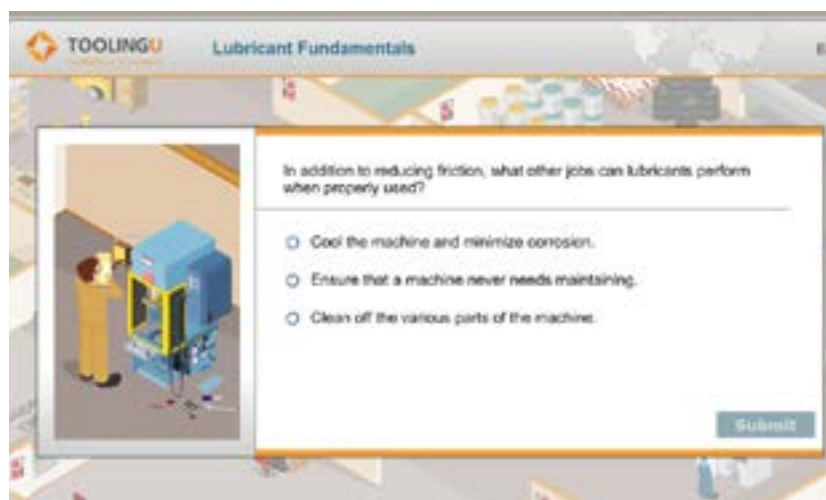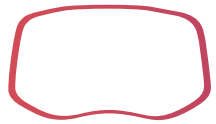

Fig 12 | Image showing the second sample of a training simulation by Tooling U-SME.

interactions in the environment. These are the regular interactions needed to keep the machine working and doing its everyday routine. It is also the perfect scenario, because in this case, nothing goes wrong.

Operational training is now done by putting the trainee in a group that teaches him all the basics on the job. The instruction paper provides also information for the training.

- Operational incident training. This training focuses on a problem that occurs in the machine or around it. Something goes wrong and action is needed to make sure the machine can continue to run again. It is important that this is done quickly, so the production time does not go down.

Operational incident training is also done in the group. When something occurs, they are taught by the experienced employees what to do, since they know what is happening.

- Maintenance. Every now and then the machines have to be checked. Since they are put under harsh circumstances, extreme heat and pressure, the machines need to have regular maintenance. This maintenance is done to prevent the machines from breaking down or repair them when they are broken down.

Maintenance is now trained by teaching the people about the machine through education and a manual.

- Safety. This is done to prevent the employees from getting in dangerous situations. When there is a fire for example, the employees are taught what to do in dangerous situations.

Mostly the employees are told what to do by speech and they do not have a training of some kind. A few times a year, they have a walkthrough in the factory and are told what

to do by the person responsible for safety.

4

4. Idea Generation

The game characteritics which are used to create a game have been explained. Important characteristics which help in teaching the player and keeping the player motivated have been shown. Also the elements which keep a player attracted to the game have been mentioned with certain possibilities. From these ideas, the concept are shaped. The different ways to transfer the knowledge into the game have also been shown.

4.1 Game characteristics Serious VR

Game elements have been used and the view that could be held regarding the game element. There has been made a distinction between elements that are important for Serious VR and that are not. Some are important, because they have the most influence on the learning process. They are needed to have the player understand what they are learning and for what purpose they perform certain actions. This idea generation is not included due to confidentiality.

Unlearn actions

Within the working environment there are limits to what an employee is allowed to do. Around machines there are safety measures to assure the safety of the employees. For example when employees cannot get too close to a machine to prevent him from getting hurt. Within the game this can be done by adding game elements to teach these rules. There can be game punishments added to unlearn these actions.

-1 Life		-10 seconds	restart scene
Push back	Retry action	Shaking	Red screen

Tab 01 | Table showing possibilities to un-learn an action.

The three examples above are very game based punishments. They have a lot of focus on the game and not necessarily aim to teach the player. The punishment does not allow them to better their actions. The restart scene does allow them to retry, but it is not focussed on learning that particular action, but rather on punishing the player for a wrong action. This does however teach the trainee that there is a punishment for the action and punishments help to unlearn an action [45]. When the focus is on winning the game, they will unlearn these actions to get the best results.

The examples in the lower row of table 01 are more focussed on making the trainee understand what they do wrong. They get the chance to redo their actions and this way they immediately know what they could have improved on their performance. Instead of having to do the whole scene again, they get the chance to improve at once. When they get the chance to improve immediately, the effect of learning could be less, because when corrected, they can very fast continue and do not have to dwell and reflect on what went wrong. It is better for the trainees to understand what they are doing though. When given feedback on their actions and given the chance to improve, they get the feeling they are improving on the spot.

5. Concepts

Three concepts have been defined, built from the ideas in the previous chapter. The concepts are based on the different roles in the learning cycle and the game characteristics have been added to create a game. Concept Doing focusses on the Do fragment, concept Choosing on Do and Review and concept Understanding on Review. The game elements have been filled to keep the player motivated. After seeing the different concepts, they will be compared to each other and the most suitable parts of the concepts will be looked for.

5.1 Concept Doing

This concept is oriented on the way people learn to do. Certain parts of the concept are depicted in figure 13 and the gameplay is explained in the flow chart shown in figure 18. The goal of this training is to create employees who know what to do at which moment, but who do not yet fully understand the impact of the actions they take. They will learn to understand later during their working hours, but during the training they do learn how to react in certain situations and what their regular working activities are. They are trained on their regular actions and learn the order, there is less freedom to choose what action to perform.

In this concept the world is consisting of the environment, in which small levels are available to play. In these small levels, a specific part of the world is depicted and a training scenario in there is the level to complete. The environment is divided in small areas, in which different kinds of trainings are available, like the regular trainings about their everyday actions and safety trainings like a fire escape. While playing these levels, they unlock new difficulties for these levels and they unlock new scenarios to play in these areas of the environment. By completing a game, points are rewarded. The rewards are higher as the levels become more difficult and advanced. Through a score table, the players can measure their scores to other players and try to keep up with their opponents.

By using this score table to motivate players, the players are focussed on the fundamental part of the training, doing the actions right and in the right order. Whether these actions are the most beneficial does not matter, only whether they perform the

Fig 13 | Ideas from Concept Doing pictured in screenshots.

actions well enough to get their points. They are already awarded for just doing simple actions, which leads to a higher score.

In this concept, rules are very important for guiding the players through the game. The players are simply performing actions in order and need to be taught the order by not allowing other interactions. This is the only important rule, to do the actions one after each other. These are the limits the players have. When they perform actions in a wrong order, they get a punishment. To guide the players through the game and to show the possibilities they have, the options for interactions are highlighted. This way they still have to look for the right order and what to do, but they are guided in the world. It creates the basic knowledge the new employees need in the world, so they know what interactions are possible and in what order they have to be done.

5.2 Concept Choosing

The second concept is a step further than the first concept in a way of understanding what the player learns. The first is mostly focussed on just teaching the new employees to do their activities in the correct order whereas the third concept has a focus on the choices that are made within those actions. The goal of this training is to create employees who know what actions are needed at a certain time, but who do not have to understand the full impact on their actions in the environment. This is a step further than only training what to do at which moment, because the actions are checked not only if performed correctly. Figure 14 shows some of the ideas from Concept Choosing.
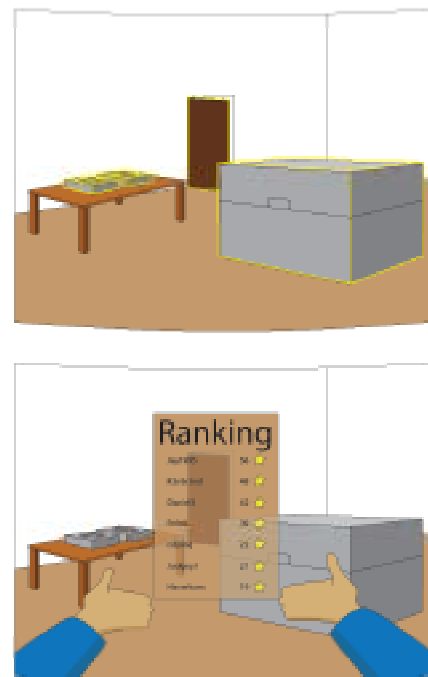

Fig 14 | Ideas from Concept Choosing ideas pictured in screenshots.

5.3 Concept Understanding

The third concept is oriented on learning to understand. These players learn to understand the environment and how to behave and react to new challenges. They become experts in the field. In figure 15 some ideas are shown from Concept Understanding.
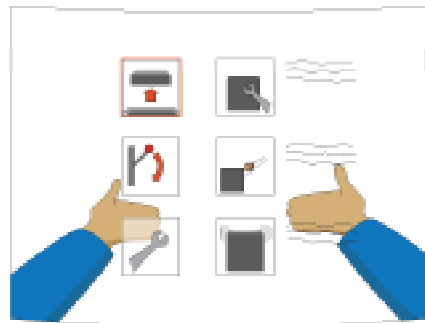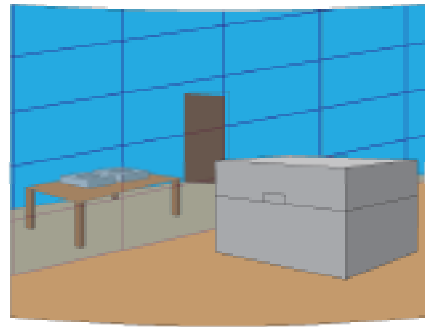

Fig 15 | Ideas from Concept Understanding pictured in screenshots.

5.4 Differences concepts

To see whether the concepts are fit to motivate the player to continue playing, the concepts and points of the ARCS model have been put together in table 02. The concepts all have their ways of keeping the user motivated. Overall, the same methods have been used in the concepts, with small differences. These differences are seen in the content that becomes unlocked and the rewards that the users receive for their actions.
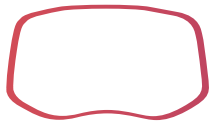
Generally, the differences between the concepts are as follows: Concept Doing trains the users to take actions and the feedback shows whether these actions were right or wrong, Concept Choosing lets the user make choices in the environment and the user learns whether he makes the right choices and Concept Understanding teaches the user about the results his actions have in the environment. There are different employees delivered by these three concepts, respectively, a basic employee who knows how the interactions work, an employee who makes the right choices in the factory and an expert who understands the full consequences of his actions in the environment.

The concepts train the users in different stages of the learning process. The training for Doing is a relatively short training. Learning how actions are placed in order, can be easily and quickly taught. Learning to make the right choices in the environment and seeing the reactions of these choices are far more difficult.

Concepts	ARCS model			
	Attention	Relevance	Confidence	Satisfaction
Concept Doing	It is kept by providing new challenges in the unlocked levels	The game is relevant as a training, because it takes place in the factory where the trainee will be working. The actions and levels also mirror obstacles to overcome in the real world	When the actions are done well, the player is rewarded with points	When performing the right actions, people gain points. Doing it faster or without errors, gives better results.
Concept Choosing	It is kept by allowing the player to improve his history and unlock new levels		The right actions are rewarded and choices that fit are rewarded too by a grade for the level	The right choice is better rewarded than the lesser choice, which satisfies the user since he becomes better at his job
Concept Understanding	It is kept by expanding the environment to give the player new possibilities		The player receives feedback from an expert employee who tells him he does well	The user sees more of the factory and when an action is done right, the user sees the environment respond correctly.

Tab 02 | Table showing how the concepts have implemented the ARCS model in the serious game.

5.5 Integration learning process

Looking at the concepts and at Kolb's learning process, shown in figure 12, it becomes clear that the learning process is not fully gone through in the concepts. Concept Doing focusses a lot on Do, same as Concept Choosing, even though the reviewing and learning part is also more prominent in the latter. Concept Understanding does focus a lot on the review part by providing a lot of feedback.

When looking at the learning cycles that have been improved for effective learning, the cycle for Active learning is the most integrated in the concepts. Especially Concept Understanding has the focus a lot on the part of making sense of what is happening. The reflection that is integrated in this cycle, makes sure the students understand what actions they are performing. This is clearly present in Concept Understanding. In this concept also the collaborative aspect can be included, which helps the players gain knowledge together. However, it is not possible to let the players train in the same environment, but it is possible to include another players' actions as a ghost player in the environment.

Concept Doing and Concept Choosing both are very focussed on the active teaching. The players are performing actions and judged by that. Concept Choosing is more drawn to the Active teaching though. Concept Doing just reflects back to the player by showing the player when something goes wrong. This is not teaching the new employee about the company in the most effective way. Concept Choosing does follow the rules of Active learning. Here the new employee gets the feedback on what actions he did and how he could improve his actions. He is not immediately punished for a wrong action, but receives feedback on how he could improve.

5.7 Conclusion

The concepts Choosing and Understanding are most suitable according to the effective training cycles. Concept Doing is suitable for the first stage of the training, teaching the new employee the basic interactions by giving the user small tasks which he can easily perform. The additional insight which is needed in an effective training, is provided by the concepts Choosing and Understanding. Concept Doing is suitable for the start of the training and the ranking motivates the players to continue playing the game. In Concept Choosing, the strong part is that the employee is taught the tricks in the field. This creates a more experienced employee, who needs far less time to be trained into an expert. Concept Understanding also cuts in the time needed to become an expert as they provide the new employee with lots of information on what went right and wrong in the process and gives the player insight in the results his actions have.

Programming the feedback and the results of every action does take a huge amount of time though. The player might gain a better understanding on what consequences his actions have, but the amount of time needed to figure out what possible outcomes a level could have and programming this, takes way too much time. Part of the programming and distribution of the feedback knowledge could be evaded by giving the facilitator of the training also the role of a trainer. Now he can reflect with the trainee on what he did in the simulation and they can talk about it with each other.

6

6. Final Concept

The best parts of all concepts have been taken and put together in the final concept. The doing part of concept Do is taken as the base to teach the user how to do interactions. There is more feedback in the game about how the player does to further improve the review part of the game.

6.1 Gameplay

In the following pages, there is a description of how the game works through a scenario. This gives insight in how the final game will work. The images show what the gameplay could look like when the gameplay is followed. This gameplay is not included in this report, due to confidentiality. Figure 16 shows images that display this gameplay.

The progress bar shown at the top of figure 23b is useful for the players. Knowing where they are in the training process, or this time in the level, increases the motivation to continue, since they know how far they are in the process.
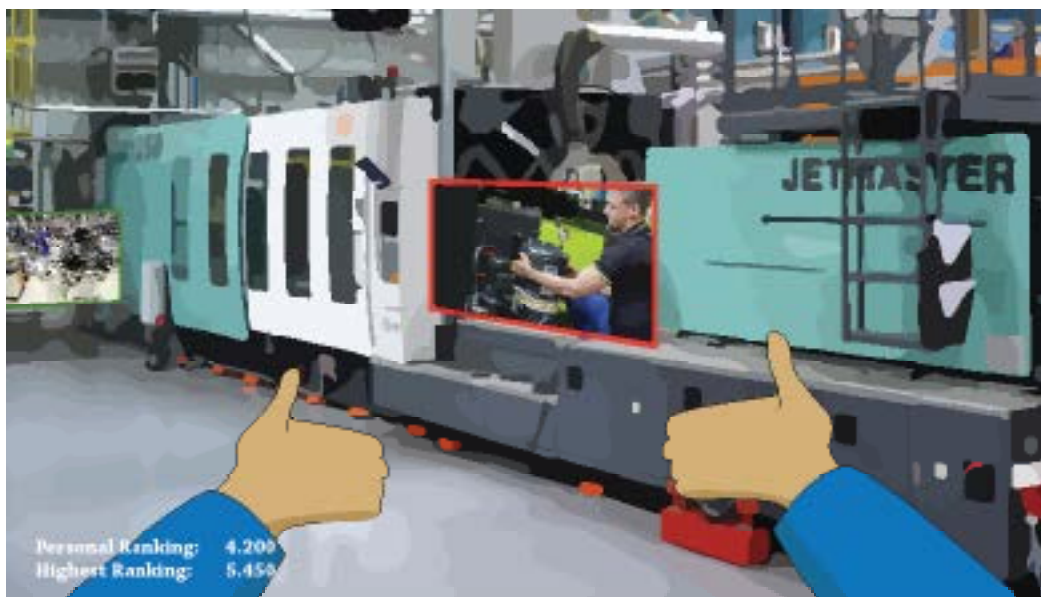

Fig 16 | a. Screenshot of the game when the player is not present inside a level.
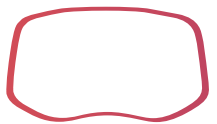
Fig 16 | b. Screenshot when the player is playing a level. The red frames show possibilities for interactions. c. Screenshot showing the ranking that is shown when a level is completed.

6.2 Effective learning

Reviewing the game next to the effective learning cycles that were found in *3.2 How people learn most effective*, the connection with this concept and the cycles is visible. The first part of the learning cycle, the effective active learning, is the basis of this concept. Trainees are asked to learn by immediately doing all the interactions they would be doing in the real job. There is not a group work anymore though, which students also rated high. This could be done by switching the trainees between the serious game and the group in which they would be working in the real environment. Then the trainees would be working in a group, but this would delay their training however.

Finally, the learning to learn is present in the strategic choices the player can make in the game. They can decide on which part they want to grow better, which type of training they want to improve. They reflect on their own training and learning cycle to look for the best way to increase their knowledge.

7

7. Conclusion and recommendations

The final concept is a motivating concept for a serious game. The concept does stimulate the trainee to learn the basic interactions and the more challenging.

7.1 Conclusion

The goal of this assignment was to design a concept for a serious training game simulation for production companies. To create the best possible design for this, the different virtualities have been researched. Virtual reality from the HTC Vive proved to be the most suitable match for a simulation training that educates the trainees.

From the research of serious games, the game characteristics have been found. These are used to create a game. From the training research the ARCS model was found and combining this with the game characteristics resulted in the best game elements to keep the serious game interesting.

A training should be built using the learning process, so the training becomes the most successful. For the training model of the process is used. To improve this model, game elements have been used.

After this research, the three concepts proved to lack certain aspects. Combining these concepts resulted in a serious game that trains the players for specific parts.

This training improves the parts of the learning model to make the learning more efficient and effective.

7.2 Recommendations

- To see if training specialists also think this training will be successful, there should be interviews held with professionals and ask their opinions about the training concept. Unfortunately, these interview were not held during this bachelor assignment due to the difficulty of finding suitable moments and trainers for the interview.

- Due to the lack of a client company, the concept training could not be discussed with a client company. There is not yet a company which already uses a training like this, so this should be done later when a training is in use.
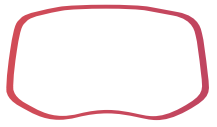
7.3 Future Research

   - Do an interview with a professional trainer to see how the training can be improved to teach the new employees how to work in a company.

   - Do an interview with a client company to evaluate the idea with them and use their advice to create the best training in their environment.

   - Create a demo to test the game with trainees who need to train with the virtual game. When they are playing the game, they can give feedback on how the game trains them and how the training can be improved for them.

   - In the long term, see if the trainees become expert employees sooner than with the training they receive now.

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9

9. Appendix

The attachments that were not added in the report, have been placed in this appendix.

9.1 Appendix A

Personas

Arthur

Arthur, a 47 year old man who lives with his wife in Liverpool, works along the assembly line in a manufacturing company located in his city. He recently switched for his place in the warehouse to the assembly line and does not fully understand his task yet. Therefore, there is a training programme in which he and Eric take part. Because of the experience Arthur already has, he already knows which knowledge for his new job he lacks and wants to learn. He already worked in the warehouse, so he does not need more knowledge on whether a package is packed correctly or not. He often talked to the packing personnel already when there was a wrong package delivered. Because of this, Arthur already arranged with his teacher that he will not have to take these training classes. Together with Eric, he tries out how the assembly line works and they reflect on their findings.

Eric

Eric is a 21 year old guy who has just applied to work along the assembly line in the same manufacturing company Arthur works. He still lives at home with his parents and little sister, just finished school and is ready to work. When he is earning enough money, he and his girlfriend can rent an apartment for themselves. Eric is not motivated to be taught things again, since he just finished studying at school. He tries to keep his attention on the training, but he makes the most progress when he is training next to the assembly line. When he is working there, he makes jokes with Arthur and can try out what the best actions are when working with the machine. He and Arthur tell about what they are doing and help each other when they can.