RAM
ROBOTICS
AND
MECHATRONICS

Designing an informative, promotional, interactive
artefact for Vopak about the RaM team,
the University of Twente, and the PIRATE

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BSc Report

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BIOMEDICAL TECHNOLOGY
AND TECHNICAL MEDICINE

Abstract

This graduation project involves the designing, realising and testing of an artifact. The goal is to design this artifact for the company Vopak and it has to be informative, promotional, interactive, and needs to be about the Ram team, the University of Twente, and the PIRATE. The best way to design this artifact is researched through looking into multiple subjects. These subjects are: Vopak, RaM, the PIRATE, how how to grab attention without being annoying, what are the suitable kinds of interactivity to get a passer by to notice an informative artifact, and state of the art. From this research ideas for the design are diverted, converted and then a final idea is specified. This final specified idea is then realised and tested through qualitative user testing, expert evaluating, and consulting with Ram and Vopak. It is concluded that five factors are important when designing an informative artifact like the one being designed in for this project. These five factors are that the artifact should: get attention, be easy to figure out for the user, keep attention, be informative, not be annoying. It is also concluded that the design created within this graduation project and report has a high probability of being a successful design to be an informative, promotional, interactive artifact for Vopak about the RaM team, the University of Twente, and the PIRATE based on those five factors.

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Chapter 1: Introduction

Situation

All over the world, pipes are being used to transport liquids and gas. These pipes can either be above or under ground and all of these pipes need regular inspection and replacing. Nowadays, all these pipes are inspected by people. This costs a lot of time and money, especially when the pipes are underground. The Robotics and Mechartronics team (RaM) was approached by KIWA in 2006 to develop a solution for in-pipe inspection. RaM is working on creating a pipe inspection robot for autonomous exploration, or PIRATE for short. This robot will be capable of driving itself through pipes and seeing if there is any interior damage or deformation.

The company Vopak in particular is very interested in this robot. Vopak is a big company that operates bulk liquids storage terminals [1]. This means that they store and transport liquid, gas, chemical, and oil products on their terminal and transport it towards ships, trucks, and trains. With this comes that they use a lot of pipes. In their settlement in Holland most of their pipes are above the ground but at their settlement in Korea all the pipes have to be underground. This means that using the PIRATE would save Vopak a lot of time, man power, and money.

Vopak is constantly innovating the way they do things[1]. They are very proud of this and have therefore established an innovation lab. In this innovation lab they display the newest and latest innovations relevant for their business. This innovation lab is located in Vopak's headquarters in Rotterdam. Because Vopak would benefit greatly form using the PIRATE in the future, they want to showcase it in this innovation lab.

Challenge

The aim of this project is to create an artifact, for Vopak, to represent the PIRATE, RaM, and the University of Twente(UT). This artifact has to explain how the PIRATE works and how it will help Vopak in the future. Getting people excited and interested for the PIRATE is the main goal of this artifact. To do this, the artifact should get people's attention and keep their attention. Interactivity will help with this.

An extra challenge with this artifact is that the innovation lab is also used as an office and as a meeting room. This means that the artifact should not distract or annoy the people working in the room, while still grabbing the attention of the occasional passer by.

Vopak would also like the artifact to be easy to move around. This way it is possible to show the artifact at different locations and possibly even speeches.

Chapter 2: Methodology

This chapter is about how the challenge describe in the introduction will be handled. First a main research question will me set up and then it will be discussed how this question will be answered.

The main research question that this paper will answer is:

How should an informative, promotional, interactive artifact for Vopak about the RaM team, the University of Twente, and the PIRATE be designed?

In order to answer this question, first two forms of research will be done, background research and state of the art. Background research will concern all the background information needed to go into the next phase of the designing process. State of the art will look into existing work that is relevant to the artifact being designed. This background research and state of the art will be structured in the following way:

Table 1: Structure of research

Subject	Way of research
Vopak	Desk research
RaM	Desk research, meeting with chairman
PIRATE	Desk research
How to grab attention without being annoying	Making a documentary
What are the suitable kinds of interactivity to get a passer by to notice an informative artifact	Literature review
State of the art	Desk research; Literature research; Observations

After collecting all this information an artifact will be designed, created, and evaluated. This will happen in the sections ideation, specification, realisation, and evaluation.

An important thing throughout this entire design process is the involvement of both Vopak and RaM. Because the artifact is being designed for Vopak, it is important to know what they want in the artifact, and because RaM will be represented by the artifact it is important that they agree with the way it does this. To keep both parties involved in the entire designing process, close contact will be had.

Chapter 3: Background research

Vopak

Vopak is a company that originated from four Dutch storage companies. These four companies merged over the years, taking on the name Vopak in 1999. The original companies where Blauwhoedenveem, Vriesseveem, Pakhuismeesteren, and Van Ommeren. The oldest of these companies was Blauwhoedenveem, dating back as far as 1616, making Vopak 400 years old this year. Vopak's logo looks back at its history by showing the type of hat that used to be worn by Blauwhoedenveem employees back in the 17th century. This logo can be seen in figure 1.

Figure 1: Logo Vopak

Because Vopak is such a big company, it is important to keep finding better and more efficient ways of doing things. They believe that innovation is key to staying competitive in their market. One example of how they do this is by their use of drones. Vopak uses drones for their inside tank inspections. The drone takes pictures and scans of the inside of the big storage tanks, making it easy to find damage. This damage can then be fixed by employees.

Vopak has settlements all over the world in places like Houston, Singapore and China. Rotterdam is where their biggest, and main, settlement is. Every place has different regulations concerning pipes. China, for example, requires all the pipes to be underground, making inspection and maintenance very labour intensive and expensive processes. Even though settlements like Rotterdam do not require every pipe to be underground, inspection in these places is labour intensive and expensive too. Vopak would love to find a better, more efficient, and innovative way to do this process.

RaM

Robotics and Mechatronics is a research group that focusses on systems and control methods that can be applied to robotics. RaM looks into three main fields of research being inspection robotics, medical robotics, and service robotics. The team has a leading role in LEO centre of service robotics and is a part of the University of Twente.

In a meeting with Stefano Stramigioli , the chairman of RaM, it was discussed how he wanted RaM to be represented. Stramigioli wanted the user of the artifact to know that RaM is a team of people with expertise. RaM creates innovative things and gets them to the point of almost finished products and is the robotica place to be. PIRATE is not the only thing that RaM works on. For example, they are now working on a drone that comes in contact with the wall it is inspecting. Although RaM does not have a slogan, Stramigioli does like to describe RaM with the saying 'Physics predicts the future. Engineers make it", or the alternate version " Physics predicts the future. We create it". Lastly, it was discussed which logo is the most important one, RaM, LEO, or University of Twente. Because the University of Twente is the most recognizable logo this will be the main logo on the artifact. Although RaM is a part of LEO, RaM is the leading researcher for the PIRATE so RaM is more important and will be the secondary logo present on the artifact.

Figure 3: Logo UT

Figure 4: Logo RaM

Figure 2: Logo LEO

PIRATE

PIRATE (Pipe Inspection Robot for AuTonomous Exploration) is being developed to do in-pipe inspection of low pressure gas pipes. To be able to move its way through all diameters of gas pipes, it needs to have a versatile design. It is especially hard to have it be versatile enough so it can make 90∘ bends [2].

The way the PIRATE does in-pipe inspection is by collecting data with a camera and a laser. While the PIRATE is in a pipe it sends data about its own state and the state of the pipe, in real-time, to a computer where it is gathered and stored [3]. This data can than later be used to find out if a pipe needs to be replaced.

Right now the PIRATE is at the stage of development that it needs to be controlled by an operator behind a laptop. The final design will be autonomous, so it can drive on its own [3].

The robot has gone through many phases in its design. The design now consists of six wheels and four different kinds of modules being the bend, rear, front, and rotational modules [3]. These different module types are shown in figure 5. Each module has a crucial part in the way the PIRATE moves and operates. The bend modules enable the robot to clamp itself into the pipes so it can move around. The rotational module enables the robot to rotate all the front modules compared to the back modules. The front module has the front camera, the rear module currently connects to a cable but will in the future have a rear camera. A previous version of the PIRATE, without front and rear module, can be seen in figures 6 and 7.
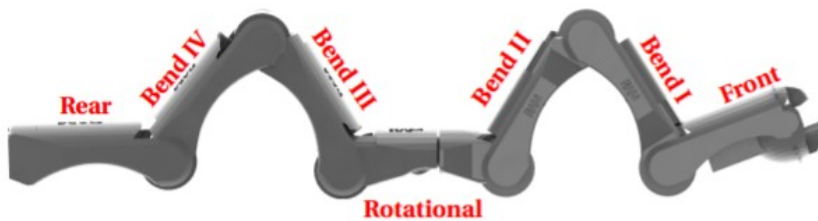
Figure 5: PIRATE modules
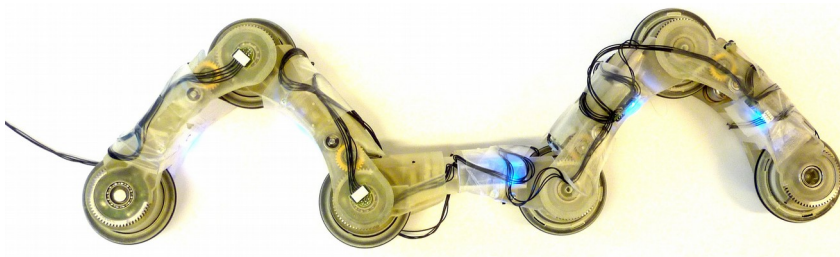
Figure 7: PIRATE

Figure 6: PIRATE

How to grab attention without being annoying

The artifact will be located in the innovation lab, which is used as a meeting room and an office, so it is very important that it is not distracting or annoying to the people working there. The artifact should however also grab attention. Because grabbing attention and not being distracting or annoying do not go hand in hand very well it is important to research how this should be done.

The notion of annoyance is subjective. What one person find annoying can be very different to what another person finds annoying. Because it is a subjective subject, it was researched by looking at the opinions of multiple people in a documentary format.

In this documentary, the main question being asked is: 'When does visual media, asking for attention, become an annoyance?' The answer is found by looking at four examples of different kinds of attention grabbing visual media, and trying to figure out what causes people to find them annoying. These examples are: product placement in television shows and movies, outdoor advertising like billboards and advertisements in bus-stops, logos, and graffiti. Although these are all viewed very differently by people, there was a very clear conclusion found. This conclusion was based on the opinions of different people, on multiple other documentaries, and on literature [4-8]

There are many personal reasons to find something annoying. In every example of attention grabbing media that was looked at in this documentary, it seems to come down to the same few principles. The order of importance that someone might give to these principles is a personal thing too. These few principles are: It should not be against your own morals, and it should not destroy, disrupt, or devalue what it is on, in, or around, and it should look like effort was put into it. So product placement should not disrupt a tv story, or a billboards should not destroy the view, logos should not disrupt the architecture, graffiti should not disrupt the way the city looks or devalue someone's property, and a poster should not look like it was put together in one minute without any thought put into it.

From this conclusion, the following things should be taken into account while designing the artifact for Vopak:

- The artifact should not tell a deceiving story about the PIRATE. It should therefore not lie, or leave out crucial information.
- The artifact should not destroy the purpose of the room it is put in. The purpose of the room is that it is an office and a meeting room. It would go about this by not constantly being distracting to the people working in the room.
- The artifact should not disrupt the room. This means that the artifact should go with the room, not against it. If it were to go against the room, it would become out of place.
- The artifact should not devalue the space it is in. By making other things work less well because it is in the same space. This can for instance mean that the artifact should not block too much natural light coming in from the window.
- The artifact should have a design that is well thought out. This is done by not forgetting to look at the details and to think about every design decision thoroughly.

To make sure that the artifact does not accidentally become annoying, it is important to keep communicating with the people at Vopak that will be seeing it the most.

A literature review on interactivity for grabbing the attention of a passer by for informational artifacts.

Introduction
With the artifact that is being designed in this paper, it is important for the artifact to grab attention. It is important that the artifact grabs attention because when it does not, it might not be used at all [9]. The main way the artifact will grab attention is already determined and is with the use of interactivity. The way this artifact will be informative, most closely relates to the view of Restörm, et al [10] on informative art. They state that informative art is not only aesthetic, but also informative. Informative art dynamically reflects and represents information.

The goal of this article is to gain insight in how interactivity can or should be used to grab attention for informative artifacts. This insight is gained by answering this following research question: *What are the suitable kinds of interactivity to get a passer by to notice an informative artifact?*

In order to find an answer to this question, it will be handled in three parts. First, a definition for interactivity will be established to use within this paper. This is done by looking at multiple different definitions that were given in other papers and combining them. Second, different ways to separate interactivity into different kinds are looked at and evaluated to see which kinds are the most suitable for an informative artifact. Third, what grabs the attention of a passer by will be looked into and compared to how interactivity grabs attention in different ways.

Definitions of interactivity
To figure out how to use interactivity, the concept of interactivity must be understood first. Even though many papers use the term interactivity, it is often undefined or under-defined [11-17].

Two examples of under-defined definitions can be found when comparing Pavlik and Steuer. Pavlik [18] defines interactivity as being a two-way, or multi-directional, communication between source(s) and receiver(s). Steuer [19] takes a different approach and writes that interactivity is the extent to which, in real-time, participation of the user modifies the form and content of the environment. The reason these two definitions are under-defined is because they only talk about one aspect of interactivity.

Papers that give a more complete definition, take one of three perspectives when creating it.

The first perspective gives the most complete definition that was found and is used by Heether [11]. He looks at interactivity from the user's point of view, giving six dimensions to the term. These six dimensions are that the user should have choice, exert effort, be able to easily add information, and be able to communicate with the artifact. The artifact should be able to communicate back and be responsive to the user.

The second perspective that can be taken is that of the technology, or artifact, itself. Downes and McMillan [20] define interactivity from this angle. Their definition adds to this definition that there should be a level of control that the user has and there should be a sense of place. Downes and McMillan's definition agrees with Heeter's definition on the facts that there should be communication and responsivenes.

Lastly a perspective van be used is the one Kiousis [12] gives a definition from. Kiousis defines a way of measuring interactivity, and with this adds one dimension to Heeter, Downes and McMillan. This dimension that Kiousis adds is that the perception of the user are very important.

So although there are many different approaches used for defining interactivity, a general definition that gives a full description of what interactivity really is, has yet to be formulated. For the rest of this paper, a combination of the definitions from the three perspectives, and from the earlier stated under-defined definitions, will be formed. This definition is: Interactivity is the level to which the user has the perception of their ability to influence, with effort, an artifact through their choice, participation and control. This perception is influenced by how the artifact responds, monitors, communicates, creates a sense of place, and is in real-time.

Interactivity for an informative artifact

When separating interactivity into different kinds of interactivity, a context influences the way this is done. To figure out which kinds of interactivity could be applicable to an informative artifact, only relevant contexts are looked at.

First, a context that is interesting to look at is communication. Communication is a part of interactivity, making this a relevant context. Looking from communication, interactivity can be divided into four kinds: transmission, conversation, consultation, and registration [21]. What separates these four kinds of interactivity is whether the central provider or the consumer, produce the information and/or control the distribution. How the kinds of interactivity are divided can be seen in table 2.

Table 2: How transmission, registration, consultation, and convesation are devided.

	Information produced by a central provider	Information produced by the consumer
Distribution controlled by a central provider	Transmission	Registration
Distribution controlled by a consumer	Consultation	Conversation

With an informative artifact it is important that the consumer learns something from the artifact. This is accomplished when the central provider produces the information and the consumer controls the distribution, which happens with consultation. Therefore, consultation would be the most appropriate kind of interactivity to use.

The second context that can be applicable with an informative artifact is media and communication. This context is applicable because both and informative artifact and many forms of media convey information to its users. This context also divides interactivity into four kinds: aesthetic, ludological, pedagogical, and empowerment [22]. These kinds are in relation to what impact they have to the user in the following ways: beauty and taste, getting the user to play, getting the user to think, and empowering the user. An informative artifact would want the user to gain information, and would therefore want the user to think in a certain way, making pedagogical interaction the most appropriate form of interactivity to use.

A very different way to divide interactivity into different kinds can be seen in the context of game design. Salen and Zimmerman [23] divide interactivity within this context into four modes. A mode can be seen as an individual kind of interactivity but can also be seen as one part of the four different levels of engagement that can be had within one interactive object. The first mode is cognitive interaction, which influences the user's psychological, emotional, and intellectual participation. The second mode is functional interactivity, which is the functional and structural aspects of the material components of the artifact, real or virtual. Explicit interactivity is the third mode and is about overt participation. This is the motion that the user does which results in interactivity. The final mode is beyond the object-interactivity. This mode is the interaction that happens outside the system. With an informative artifact clarity of information is most important, making functional interactivity the most important mode to focus on. For the reason that the modes can be seen as different levels of engagement within one interactive object, all the modes are important.

In conclusion, the most suitable kinds of interactivity to use for an informative artifact are: Consultation interactivity, pedagogical interactivity, and functional interactivity.

<u>What grabs the attention of a passer by</u>
Müller et al [9], states that when a human gives attention to something or someone, this is because their brain has decided which sensory input is the most important. What the brain decides to give its attention to can be influenced in many ways, of which different ones have been explored in different papers. It has been hypothesised that attention is given to stimuli that indicate immediate need for action [24]. This immediate need for action stimuli that grabs attention can be caused by movement [24, 25], looming [24], luminance contrast [26], and the appearance of new objects [27, 28].

Need for action is not the only way to grab attention that has been found. Franconeri and Simons [24] argue that the need for action probably grabs attention because humans have evolved or learned this as a default attentional bias. They argue that, therefore it could also be possible that humans pay attention to stimuli that are not action based and are consistent with the goals a human has.

An interesting, attention grabbing, phenomenon that has been observed by Brignull and Rogers [29] is the 'honey-pot' effect. This effect means that a crowd of people attracts more people. There are two reasons why a crowd of people causes more people to enter the crowd, the first one being that a crowd creates a social 'buzz'. A social 'buzz' signals that the people in the crowd are open to discussion and want to meet new people. The second cause for a crowd attracting more people is that a crowd indicates that something is worth the individual's attention and that it will benefit them. So a crowd grabs attention by creating a social 'buzz' and indicating that something is worth an individual's time.

All of the previously stated ways to grab attention were not specifically aimed at passer bys. One way to grab attention that could potentially only be focused on passer bys is by taking advantage of 'change blindness'. Change blindness is a phenomenon that happens when something changes gradually instead of rapidly [30]. This means that change blindness could cause a person that is in the same vicinity as the changing stimuli for a long time will not observe the changes, but a person that is just passing by will.

In conclusion, there are many ways to grab attention, but to only grab the attention of a passer by, change blindness could be used.

Conclusion

In this paper the following question was researched: "What are the suitable kinds of interactivity to get a passer by to notice an informative artifact?" This research was done by looking into the definition for interactivity, the best kinds of interactivity to use for an informative installation, and what grabs the attention of a passer.

From the research in this paper a few things can be concluded. First, although there are many different approaches used for defining interactivity, a general definition that gives a full description of what interactivity is, has yet to be formulated. Therefore, within this paper the following definition was formed: "Interactivity is the level to which the user has the perception of their ability to influence an artifact through their choice, participation and control. This perception is influenced by how the artifact responds, monitors, communicates, creates a sense of place, and is in real-time." Second, by looking into how different papers divide interactivity into different kinds, it was concluded that consultation, pedagogical, and functional interactivity are the most suitable kinds of interactivity to use in an informative artifact. Last, even though there are many ways to grab attention, there is one way found that can only grab attention of a passer by. This way to grab attention is called 'change blindness'. So to grab the attention of a passer by to an informative installation, consultation, pedagogical, and functional interactivity could be used in combination with the phenomenon of change blindness.

This is only a small literature review so, to establish what is concluded in this paper as truth, more research needs to be done on its subjects. The definition for interactivity that this paper provides is only based on the definitions from five other papers, therefore more papers need to be looked into to establish this definition to be true and complete. This paper only looks at three different contexts in which interactivity can be divided into different kinds. In order to have a full grasp on all the different kinds of interactivity, more contexts need to be looked at. In this paper, only one passer by specific way of grabbing attention was found. To figure out what is the best way to grab attention of a passer by, more ways of doing so need to be looked into. For all tree subjects researched in this paper, more research needs to be done.

Chapter 4: State of the art

To get a full grasp on a wide variety of existing work, three forms of research where done. These three forms are desk research, literature research, and observations. For something to be considered as existing work it had to be an interactive installation. Because the artifact being designed should allow multiple people to look at it at the same time, existing work that does not allow this was not looked at. An example of this could be installations using Virtual Reality headsets. The things found were divided into four groups. These groups are attention grabbing, informative, advertising, and other. Installations that could be placed in two or more of these groups are placed based on their main attribute and/or purpose. In the category of informative installations the NEMO Science Museum was an interesting space to look. Because there are so many installations at NEMO it will be handled and talked about in a separate category to informative installations.

Observing: NEMO Science Museum

NEMO Science Museum is filled with interactive informative installations. The museum is set up in a way that there are big open spaces, filled with many installations. Almost all these installations are interactive in some way and all of the installations try to give information about a topic. This information is often in the format of big written text in a colourful banner close to the installation, sometimes it is written on a small plate next to or on the artifact.

Figure 8: Information at NEMO

The fact that there are so many installations in one place means that they are all competing for attention. This makes it interesting to look at which installations do a great job at getting attention and which do not. It is also interesting to see which installations are good at getting their information across and which installations keep your attention to the point that you want to read the information. Even more interesting could be looking at how some installations get their information across without the user needing to read the text provided.

Something important to keep in mind when looking at NEMO Science Museum is that its main target group is children and so some techniques the installations use might not be applicable to adults. It is also important to keep in mind that the people at NEMO Science Museum are there to look at the installations, people in Vopak's innovation lab will not necessarily be there to look at the installations and might only be passing through. Still most attention grabbing techniques, and especially attention keeping techniques, will probably be applicable to the artifact being designed.

Because NEMO had way too many interesting interactive informative installations, all the installations from NEMO are discussed in appendix A1. The statements made about the installations at NEMO are based on observations which were worded in short notes. These notes can be found in Dutch in appendix A2. What can be concluded from these observations is that the top three things used to grab attention at NEMO are: light, movement, and placement. The easy to figure out installations most often used written instructions and/or offered a clear way of interaction like bright buttons. People kept interacting most often because there was competition and/or multiple outcome possibilities. It helped when installations did not get annoying, provoked curiosity, and stimulated the feeling of wanting to finish a task. The number one thing that caused users to read the provided pieces of text with the installations was getting the users to invest time into the installation, once they have invested enough time they become curious enough to read the text. Some things that should be avoided for a successful installation are: cheating possibilities, unclear information, hidden information, unclear interaction, confusing interface, ugly interface, language errors, non visual placement, and annoying the user.

Attention grabbing installations

The most important goal of an installation in this category is to grab attention of potential users. This is an interesting category to look into different ways that are already being used for attention grabbing that could be applicable for the artifact that is being designed for Vopak. With every installation it is discussed what they do, what technology they use, how attention is gained, how attention is kept, and what type of interactivity are used and are most important from Salen and Zimmerman's [23] division referring back to the literature review done earlier in this paper.

Science Night – 100% FAT

Science Night is a game that is projected onto a church in Enschede. The game is very similar to the old school game called 'Breakout' but Science Night incorporates parts of the church building in its game. Users can play the game using hand motions that are detected with a sensor. In real-time these hand motions are translated in to the projected game on the church. The installation grabs the attention of passer by's in two ways. The first way is visually. Because it is bright [26], big, and constantly moving it catches the eye of a potential user. The second way it grabs attention is with gathering groups of people looking at the

Figure 9: Science Night

installation [29]. The way the installation keeps the attention of the user is through competitiveness and through many interactive options. Competitiveness keeps attention because it gets the user to want to beat the game of other users, something that could have strengthened this would have been a high-score board. That the installation has many interactive options means that the user can influence it a lot and have many different outcomes. This keeps the installation interesting for a very long time. It even seems that there are multiple game types that can be played.

The types of interactivity being used are consultation and ludological. Explicit interaction is the most important kind of interactivity from Salen and Zimmerman.

City Lights – 100% FAT

This installation allows users to draw on a building. Using a controller that looks similar to the Sony Playstation Move, participants can draw with colourful static light or even video. The drawing is shown in real time with a projection on the building. The installation gets the passer by's attention in a similar way of Science Night. It gets attention by being bright [26], big, and often moving [24, 25]. The visuals are only moving when someone is using the

Figure 10: City Lights

installation or when a previous user had drawn with video. The installation keeps the user's attention by having infinite possibilities and being infinitely customizable. The user can keep using the installation for a very long time without ever running out of possibilities.

The types of interactivity being use are consultation and aesthetic. Explicit interaction is the most important kind of interactivity from Salen and Zimmerman.

VideoMob [31]

This installation creates a painting filled with people. It does this using live video feed and a continuous interaction feedback loop. A participant stands between something that captures their image and a green screen and is then added to the painting. This painting is shown with a projection or on a screen and would look something like figure 11. There are several ways this installation grabs attention one of which is with the light that the painting is creating [26]. The installation is also constantly showing movement [24, 25], because the painting is made up out of many little videos. A later version of the installation also had sound that grabbed attention. The installation keeps the users attention for two different things. It keeps the users attention to interact with the installation for a very short time, because there is only one way the user can interact with it. The installation also keeps attention for the user to look at the painting. While the user is looking at the painting they are not interacting with it but still directing their attention to it. It does this by showing a very complex picture, with many different things to see.

Figure 11: VideoMob

The types of interactivity being used are consultation and aesthetic. Functional interactivity is the most important kind of interactivity from Salen and Zimmerman.

Short conclusion:

Ways to get attention seen with this type of installation from most used to least used are light, movement, and sound.

Ways to keep attention seen with this type of installation from most used to least used are multiple outcomes/possibilities, competition, complexity.

Informative installations

The main goal of the installations in this category is to inform the user. This information can be something like learning a skill, learning new information on specific topic, or raising awareness. This is an interesting category to look at to figure out how other installations present their information. These different ways of presenting information can be an inspiration for how the artifact that is being designed in this paper could possible present its information. With every installation it is discussed what they do or are, what technology they use, how information is communicated, and what types of interactivity are used and are most important referring back to the literature review and what type of interactivity are used and are most important from Salen and Zimmerman's division referring back to the literature review done earlier in this paper.

Centrifuge Game – 100% FAT

The centrifuge game is a table that aims to explain the principle of centrifugal separation to kids. It does this with a game that can be operated with four push buttons. The game is displayed on a screen on top of the table and the game is explained with recorder voice. The way the centrifuge game brings information is through play. While the user plays the game, they learn about centrifugal separation.
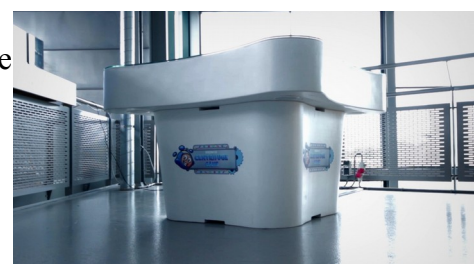
Figure 12: Centrifuge game

The kinds of interactivity being used are the most are consultation interactivity, and pedagogical interactivity. All the kinds of interactivity described by Salen and Zimmerman are very important.

Smartware – 100% FAT
This installation is located in the hallway of the gallery at the
UT. Smartware lets user use hand motions to go through
information about projects being done at the UT. A screen
shows the information while a small display table rotates the
project that the information is about. The way Smartware
brings information is through text, pictures, video, and physical
models.

Figure 13: Smartware

This installation uses most are consultation, and pedagogical,
cognitive. Explicit interaction is the most important kind of
interactivity from Salen and Zimmerman.

Arbor Vitae – The fellowship
Arbor Vitae, or the Tree of Life, is located at the entrance of the design
lab. The installation shows the levels of endangerment and extinction
of mammal species, and with that tries to raise awareness. The
interaction consists of eye catching LEDs and a tablet that can be used
to change the colours of these LEDs. The tree also has small speakers
playing calm music, but these are rarely turned on by the design lab.
The way the tree shows information is with simple colours that are
explained with a legend that is right above the tablet.

Kinds of interactivity that are used here are consultation, and
pedagogical. All the kinds of interactivity described by Salen and
Zimmerman are important.

Figure 14: Arbor Vitae

Short conclusion:
Ways to show information used are through play, text, pictures, video, physical models, simplicity.

Advertising installations
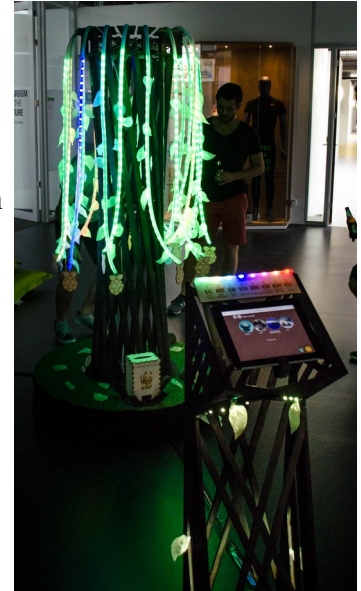
The installations in this category were created for the purpose of advertising. Advertising in particular is an interesting category to look at because it is promoting something, just like the artifact that is being designed in this paper. The way that already existing installations promote something can be an inspiration to the artifact that is being designed in this paper. With every installation it is discussed what they do or are, what technology they use, how the installation communicates its advertising message, and what type of interactivity are used and are most important from Salen and Zimmerman's division referring back to the literature review done earlier in this paper.

Pick n' Play – McDonalds

Figure 15: Pick n' Play

This was an advertising campaign in Stockholm where a digital billboard was turned into an interactive game of pong. The user could go to a website and play pong on their phone against a computer, which would be shown in real-time on the billboard. If they won they would get rewarded with a free food of choice from McDonalds. Giving away free food with this game got people to invest their time in a McDonalds ad and to often even go to a McDonalds afterwards to collect their reward. With this installation it is also very interesting to look into how it grabs and gains attention. Attention is grabbed in a few ways. First with the moving picture on the billboard, secondly with people standing still playing the game. The installation keeps the users attention by being a challenge. The user wants to win the game to get some free food.

The types of interactivity being used are consultation and ludological. Cognitive and beyond the object-interactivity are the most important kinds of interactivity from Salen and Zimmerman.

Interactive window display – NIKE+ Fuelband

Figure 16: Interactive window display

To promote NIKE's activity tracker Fuelband, an interactive window display was created. The display reacts to people that are passing by the installation, grabbing attention with motion [24, 25]. When a user walks by it is detected with a sensor and the installation reacts by lifting the hanging balls in the display, see figure 16. The way this display gets the message across is by relating back to a very prominent design choice in the product, the red to green colour scheme, see figure 17. It also relates back to the way that movement is visualised by the Fuelband app and website, see figure 18. Although this is a very eye catching installation, it only takes the user back to looking into the product if the user already knew about it before. The installation does not explain anything about the product it is promoting, so users that have never heard about the Fuelband before will not learn anything from the installation. It does create positive brand awareness [7] by placing the NIKE brand into the mind of the user interacting with the window display.

Figure 17: NIKE+ Fuelband

Figure 18: Fuelband graph

The types of interactivity being used are transmission and aesthetic. Beyond the object-interactivity is the most important kind of interactivity from Salen and Zimmerman.

Crunch-o-meter – Crunchums

This installation tries to promote Crunchums, a crunchy chocolate. The user was encouraged to shout as loud as they could, and if they were loud enough they would win packets of Crunchums. Because a big part of this chocolate's promotion is that it makes a big crunch sound, getting potential customers to try and make a lot of sound would relate back to that. Making users shout also gets people passing by to notice that there is something going on and might encourage them to interact with the installation as well. There is also the competitive part of the installation where you can win something if you are loud enough. Even though this installation does all these things well, it makes a few mistakes that make it fail to get people to interact with it. One of the big mistakes it makes is that it is not tailored to its surroundings. Somewhere that people would not mind screaming their lungs out for some chocolate could be a festival for example, but this installation is placed in a big hallway. This placement makes it embarrassing to shout really loudly because it would not only attract attention to the installation, but mostly to the user. Something else the installation does wrong is that it is accompanied by employees working for Crumchums that are already handing out free chocolate. This takes away the reward encouragement of possibly winning with shouting the loudest.
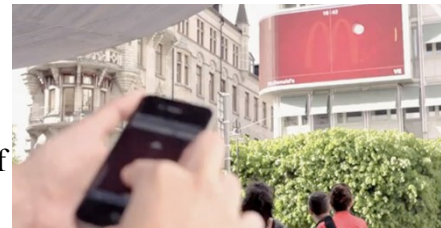

Figure 19: Crunch-o-meter

The types of interactivity being used are consultation and ludological. Cognitive and beyond the object-interactivity are the most important kinds of interactivity from Salen and Zimmerman.

Short conclusion:
Ways to convey the advertiser's message from most used to least used are relating back to the product in some way, getting the user to invest time, giving away free things.
Ways to get attention seen with this type of installation from most used to least used are: movement, crowds, noise.
The one way to keep attention seen with this type of installation is competition.
An important thing to note from the observations in this category is that an installation needs to take its surroundings into account and should not embarrass its users in order to not be annoying.

Other installations
In this section, a few interesting installations are discussed that do not fit into the other three categories but still had something interesting to them. For every installation it is discussed what they do or are, what technology they use, what is interesting about the installation, and what type of interactivity are used and are most important from Salen and Zimmerman's division referring back to the literature review done earlier in this paper.

Blobulous [32]

Bobulous is an installation that interacts to the heart rate of users. The heart rate is translated into shapes that are projected onto a wall. The installation grabs attention with its moving [24, 25], light up [26] projection. The aim of this installation was to strengthen social connectedness between participants by getting them to interact with this installation together. What's interesting about this installation is that it uses heart rate as the form of input for the user. This gives the opportunity for the user to find their own way to change their heart rate.
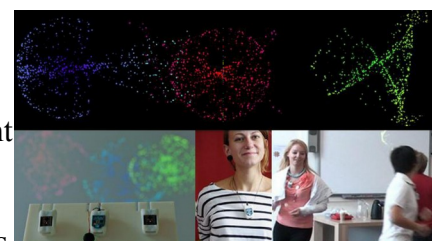

Figure 20: Blobulous

The types of interactivity being used are consultation and ludological. Explicit interactivity are the most important kinds of interactivity from Salen and Zimmerman.

The dancing white man – Leonard van Munster
This installation is an art piece that looks like normal man standing still until a user gets close enough to trigger its sensors. When this happens the man starts to do a very stiff dance. What is interesting about this installation is that it does not really want to grab attention before it is triggered. This is done by making the installation look like a real man instead of an installation. Once the installation gets triggered and starts to dance it does want attention, which it gains through movement [24, 25]. At this point it is revealed that the installation is not a man but a robot.

Figure 21: The dancing white man

The types of interactivity being used are transmission and pedagogical. Cognitive interactivity are the most important kinds of interactivity from Salen and Zimmerman.

Short conclusion:
Ways to get attention seen with this type of installation are: movement and light.

Conclusion
When combining all the short conclusions of the different sections and the section about NEMO the following things become clear. The first and most important thing is that the artifact will need to take the user through four steps of interaction. These steps are: artifact gets the attention of the user, the user figures out how to interact with the artifact, the artifact keeps the attention of the user, the artifact gets its message across to the user.

The most-used effective ways of attention grabbing are light and movement. To get the user to figure out how to interact with the artifact, it is important that the installation is easy to figure out. This is often achieved with easy to understand written instructions and/or clear ways of interaction like bright buttons. Once an installation is figured out, competition and/or multiple outcome possibilities are good options to keep the attention of the user. It helps when installations do not get annoying, provoked curiosity, and stimulated the feeling of wanting to finish a task. To get an advertiser's message across or to get a user to read provided information the installation needs to get the user to invest enough time to get them interested. Relating back in some way to the product you are promoting helps as well. Information can be shown in many different forms. These can be: play, text, pictures, video, physical models, and simplicity.

Some things that should be avoided for a successful installation are: cheating possibilities, unclear information, hidden information, unclear interaction, confusing interface, ugly interface, language errors, non visual placement, and annoyance to the user. To not annoy the user it is very important that the installation takes its surroundings into account and does not embarrass the users.

With these observations from looking into all of this existing work, enough examples and possibilities have been seen to be able to go into the ideation phase.

Chapter 5: Ideation

Ideation for this particular project consists of two steps: divergence and convergence. In the divergence phase the aim is to generate multiple ideas for the artifact. This is done by using multiple different brainstorming techniques. After generating a significant amount of ideas the best idea will be determined in the convergence phase. When this is done it is time to go into the next part of the design process: specification.

Divergence phase
As stated before, the aim of this phase is to generate multiple ideas for the artifact. The amount of ideas that need to be generated needs to be enough for Vopak and RaM to be able to give their opinions on. The rough number set for this was ten, keeping in mind that they need to be broad enough to have many possibilities for customization later on.

Before generating ideas a few things needed to be done. The first thing to do was organising the collected information from the research phase. This was done in two ways. The first one was making a big mind map, which can be seen in figure 22. To see the mind map in more detail, it can also be found in appendix B1. In this mind map there are five obvious categories that are important in the final artifact: grab attention, keep attention, information, show PIRATE, RaM/UT, not be annoying, and interaction.
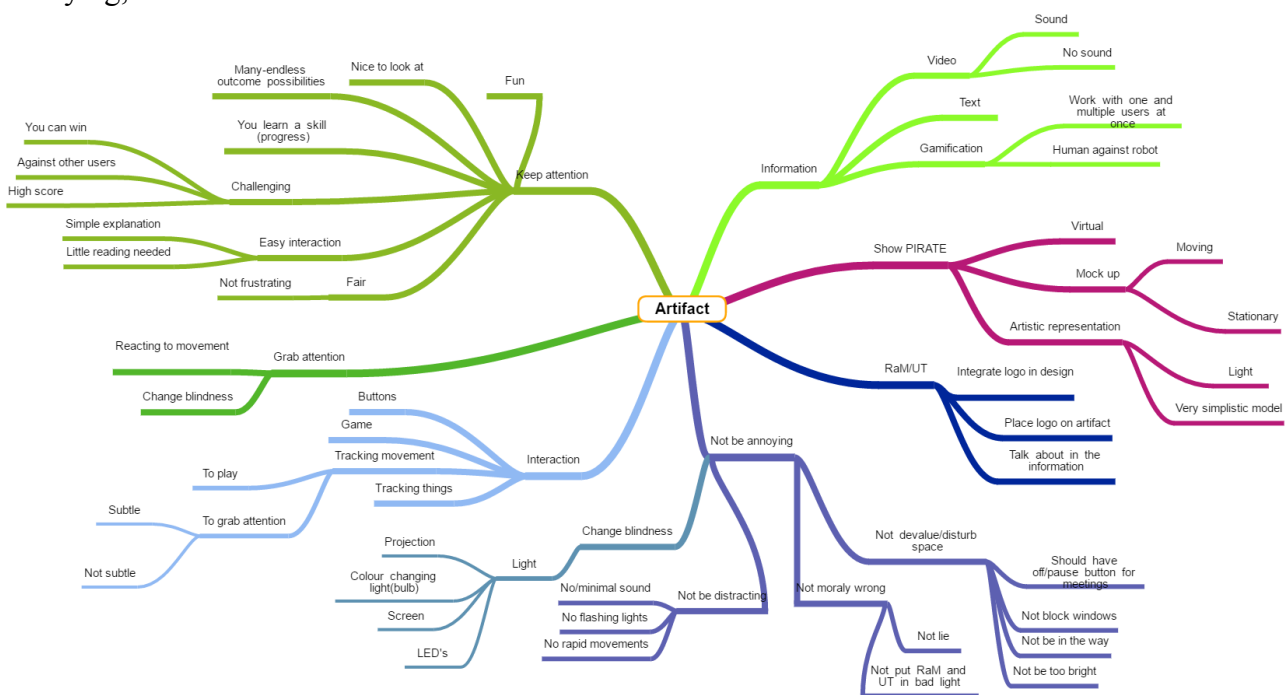

Figure 22: Mind map of background research

The second thing that needed to be done was create a list of factors that are important in an artifact like the one that is being created for this project. This list was made by looking back at the important points made in the research phase of this report. The list of factors is as follows:

1. The artifact needs to get attention from the user
2. The artifact needs to be easy to figure out for the user
3. The artifact needs to keep the attention of the user
4. The artifact needs to get its informative and promotional message across
5. The artifact can not be annoying to both the users and the people working in the innovation lab.

Or in short, the artifact needs to:

1. get attention
2. be easy to figure out
3. keep attention
4. be informative
5. not be annoying

In a meeting with the supervisor of this project it was determined that the artifact needs to show the level of innovation of the PIRATE. With that it would also show how innovative RaM and Vopak are. Another thing that was determined was that a 1:1 model of the PIRATE needs to be part of the artifact. This is important to give the user a clear idea of how big the actual robot is going to be. It was also established that it would be easiest to start brainstorming by choosing different kinds of 'user point of view', or 'perspectives'. This means that first the different types of perspective needed to be determined before thinking about the artifact itself. Some small notes from this meeting can be found in appendix B2.

The six perspectives that were conceived will be briefly explained in the following table:

Table 3: Conceived perspectives and short explanation

	Perspective	Short explanation
1.	Looking at the robot	While the user interacts with the artifact, they look at a small scale version of the PIRATE.
2.	Looking with the robot	While the user interacts with the artifact, they see what the PIRATE sees. This means that they see the inside of pipes and the possible small damages within them.
3.	Robot looking at you	The form of interaction is the PIRATE looking at the user. This can mean that the interacting is the PIRATE reacting to the user by doing something itself, example: following the user around.
4.	Looking from the perspective of the designer	While the user interacts with the artifact, the user has to look through the eyes of the designer to see how they created the PIRATE.
5.	Robot looks with you	While the user interacts with the artifact, the PIRATE is looking at what they are doing and reacts to it. This perspective is very similar to perspective three. The difference is that in perspective three the interaction is the PIRATE looking at you, while in perspective five the interaction is something different while there is an extra interactive aspect that is the PIRATE at what the user is doing.
6.	Be the robot	While the user interacts with the artifact, the user is in the shoes of the robot.

With these perspectives it was possible to start brainstorming some more specific ideas. This was done by creating a list of simple customizable ideas, at least one per perspective, and then broaden them by adding points of variation. These points are based on the five factors that are important for the artifactent. The points where variation is possible are:

- Get attention. How does the artifact get attention?
- Interaction: How does the user interact with the artifact?
- Keep attention. How does the artifact keep attention?
- Representation PIRATE/ 1:1 model of PIRATE. How is the PIRATE shown?
- Representation of information. How is the information presented?
- RaM/UT. How is it made clear that the PIRATE is developed by RaM at the UT?
- Extra points specific to the one idea like 'what is on the screen' or 'how does the maze look'

From these six perspectives, eleven ideas were formed that had a varying amount of variation possibilities. These 11 ideas, with their perspectives, in short are:

1. Perspective 1. *Choosing information 'game'*; There is a small maze that the PIRATE can ride through. Each part of the maze shows some different information about the PIRATE. The user controls the PIRATE's direction and with that can choose the information they see.

2. Perspective 1. *Simple 'push play' interaction*; The PIRATE moves itself through a pipe while information is shown. The user interacts with the artifact by pressing the 'play' button to start the PIRATE's movement.

3. Perspective 1. *Race against other inspection options*; Multiple inspection options are represented on the artifact (human with dog/PIRATE/PIG/possibly more). The user chooses an inspection option and tries to beat the other options in things like speed, efficiency, movability, safety, etc. Multiple users can interact with this artifact at once.

4. Perspective 1. *Marble run*; The PIRATE moves through a 'marble run' type of construction. Each part of the marble run would present some information. The user interacts with this artifact either by pushing a start button, or by tilting the marble run in order to get the PIRATE to their desired destination.

5. Perspective 2. *Looking through the front piece*; A very big version of the front module of the PIRATE is attached to a screen so you can look through the front module and see what the PIRATE would normally see on the screen. The screen would show the inside of a pipe. The interaction would be that the user starts the artifact but nothing more.

6. Perspective 2. *Find the damage 'game'*; With the same set-up as the previous idea, but with an added part on the screen showing the 'maze' of pipes. The interaction is that user guides the PIRATE through the pipes to find if there is damage.

7. Perspective 3. *Robot coming from the pipe, inspecting you*; The front module of the PIRATE is coming from a pipe, moving around to look at its surroundings.

8. Perspective 3. *Robot follows you through a maze*; The PIRATE is looking at the user and by tracking their movements the PIRATE moves through the pipe 'maze'. The PIRATE could possibly even react to users that are not actively interacting with the artifact.

9. Perspective 4. *Disassembled PIRATE on the table that has to be re-assembled by the user*; The user gets an array of parts that can be put together to create an inspection robot. These parts are 1:1 based on the actual PIRATE and have been 3D printed to make them accurate. Parts are both the different parts of the outside shell and a simplified version of the electronics (that are also 3D printed)

10. Perspective 5. *PIRATE looks at you interacting with the artifact*; While the user is interacting with the artifact, the PIRATE (1:1 3D printed version) keeps looking at them and reacting to what they are doing. The PIRATE could move its front module in order to look at the user. This idea has to be combined with another idea. Ideas this could work with are 1, 3, 4, 6, and 9.

11. Perspective 6. *Floor projection of a pipe maze that the user has to manoeuvre through.* The user is the PIRATE that has to find its way through a maze. The interaction is that the user physically walks through the projected maze.

For a more in depth explanation of the ideas, and to see all the variation options, go to appendix B3.

Convergence phase
In this phase of ideation all the generated ideas will be narrowed down until there is only one idea left. Because the ideas generated have multiple variations, these variations need to be narrowed down as well. The goal of this phase is to find out which idea is the best in order to start the specification phase.

To determine which ideas were favoured by the stakeholders of this project, Mathijs Kossen and Edwin Dertien were contacted. Mathijs Kossen is part of the innovation team at Vopak. From talking with him two clear favourites were found. These two ideas were: *choosing information game*, and *find the damage 'game'*. From talking with Edwin Dertien a method was chosen to narrow down the variation possibilities of these two ideas. This was done based on, among other things: feasibility, durability, cost, and how well it would accomplish the five factors that are important for the artifact. These best variations can be seen on the next page in table 4.

Table 4: Best variations of the top 2 ideas

	Choosing information 'game'	Find the damage 'game'
Short description	There is a small maze that the PIRATE can ride through. Each part of the maze shows some different information about the PIRATE. The user controls the PIRATE's direction and with that can choose the information they see.	With the same set-up as the previous idea, but with an added part on the screen showing the 'maze' of pipes. The interaction is that user guides the PIRATE through the pipes to find if there is damage.
Representation of the PIRATE in pipes	Miniature printed version in small pvc pipes, the whole thing could possibly look like a small architectural model of a part of Vopak	The PIRATE in the pipes is a 1:1 3D printed model
1:1 model of PIRATE	Paced at the same place as the RaM/UT logo (on the artifact), either full model or half with a mirror.	
Presentation of information	Projected next to the pipe's/ small screen on the table	• On the screen that also shows the inside of the pipe (could be scrolling text/ still text/ video with or without sound/ etc.) • Printed next to/ on the artifact
Interaction	Arrow buttons to move the PIRATE around, they could light up to show which are possible to click. A joystick is also a possibility	• When the artifact detects movement it starts the video on the screen. • User moves the PIRATE through the pipes using a joystick, or a set of buttons. To know which way to go, the pipe lay out is shown as a map on the screen. Where the user has been will turn a different colour.
RaM/UT	• Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be) • Talk about in one of the information parts	• Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be) • Talk about in one of the information parts
Get attention	• Reacting to movement • Change blindness	• Reacting to movement • Change blindness
Keep attention	• With the interaction chosen. • By making it work well, no glitches. • By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc. • By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)	• With the interaction chosen • By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.) • The 'maze' could possibly be different every time. (only works when it is shown on the screen, not as LED's) • By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.
Point specific to the idea	Maze: 2D, on a table or against a board (but with 3D entering point and exiting point) This means that the maze is laying flat on a table	What the screen shows: • The inside of the pipe • The data the PIRATE would collected • Information about the PIRATE

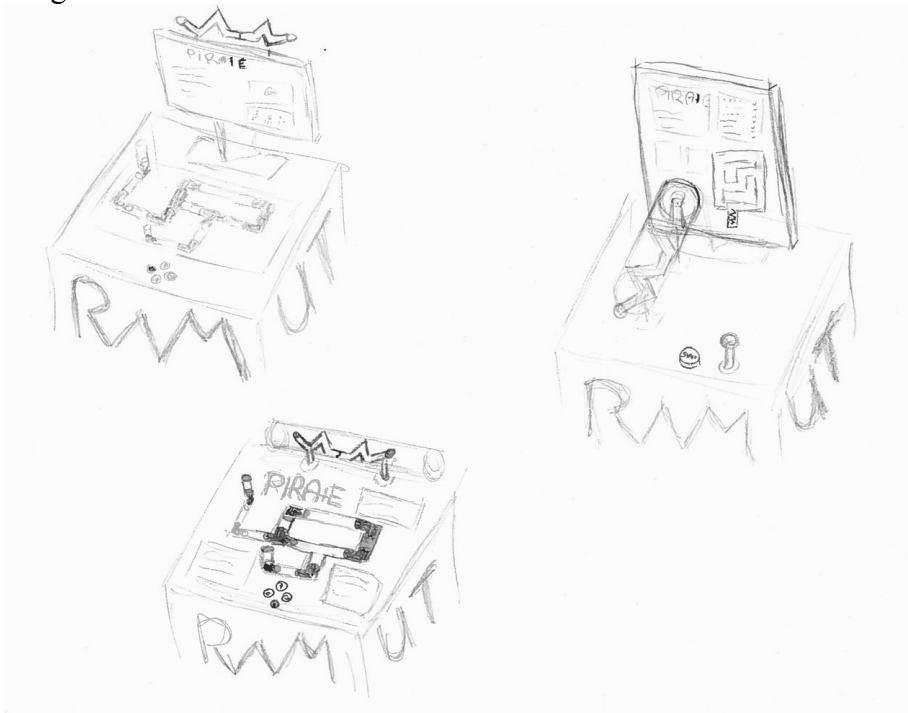In order to have a better grasp on the ideas they were roughly sketched. These sketches can be seen in figure 23-25.
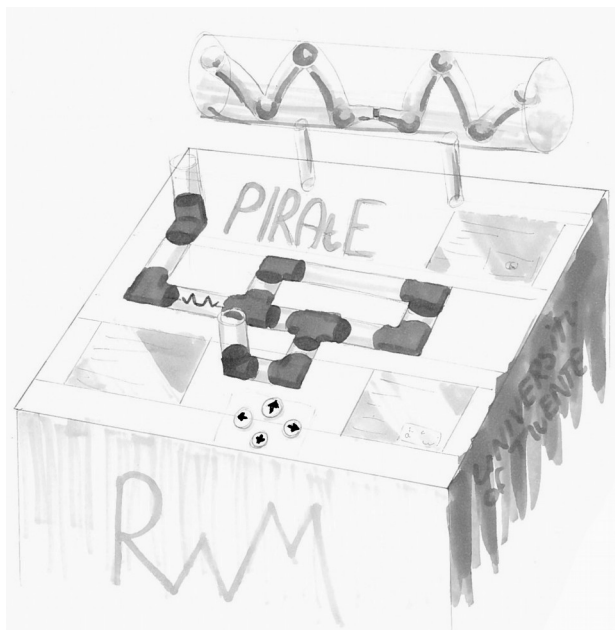

Figure 23: First rough sketches

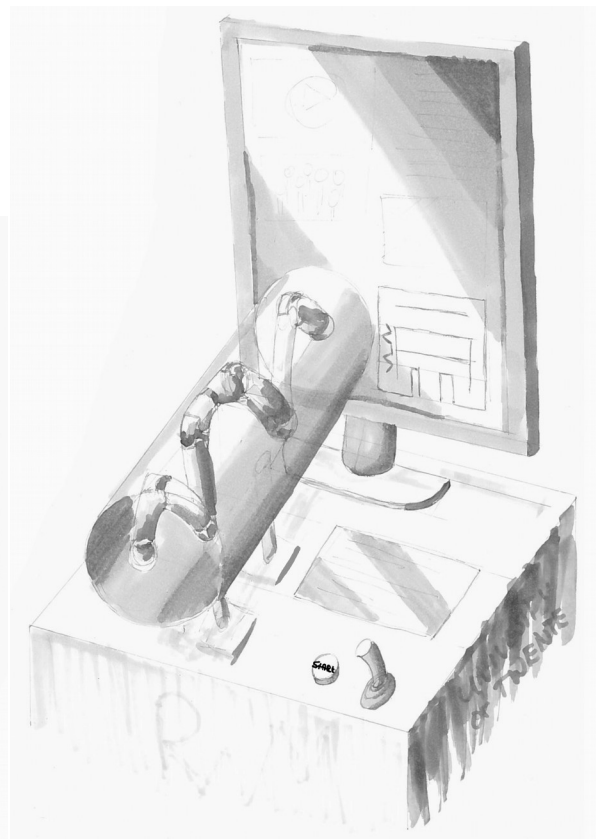*Figure 25: Sketch idea "Choosing information 'game'"*

Figure 24: Sketch idea "Find the damage 'game'"

To figure out which of the two ideas would work the best for this project they were analysed. This was done by looking at al the important features of the two ideas, rating them on a scale from 0 'bad' to 5 'good', and giving each feature a weight of importance from 1-3. How this was done can be seen in the following table:

Table 5: Rating the top 2 ideas

	Choosing information 'game'	*Find the damage 'game'*	weight
Feasability	3	4	2
Feasability of a less interactive version	3.5	5	1
Durability	3	4	2
Cost (0 is most expensive 5 least)	3	4	1
Engaging	4	2	2
Clear/informative	4	4	2
Attention grabbing	4	3	2
Visually pleasing	4	2	2
Innovative	4	3	2
Amount of different information shown	5	3	1
Most important information is focus	3	5	2
Preference Vopak (1-2)	1	2	2
Preference Designer (1-2)	2	1	2
Total (with weight taken into account)	75.5	73	

As can be seen, both ideas are very close with their total score. This theoretically means that both ideas would work for this project. As can be seen, Vopak and the Designer have a different preferred idea. Something that is important to note here is that Vopak's preference is only slight. This means that, because of its slightly higher score, *Choosing information 'game'* is the most logical choice.

Chapter 6: Specification

In the ideation phase the choice was made to continue with the *choosing information 'game'*. In order to be able to go into the realisation phase it is important to go through the specification phase. In the specification phase all the details of how the artifact will turn out get as thought out as possible without actually building it. This is done by, among other things, determining when the artifact is successful and figuring out the final design. In order to be sure of RaM and Vopak's approvals of the artifact, everything that is done in this specification phase was thoroughly discussed with Edwin Dertien, Mathijs Kossen, or both of them.

When is the artifact successful
It is important to determine what would make this artifact a successful one. When the artifact is successful is determined by the five previously stated factors. These factors are the most important part of the artifact. When the artifact full fills these five factors it is successful.

These five factors are that the artifact needs to:
1. get attention
2. be easy to figure out
3. keep attention
4. be informative
5. not be annoying

Must/should/could haves
In order to accomplish these factors successfully multiple things are needed in the artifact. To determine which things are most and least important a must/should/could haves list was compiled:

Must have:
- movable PIRATE by buttons or joystick
- a start button, a stop button, and a possible skip button (the skip button could allow the user to skip some information that they are not interested in that might take a while to look at)
- room for information to be shown on the table
- a logical information layout within the pipe maze
- a 3D representation of the pipes on the screen
- a 1:1 model of the PIRATE in a pipe
- artifact has to be easy to take apart, to fix broken parts and/or to replace the screen
- parts have to be easy to be replaced, therefore there must be little to no soldering
- a simple way for the user to see which track tells which information
- possibility for people from RaM to add/replace information
- UT and RaM logos on the artifact
- the PIRATE moving around when no one is interacting, for change blindness.

Should have:
- light underneath the 1:1 model that slowly turns on and off for change blindness
- light inside the buttons to show which buttons can be interacted with at what time
- a nice looking table top with things like a puppet, a fake terminal, fake grass, etc.
- a more stylistic and nice looking way for the user to see which track tells which information.

Could have:
- reaction to movement, to start the PIRATE driving around in the maze when a user walks by
- only one cable to connect to a power source
- the table starts itself up when it is connected to a power source

In a meeting with Edwin Dertien this list was discussed. It was discovered that making the movable PIRATE a small scaled moving 3D model not a feasible or a durable idea. It would take way to much hardware and software work to get it working and it would be very fragile. A good solution to this would be to have the PIRATE be an animation on a screen that is underneath the pipes. The screen outside of the pipes would need to be covered with something like fake grass, leaving room for information, to give the illusion that the pipes are coming from the screen. This would give the same feel as the physical small scaled model with less work and way better durability. This change would make the artifact more expensive though, because now there would have to be put in a big screen instead of a few small once. Mathijs agreed with this and it was determined that durability and feasibility are more important to Vopak than it costing some extra money.

Construction of the table

In order to be able to build the table, the basic structure of the table needed to be figured out. This was done by making a Solidworks model. This Solidworks model only shows the wooden structure of the table itself. In addition to this structure the table will stand on wheels and the outside will be covered with black fabric. The top of the table will also have a 1:1 model of the PIRATE, fake grass, halved plastic pipes, information indicators, buttons, and a little playmobil Vopak employee. Screenshots of the Solidworks model can be seen in figures 26-29.
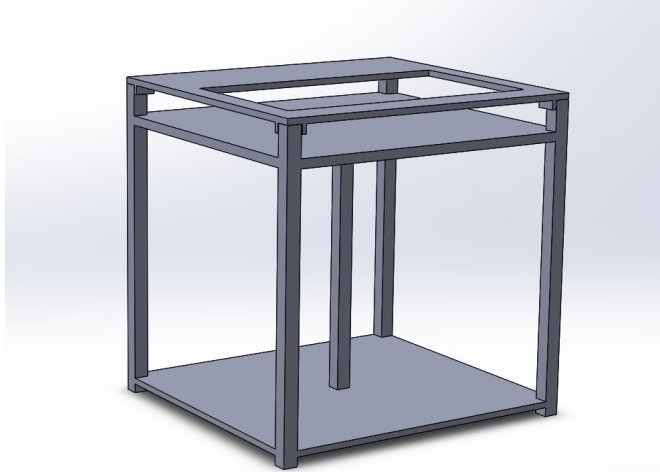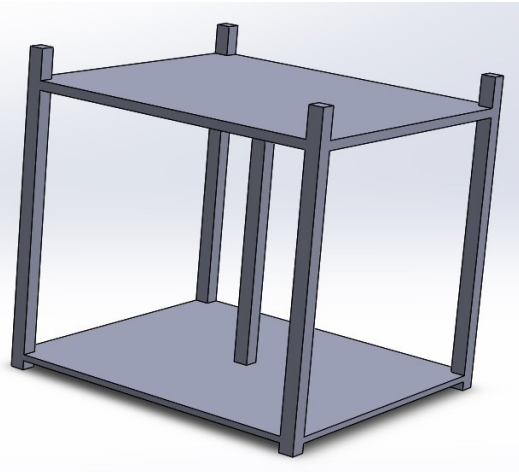

Figure 26: Assembled table
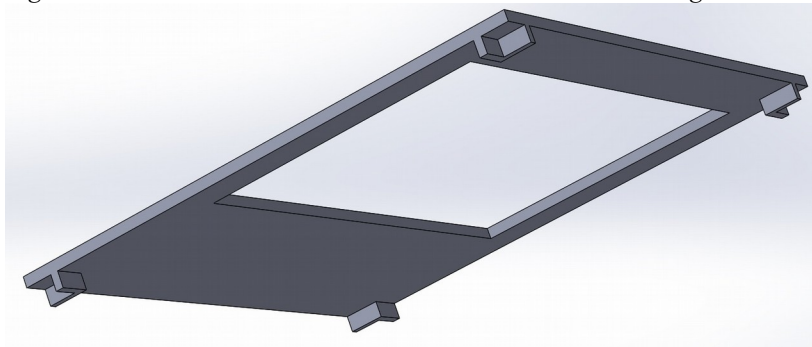

Figure 27: Table without top layer
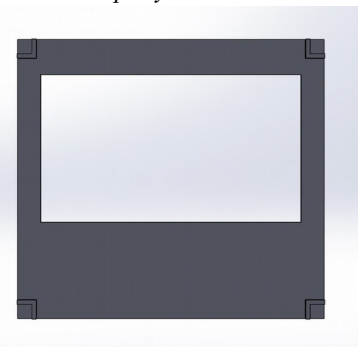

Figure 28: Top layer

Figure 29: Top layer bottom view

The table will have three layers. All the unseen electronics will be on the bottom layer. This layer is also for extra sturdiness so the legs of the table will not separate. The screen will lay flat on its back on the second layer. The third layer will have a big hole that will show the screen. This layer will hold things like the buttons and the 1:1 model of the PIRATE. This top layer is also detachable for easy access to the screen. Both the bottom and the second layer will be made out of a thicker wood to be able to hold enough weight. The top layer will be lasercutted out of thinner wood because it needs to be more accurately cut and does not need to hold a lot of weight.

There are five legs in this table. This way the heaviest point, the middle of the table where the screen will be, is supported by the fifth leg. There will also be five wheels underneath the table. Because of this the plates used for the bottom and second layer can be thinner than if there were only four legs and four wheels.

This plan for the construction of the table was discussed with both Edwin Dertien and Mathijs Kossen to make sure that they agreed with it. While talking with Mathijs it was concluded that it would be a good idea to purchase a screen for the table instead of borrowing one from the University of Twente. This would be better because it would mean that the project would be able to almost instantly move to the innovation lab and Vopak when the graduation semester was done.

User interface

With this artifact the user interface consists of how the user will interact with the artifact and how clear it is what each action will do. This means that the things that are part of the user interface are: the button layout, the maze layout, the information layout, the thing that makes it clear which information is where. In order to make a good user interface all these things need to be carefully thought out.

Button layout

As stated before, the artifact must have a start button, a stop button, a possible skip button, and buttons or a joystick. These buttons need to be placed perfectly to make the artifact as easy to use as possible. For the following analysis it will be assumed that arrow buttons will be used. If it turns out that a joystick would be a better choice the arrow buttons can easily be replaced with a joystick because navigation buttons/joysticks are usually in the same spot no matter which is chosen.

For the buttons there are two possible layouts (four if you count the presence of the skip button) were found that can be seen in figures 30-33. The green button = start, the orange button = skip, the red button = stop, the grey buttons = arrows.
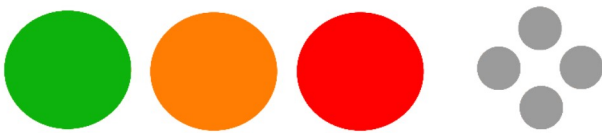

Figure 30: Option 1 with skip button

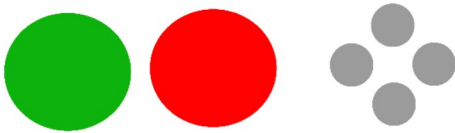*Figure 31: Option 2 with skip button*

Figure 32: Option 1 without skip button

Figure 33: Option 2 without skip button

There are three things that are the same in the possible layouts, the placement of the start button all the way to the left, the four arrow buttons being in the same formation, and the skip button being the second button from the left.

The reason that the most logical place for the start button is always on the left is that the artifact will be used by people that read from left to right. With the start button being on the left and people reading from left to right people will automatically find the start button as the first button to press.

The reasons that the arrow buttons are always in the same formation is because this is the most universally used lay out for buttons like this on game controllers, see figure 34. Because this is such a universally used lay out, it will be familiar to most if not all users of the artifact. This layout does limit the size of the buttons in order to fit them on the table.

Figure 34: Universal controller button layout

The reason for the skip button always being the second button from the left is different for both layouts. The reason in the first layout possibility is that, with the start and stop button being next to it, it is both grouped with buttons that have a similar function and it is in chronological order with them. The reason for the placement of the skip button in the second layout possibility is that it is now grouped with the four arrow buttons, making this layout in chronological order as well.

The difference with the two layout options is the placement of the stop button. Both layouts can be argued as the best option for the following reasons. The first layout is better because it groups all the buttons by size, making it look more logical to the eye when the skip button is also there. This first layout also groups the buttons together by function. The buttons that control movement are together and the buttons that control the state of the artifact are together. The same game controllers mentioned earlier do this as well. Some examples of this can be seen in figure 35 where the start button is always grouped with the select, back, or home button.

Figure 35: Grouping of similar buttons on controllers

The second layout is better for other reasons. The first reason is that in this layout everything is in chronological order, making it easy for the user to follow what to do when. Since making the user interface as easy to use as possible is a very important thing, this is a big plus for the second layout. The second reason is that this layout looks more visually pleasing when there is no skip button added. This layout does have the downside that it looks a bit awkward when the skip button is added.

From all of this it can be concluded that the first layout is better when there is a skip button, because the second layout looks awkward with the skip button, but when there is no skip button the second layout is only slightly better because it has the buttons in chronological order. So in order to determine the best button layout it first needs to be tested if a skip button is beneficial for the user interface. This will be done later in this chapter when a paper prototype is made and user tested, but before that some other user interface aspects need to be figured out.

Maze and information layout
In order to figure out the pipe layout the information that will be going into the artifact needs to be determined. This was done by establishing which information needs to be told in order to understand the PIRATE. By doing some brainstorming and some consultation with Edwin Dertien it was determined which information would roughly be in the artifact. The information was chosen on how interesting it would be, how brief it would be, and what message it would give to users. This means that subjects like 'Where will the PIRATE be used in the future' are not chosen because of irrelevance and subjects like 'When will the PIRATE be finished' were not chosen because it would put a hard deadline on the RaM team that could be misleading. The final subjects chosen were the following:
- Start: a short summary about the PIRATE.
- Option 1: How does the PIRATE move?
- Option 2: How does the PIRATE detect problems?
- Option 3: Who created the PIRATE?
- End: Implementation at Vopak.

While choosing these subjects, the placement on the maze was already taken into account. The maze would consist of a starting point, three possible middle tracks to chose from, and an end point. However, because the information that would need to go into the artifact does not yet exist, the artifact will be build in a way that allows someone else to put information into the artifact. This means that these five information tracks could possibly change over time. Because the information tracks are not permanently determined it will be impossible to decorate the table with a more abstract indicators that show the user which information is in which pipe track. Therefore, the only possible way to indicate which information is where is by showing it on the screen.

Regarding the maze layout, there are two main possibilities. These two possibilities are that the pipes leave the screen or they do not. One example of each of these possibilities can be seen in figures 36 and 37.
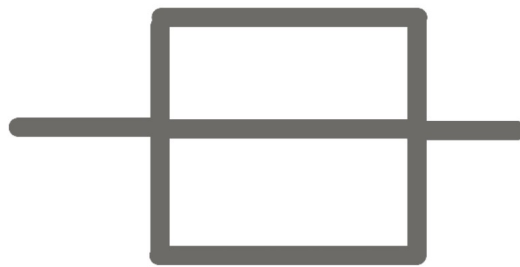

Figure 36: Maze layout option 1   *Figure 37: Maze layout option 2*

Both possibilities have their positives and negatives. Where the pipes leave the screen would be a more realistic representation of how pipes are actually laid out because pipes normally do not split and come back together like in the second possibility. A big negative to the first possibility is that it is very user unfriendly. It is unclear how you would get from one path to the other. This means that there would need to be many indicators to help the user with this, making it a more complicated interface. This is not a problem with the second possibility. The second possibility not being an accurate layout for real pipes does not have to be a big problem. It is made less of a problem by making sure the user knows that this is not an accurate layout and this can be done with things as simple as adding other slightly inaccurate things around it, like some fake grass and a small puppet with a Vopak helmet on. Because user friendliness is more important than accurate representation of the pipe layout, the second possibility was chosen.
Within this second possibility there are still many possible variations. A few of those can be seen in figure 38.
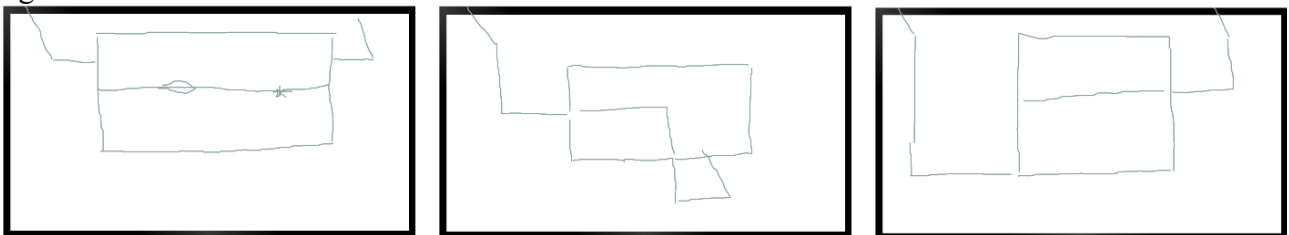

Figure 38: Maze layout option 2 variations

Interface wise, the options with a start, end, and three parallel middle tracks looks the most logical so this will be used. The height placement of the start and the end tracks is something that will depend on the size and shape of the screen that the pipes will be on. This is because the pipe layout will need to keep enough room on the screen for information.

Information indicators

It was previously figured out that the information tracks would be: a short summary about the PIRATE, how does the PIRATE move, how does the PIRATE detect problems, who created the PIRATE, implementation at Vopak. It was also stated that this information is not yet existent and will be added later on by someone else. This might mean that the information tracks will change in the future, resulting in a need of customization ability. In order to have the information tracks customizable there can not be any complicated to customize physical indicators to show the user which information is in which pipe. However, it is safe to say that the end track will keep the same information, so this track does allow for a non customizable physical indicator.

The easiest form of customizable indication is showing it on the screen. This way it can be easily changed in the code of the artifact. There are roughly three options of indication on the screen. The first is by simply showing the header of the information in text on the screen inside the pipes. This option is very clear and obvious to the user but it is not very fun to look at. The second option is showing a picture that represents the information next to the pipes. This would be less clear and obvious to the user, it would require a space next to the pipes to not be covered by fake grass, but it is more fun to look at. The last option is to show what the information is about with pictures inside the pipes. This combines both options strong points but it does limit what kind of pictures can be used. It might also look a little strange to have pictures inside the pipes. Pictures are also harder to customize than text. Another big factor in seeing which option is best is ease of customization. Text is by far the most customizable option. When the text needs to be changed it would take seconds, while changing pictures means that someone needs to make a new digital picture before being able to change the pictures. This makes text the most obvious choice when going with a digital indicator.

Indicating the information with a physical object is also an option. This physical object can be a more abstract object or a simple sign with written text on it. The sign is obviously more easy to customize if the sign is made in a way that the written text can be easily changed. The big problem with this option is that it is easily vandalized, every person can change the text as they please. This can be avoided by making it slightly harder by laser cutting the signs for example. Laser cutting a small sign is nearly costless and a laser cut sign is way less easy to vandalise.

The end track does allow for a non customizable indicator. This is not required but could make the table look more interesting. This non customizable indicator can be small scale objects associated with Vopak, something with the Vopak logo on it, or a small puppet dressed like a Vopak employee. The small Vopak employee is the most logical choice out of these options. This is because it would be easiest to make out of all three of them and would indicate that the information is most interesting to Vopak employees.

Paper prototyping and user testing

Now that the interface has been thoroughly worked out, there are still a few uncertainties that need to be figured out. These uncertainties are the need for a skip button and whether four arrow buttons or a joystick would work better. It is also important to verify that the designed interface so far works well, if small changes need to be made, or if it should be done completely differently. In order to figure these things out two things need to be done. First a paper prototype, or simplistic representation of the future user interface, needs to be made and then this prototype needs to be user tested.

Making everything needed for testing

To test if a skip button was a useful button it was chosen to use the button layout with the skip button in it and see if users would use it. If the interface was understandable and comfortable to use was tested using a questionnaire. To find out if people would prefer a joystick it was observed how users got along using the buttons and it was asked in the questionnaire if a joystick would have made interaction easier.

To make the paper prototype the website marvelapp.com was used. This website was chosen as the platform for this paper prototype because it is easy to use, specifically for making paper prototypes for interfaces, and has previously been used by the designer multiple times. One big down side to this website is that it is not capable of showing animations. To minimize this problem the instructions for the user test need to state that animations will be there in the final artifact and that the user will need to imagine them for now.

The way that marvelapp works is like a slightly smarter power point presentation. To create a prototype in marvelapp you create pictures of all possible button press outcomes and upload them. Then you tell marvelapp which picture needs to be shown when every possible button is pressed in every possible state. Three examples of pictures in the paper prototype can be seen in figure 39.
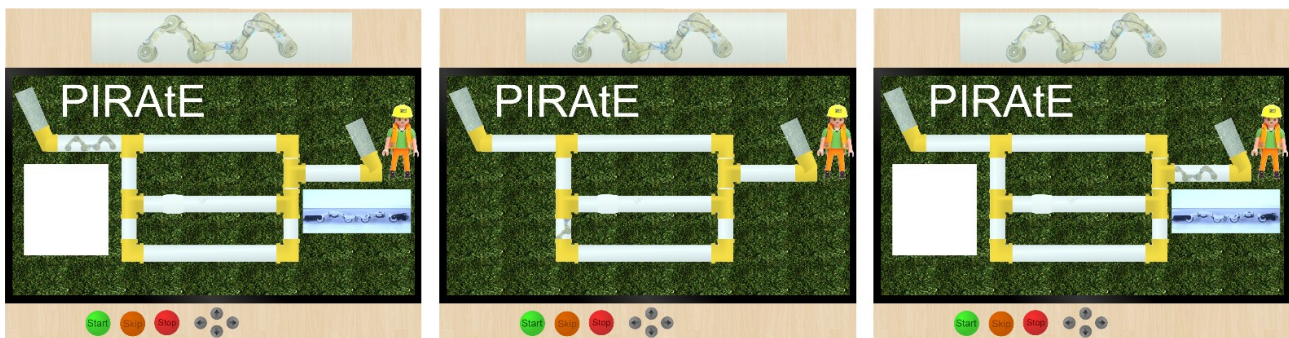

Figure 39: paper prototype

One mistake was made while creating the paper prototype. This mistake is forgetting to put in the text indicators so the user would be able to see which information goes where. This problem was partially fixed by telling the user in the instructions what each track stood for, but this was still a little bit more confusing that if it would have been written directly on the prototype.

In order to be able to test the paper prototype both an instructional text, with a short explanation and some assignments, and a questionnaire needed to be made. The created instructional text can be found in appendix C1 and the created questionnaire can be found in appendix C2.

<u>Results</u>
Over the course of two days ten users were tested. The complete analysis of the user test, both notes that were made during testing and the results analysis, can be found in appendix C3 and C4. Even though the assignments were sometimes no completely clear and/or hard to complete, some things can be concluded from this test. While navigation was mostly clear the way it was made and the navigation buttons were mostly seen as easy to understand. People mostly agreed/were neutral about whether changing out the arrow buttons for a joystick would be better. Nearly no one used the skip button. This resulted in most people agreeing that the skip button was redundant and was not very useful. Overall people were mostly positive about how easy the interface was to understand, how well it was designed, and that the people mostly felt comfortable while using it.

Looking at these results it can be concluded that the overall interface is good but that a skip button is not needed. It is also clear that a joystick would not necessarily be better to use than arrow buttons. Due to a joystick bein more complicated to program it can be concluded that arrow buttons should be used.

Even though it was possible to conclude something from this research it must be said that there are a few flaws that might make it less credible. That this paper prototype shows that there is no need for a skip button might be because it has no animations or information to be skipped. When the final artifact is build it might show that users would like to use a skip button to skip the animations and information that was not in the paper prototype. This is because these animations and information would slow down the interaction, giving the user the need to maybe skip something. However, this problem is easily solved when users would be allowed to skip animations or information by clicking the navigation buttons in order to move forward, past this animation or information. This is what users were doing in the paper prototype too and this would still work and be understandable in the final artifact.

Needed materials

From going through all the previous steps in this specification phase the following list of materials could be constructed:

(not including screws, glue, and sewing thread)

Table 6: List of needed materials

Wooden structure of the table: • 2 thick plates: 100 by 110cm • 5 long table legs: 66,5cm • 4 short table legs: 10,5 cm • Lasercutted top plate
Outside of the table: • Black, non stretch, fabric: little over 310cm by 86,5cm • Netted fabric: little over 110cm by 86,5cm • 5 swivel wheels that can lock capable of supporting more than the weight of the table
Top of the table: • 1:1 3D printed model of the PIRATE in a clear pipe • Clear piping: 40mm outside parameter, +/- 3 meters • Opaque pipe connector pieces: 40mm inside parameter, 4 corner pieces, 4 T pieces. • Fake grass: 110cm by 100cm • Lasercutted information signs • Playmobil construction worker
Harware: • The screen: 43inch, flat, and with removable stand • 2 big buttons: a green 'Start' button and a red 'Stop' button • 4 small buttons as navigation buttons • Arduino for receiving the signals of the buttons • Computer to run processing • Cables

Chapter 7: Realisation

The aim of this realisation phase is to build a prototype based on the idea created in the ideation phase and specified in the specification phase. This prototype will have three main parts that need to be built: the physical table, the hardware, and the software. These three parts are built simultaneously but are discussed separately in this thesis. In addition to these three parts it is also important that a manual is made for the people that will be moving, setting up, changing the information, or switching the table on in the future.

Design priorities

Before delving into building the table itself it is important to have clear design priorities for developing the structure, hardware and software. Whenever a choice is made while building the table these design priorities need to be kept in mind. Most of these design priorities have already been touched upon in the specification phase. The design priorities, in no particular order, are:

- It is easy for the user to understand how to interact with the table
- The table is sturdy
- The table is portable
- Parts are easy to replace when needed
- The information inside the table is easily changed

Structure of the table

The structure of the table is built out of three main parts: the skeleton, the outside, and the top. How each particular part was made and the choices made in the process will be discussed in this section of the report.

Skeleton of the table

To build the skeleton the Solidworks model created in the specification phase was used as a starting point. First the two bottom layers were screwed together and the wheels were attached. The wheels used are chosen based on their price, whether they can be locked, whether they can carry the weight of the table, and whether they will stick out from underneath the table. How the table looks after adding the wheels can be seen in figure 40.
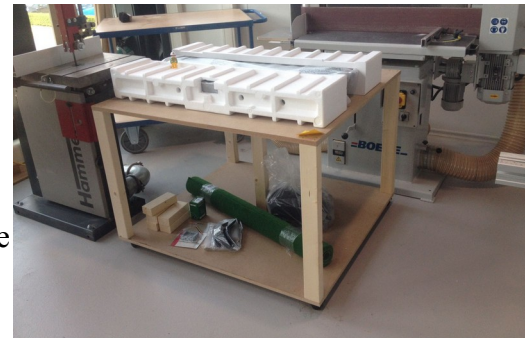
Figure 40: Two bottom layers of the skeleton

There were two ideas as to how to attach the screen to the table. The first idea is to screw small legs to the back of the screen for it to lay flat. This way of attaching the screen is not stable enough and therefore the second idea was used. To have the screen lay flat the foam packaging that the screen was delivered in was used. How the foam packaging looked after cutting it in a way that it would allow the top layer to lay flat on top of it can be seen in figure 41.
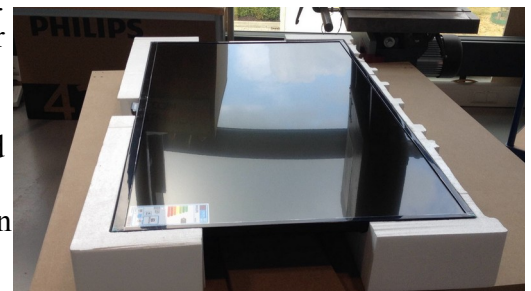
Figure 41: Foam casing of the screen

The top layer was lasercutted out of 6mm thick wood. This thickness was chosen because it was the biggest thickness, to provide the most sturdiness, that would still fit the buttons. Because the lasercut machine at the University of Twente is not big enough to do the top in one go, it needed to be in two parts. To make them attach easier they were given merlons. While making the lasercutted top it was very important that everything would fit perfectly leaving the top almost seamless. To do this the screen and buttons were perfectly measured. However, a mistake was made while transferring the measurements into Solidworks, leaving the hole for the screen not wide enough, see figure 42. This was easily fixed by cutting out the hole with a table saw. The digital lasercut pictures of the tabletop can be found in appendix D1.
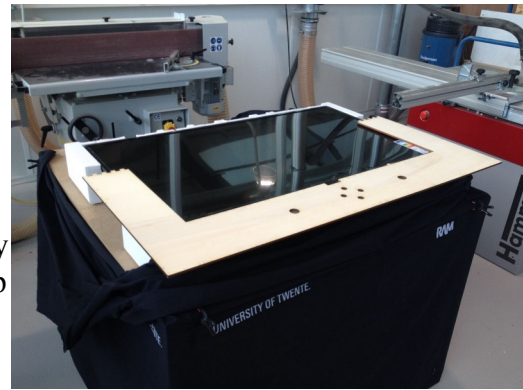
Figure 42: Lasercut mistake

The tabletop was glued together and small reinforcement pieces of wood were screwed on. Four short table legs were screwed on to the table but this turned out to not be stable enough to be able to prevent the tabletop from breaking when someone would lean on it. Therefore it was decided to have nine short table legs, one on each corner, one in the middle of the back and sides, and two in the middle at the front. The front needed to have two short table legs because it was impossible to place one in the middle due to the buttons being there. This resulted in what you can see in figure 43.
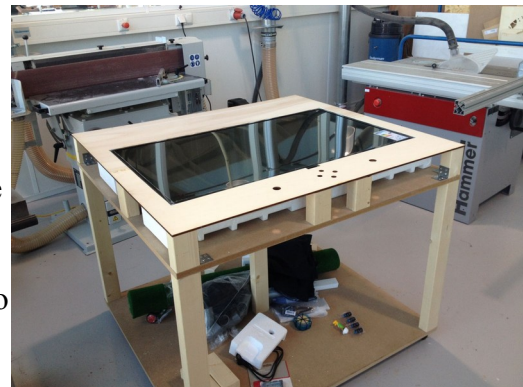

Figure 43: Finished skeleton

To make sure that the tabletop would always fall back into the exact same position after it would have been removed, small splints were added underneath that would perfectly fit around the corner table legs. This was already planned in the Solidworks model. A picture of one of these corner splints can be seen in figure 44.

Figure 44: Splints tabletop

Outside of the table

In order do disguise all the electronics inside the table, the outside of the table needed to be covered in fabric. For this black, non stretch, fabric was chosen. This fabric is the perfect place to add the RaM and University of Twente logos. These logos were added to the fabric using a heat press and white foils. The logos were placed around the front two table legs.

If the entire outside of the table were to be covered in black fabric it would hinder the ventilation of the electronics. Because of this the back of the table could not be covered in the black fabric. To still disguise the electronics a little bit, and to prevent future users of the table from touching the electronics in the table, it was decided to cover the back of the table in a mesh fabric. For this the most basic non stretch black mesh fabric was chosen. To make it all look a little bit nicer and more finished the inside of the table was painted black, the effect this has can be seen in figure 45.
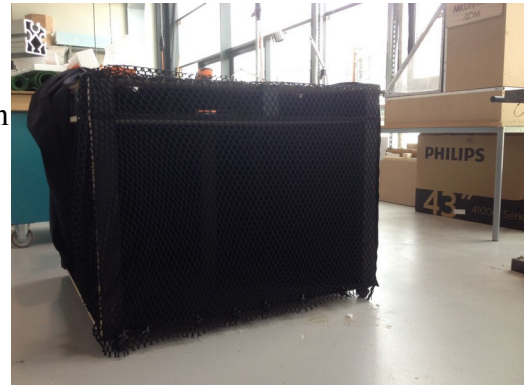
Figure 45: Back of the table, painted inside

Because the table still needed to be easy to take apart the fabric could not be permanently attached all around the table. This would not only hinder the taking apart of the table, but would also make it harder for the table to be lifted of the ground if needed. It was decided that the back of the table, with the mesh fabric, could be permanently attached without it hindering any of the design priorities but the black fabric could not be permanently attached.

To attach the mesh fabric it was stapled to the table legs and glued to the bottom of the table. This left the top of the fabric hanging awkwardly. To fix this it needed to somehow get attached to the top of the table without it being permanent. The method that was chosen for this was adding small screws to the back of the table top that would allow the mesh to hang on the screws. This allowed the mesh to nicely tighten without being permanently attached to the table top. How this looked can be roughly seen in figure 46.
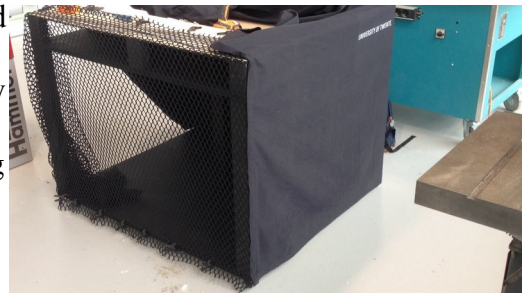

Figure 46: Tightend mesh fabric

To attach the black fabric to the front and sides of the table it was decided that to permanently attach one of the corners with staples and attach the fabric to the rest of the corners with velcro. The corner chosen to have the fabric attached with staples was the right back corner. The places that got velcro were the left back corner and the tops of all the small table legs. The one side of the pieces of velcro were attached to the table with staples and the other side of the pieces of velcro were sewn to the piece of black fabric.

Figure 47: How the velcro is attached

The long strip of velcro was attached using a sewing machine but the smaller pieces were hand sewn. This method was chosen to get better precision while sewing the smaller pieces. The way the long strip of velcro turned out can be seen in figure 47.

The fabric was hanging a little bit lose which created wrinkles and created some gaps at the sides of the top of the table. This can be seen a little bit in figure 48. To fix this problem the fabric was taken in a few centimetres near the long strip of velcro.
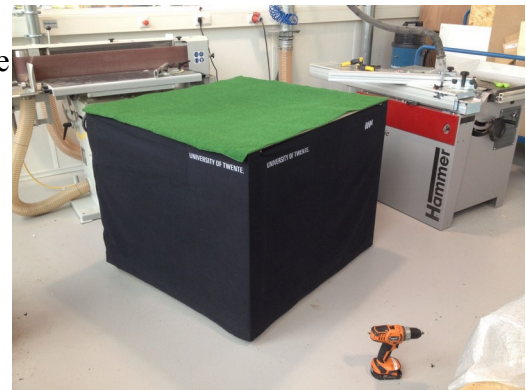

Figure 48: Wrinkly outside of the table

Top of table

The top of the table roughly consists of seven parts. These seven parts are the: indicator signs, miniature Vopak worker, buttons, 1:1 PIRATE model, pipe maze, fake grass, and the holes for information. These seven parts were worked on simultaneously but will be discussed separately.

The indicator signs were lasercutted out of 6mm thick wood and consist of two pieces. These two pieces are the stand and the sign. The stand would become permanently attached to the table but the sign needed to stay interchangeable in case RaM would decide that different topics would be better. The signs were first made in Solidworks, this was the easiest way to get perfect measurements, and then the text was added in CorelDRAW. The font chosen was Open Sans. This font

Figure 49: Lasercutted indicator signs

was chosen because it is easy to read, clean, but not too stiff. The digital lasercut picture of the indicator signgs can be seen in appendix D2 and the final lasercutted signs can be seen in figure 49. After the signs were lasercutted the stands were ready to be glued to the table.

In order to have an indication that the table was for Vopak without putting the Vopak logo on the black fabric with the University of Twente and RaM logos it was decided that it would be a nice idea to place a small Vopak employee on the table. This Vopak employee would be one of the employees that you see walking around with the Vopak logo on their helmets. This option would both look nice and would be a nice hint to the Vopak logo relating back to the hats of the Vopak workers of the past. This Vopak employee was made from a small playmobil construction worker, the exact model is 6961. The hat of this playmobil puppet was repainted to look like the Vopak helmets and then varnish was added to add durability and shine. The finished playmobil employee can be seen in figure 50. When this was all done, the playmobil employee was ready to be glued to the table near the sign indicating the information about implementation at Vopak.

Figure 50: Playmobil Vopak employee

The buttons are a very important feature of the table. They need to be very visible, easy to understand, and very inviting. The best buttons for this would be arcade buttons because they are bright, big, obvious, and satisfying to press due to their feel and clicking noise. The buttons that were bought did not have any writing on them however. This could be a problem with how easy the buttons would be to understand for the user, especially if the user would never have dealt with an artifact similar to this one or if the user were to be colour blind. Because of this, writing was added by cutting out white stickers with a Stanley knife, sticking them to the buttons, and then adding varnish. Varnish would make the stickers permanently attached and less prone to wear and tear while also adding a nice looking glossy finish. The finished result can be seen in figure 51. Once this was all done the buttons were ready for soldering and after soldering they could be easily attached to the table top because they can be screwed on.

Figure 51: Finished buttons with text

The biggest and most important feature of the top of the table is the pipe maze. This pipe maze was made out of approximately three meters of clear acrylic pipes with an outside diameter of 4mm and opaque PVC corner pieces with an inside diameter of 4mm. In order to know how long each piece of pipe needed to be, first the maze was laid out on top of the screen in pieces of paper. This can be seen in figure 52.
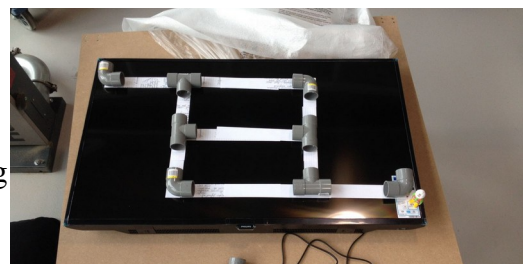
Figure 52: Paper layout of the pipe maze

After this the acrylic pipes were cut to the right length and then cut in half. The corner pieces were also cut in half, most of them in a way so they would lay flat on the screen and two in a way so they would stand up on the screen. Because it was impossible to accurately cut the pipes perfectly in half only one side of each piece could be used and the other half had to be thrown away. At this point the corner pieces were spray painted yellow. This was done because yellow is the colour for i.e. underground gas and oil pipes, see figure 53. These are the pipes that the PIRATE would be used for at Vopak.

Figure 53: Underground utility colour codes

All the cut and painted pieces of pipe needed to be sanded down. This was done to make the pieces lay perfectly flat and to make them fit together better. Sanding down the pieces of the maze was also done to prevent the maze from scratching the screen when they would be placed on the screen. After sanding the maze pieces they were ready to get glued together. It was very important that the pieces were glued together as straight as possible because this would make the coding process a lot easier.

Figure 54: Glueing the pipes

In order to get the maze glued perfectly straight on the table first a big piece of grid paper was laid down on the paper and a grid was displayed on the screen. With these grids perfectly aligned the maze was put on top of the grid paper and traced, see figure 55. Then the maze was cut out of the grid paper and put on top of the grass that was roughly cut to fit the table. With this grid paper on top of the grass the maze could be accurately glued to the grass. When the maze was glued to the grass it was time to cut away the grass behind the maze. This was done with a Stanley knife. Now all that needed to be done regarding the pipe maze was glueing down the grass to the table top.
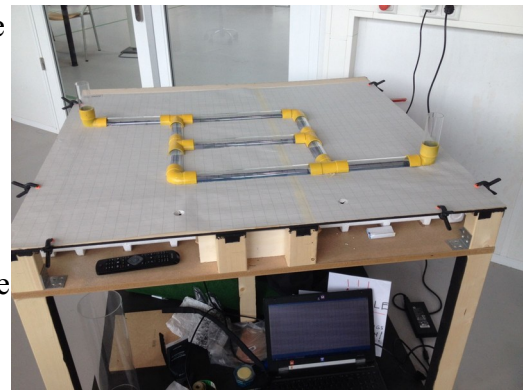

Figure 55: Aligning the pipe maze

For the 1:1 model of the PIRATE an old 3D printed show model was recycled. Even though this model was distorted, outdated, and discoloured it would still work to give the user a size reference. With a little bit of glue and some wires the 3D model was put back together and placed in a size appropriate see through piece of pipe, see figure 56. While putting the model back together close attention was taken to make sure that the model was still removable from the pipe. This was done to make sure that, if RaM or Vopak would want to replace the model, it would be possible to remove the model.
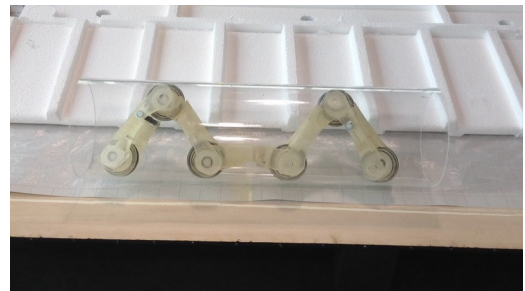

Figure 56: Put together 1:1 model

Because the model was discoloured it was coated with a layer of white paint. The pipe that the model would be in was glued to two grey pieces of pipe that would function as legs for the pipe to stand on, see figure 57.

Figure 57: Repainted 1:1 model

The sturdiest way of attaching the now created stand for the 1:1 model to the table would be by making the legs go through the table top and attaching it to the second layer of the table. The problem with this would be that, by attaching the stand to the second layer of the table, the table top would now not be removable any more. Because of this it was decided that the best way to attach the stand would be to still have it go through the table top but not have it be attached to the second layer. So two circles were cut out of the table top that would fit the legs of the stand perfectly. How everything looked at this point can be seen in figure 58.

Figure 58: Attached 1:1 model and stand

The way that the holes were cut in the grass for information was by first making a digital template to show on the screen, see figure 59. For this template it was chosen that it would be best to have one big space for written information and two smaller spaces for pictures or videos. The choice for two smaller spaces was made because this would optimise the use of the screen and it filled out the table nicely.
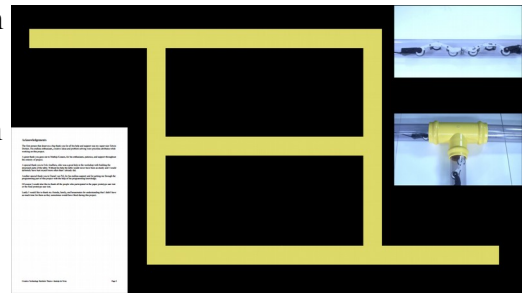

Figure 59: Digital template of the table top

The digital template was projected on the screen and a big piece of grid paper was placed on top of the table to outline the holes that needed to be cut out. This grid paper was placed on top of the grass and used to roughly cut out the holes. Now the grass was put back on top of the screen and, with the template showing on the screen, a piece of see through rubber on top of the screen for protection, and a small Stanley knife, the holes were precisely cut to fit the information holes. After this was all done the grass, the

Figure 60: Finished table top

information stands, and the Vopak worker glued to the table top resulting in what can be seen in figure 60.

With the structure of the table itself done, the final result of the table structure can be seen in figure 61. The finished table has the following dimensions:

Table 7: Table dimensions

Piece	*Dimension*
Height complete table without 1:1 model	87cm
Width compete table	110cm
Depth complete table	100cm
Height 1:1 model	18.5cm
Height wheels	5,2cm
Height long table legs	66,5cm
Height short table legs	10,5cm
Height thickness plates	1,8cm
Thickness table top wood	0,6cm
Thickness entire table top	0,8cm

Figure 61: Finished structure of the table

Hardware

The hardware of the table is relatively simple and only consists of five parts: the screen, a laptop, an Arduino, buttons, and connector pieces.

The screen that is inside the table is the 'Philips 43PFS4131'. This screen was chosen because it was completely flat, only had small edges, had a removable stand, and was the right size for the table.

This screen is connected to a laptop with an HDMI to HDMI cable. This laptop is an old HP laptop that is still in a good enough shape to run Arduino and processing code. Where the laptop is placed in the table can be seen in figure 62.

Figure 62: Laptop inside the table

The laptop is connected to an Arduino UNO. To prevent people from taking the cables out of the Arduino, the Arduino was put inside a little lasercutted box. The lasercut file can be seen in appendix D3.The box has three holes, one for the cable connecting the Arduino with the laptop, one for the cable going to ground, and one for the cables going to different pins. The box is glued together and glued to the table but the top of the box is still removable. This is so the Arduino can be replaced in case it breaks and so the cable could be reattached in case they come lose. The box can be seen in figure 63.
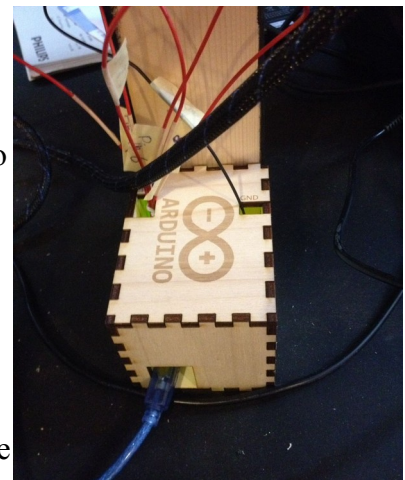
The Arduino is connected to the buttons. Between the Arduino and the buttons connectors are placed, see figure 64. These connectors are there so the buttons can be disconnected from the table without needing to touch the Arduino. The buttons would need to be disconnected if they break but also if the top of the table needs to get removed. The buttons and connectors have been soldered to the cables. How these parts are connected can be seen in the picture created in Fritzing, figure 65. To make it easy for people who need to disconnect and/or reconnect the different parts, each cable has a label attached to it at both ends.
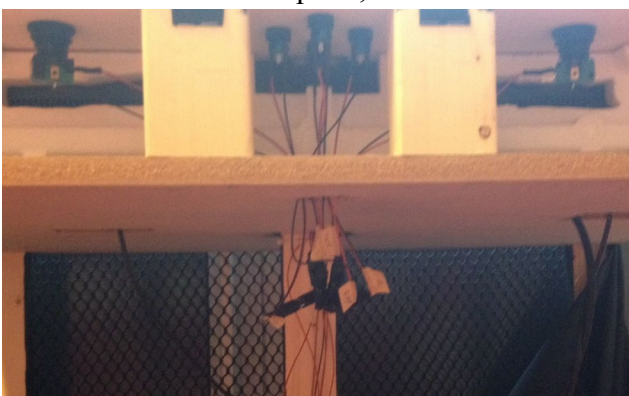

Figure 63: Arduino box
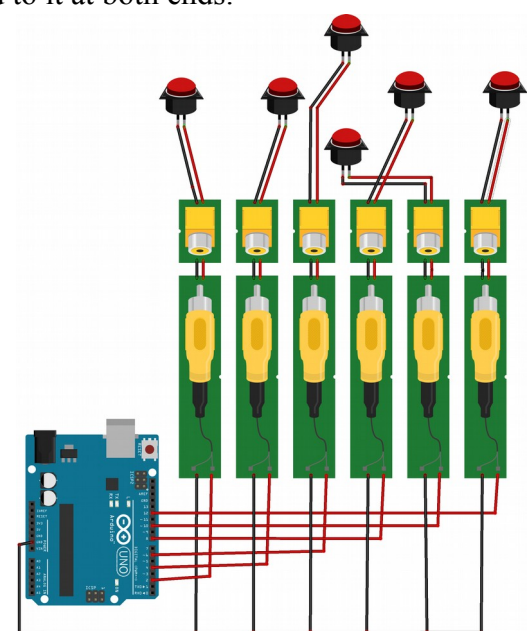

Figure 65: Buttons and connectors in the table

Figure 64: How everything is connected

The exact hardware materials that are inside the table are:

Table 8: Hardware materials inside the table

Material	*Specification*
Screen	Philips 43PFS4131
Laptop	Old HP laptop
Arduino	Arduino Uno
Start button	Big green reset button 40mm from tinytronics.nl Model: PBS-32-2-Green
Stop button	Big red reset button 40mm from tinytronics.nl Model: PBS-32-2-Red
Arrow buttons	Black reset button 16mm from tinytronics.nl Model: AB6Y-M-BLACK
Connectors	RCA male and female connectors

Software

The software part of the table will be explained in three parts. First it will be explained how all the visual parts in the processing code were aligned perfectly with the physical table. Second the Arduino code will be explained. Lastly the Processing code will be explained.

Aligning the visual digital parts of the table

After the pipe maze was glued to the grass, a template was needed of the screen layout. This template was needed for cutting out the places for information in the grass. The way this template was made was as follows. First the grass with the pipe maze was placed on top of the table. The following short piece of Processing code was used to trace the pipe maze:

```
void setup() {
  fullScreen();
  background(102);
}

void draw() {
  stroke(255);
  if (mousePressed == true) {
    line(mouseX, mouseY, pmouseX, pmouseY);
  }
}

void keyPressed(){
  if (key == 's'){
    save("Background.png");
  }
}
```

With this method the picture in figure 66 was drawn. This picture made it possible to make a much cleaner version and add in the places for information. This cleaner version could then be used as a template. This template was then used, among other things, as a template for cutting out the places for information in the grass. The template can be seen in figure 67.
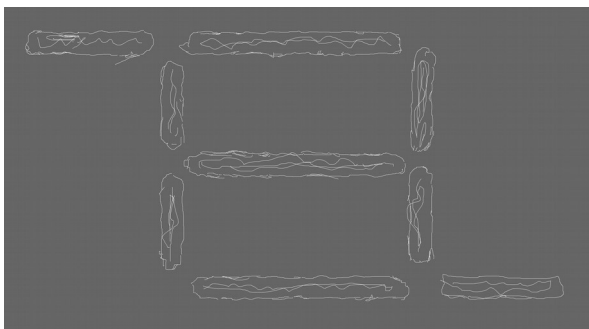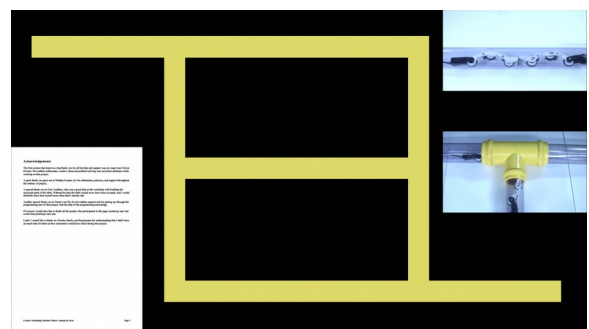

Figure 66: Digitally traced pipe maze

Figure 67: Digital screen layout template

This template was also used for other things. One of these things was determining within the code at which X and Y coordinates the information pieces should be and what their height/width was. The size for the information pictures and videos that would go inside the data folder was chosen to be 1920x1080px, or a ratio of 16/9. The size for the text pieces in the data folder was chosen to be 437x263px. Because it was not part of this graduation project to create the information that would go inside the table there was no real information created. For the evaluation phase later in this report, the table did get to have some information inside. This was stakeholder information that was quickly put together to create a feel for how the information would look in the final version.

The template was then also used in combination with looking at the maze on top of the screen. With this it was possible to determine what the X and Y coordinates of the corners, begin point, end point, and information points were. With looking at the template and looking at the screen it was also possible to determine how big the picture of the PIRATE would need to be. Both these things were done at the point that the Processing code was capable of moving around something through cases. To determine how big the PIRATE would need to be a circle was placed inside the maze and moved around, changing the diameter every time until it fit the maze perfectly. The X and Y coordinates within the maze were figured out by entering different X and Y coordinates until they matched the maze perfectly as well. This was made a little bit easier by adding a small piece of temporary code that made these X and Y coordinates visible on the screen. This code was commented out in the final version of the code and can be seen on the following page. How these coordinates looked on the template can be seen in figure 68.
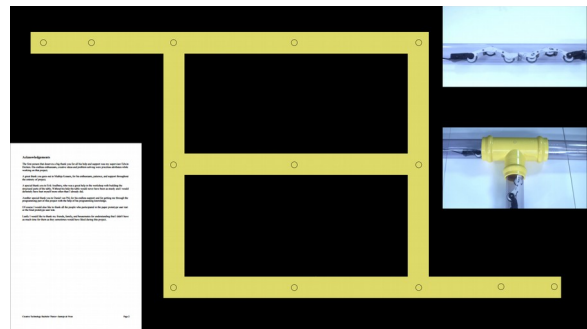

Figure 68: Digital template with visual coordinates

The template was not going to be the final background image for the table. In order to make a nice looking background image it was made in the program Gimp. The image was built up out off two layers. The first layer was the flat colours of the background and the second layer was see through grass and dirt textures. Making it in these two layers allowed customization of the flat colours so it was possible to make them match the table nicely. The final background image was then exported as a png and can be seen in figure 69.
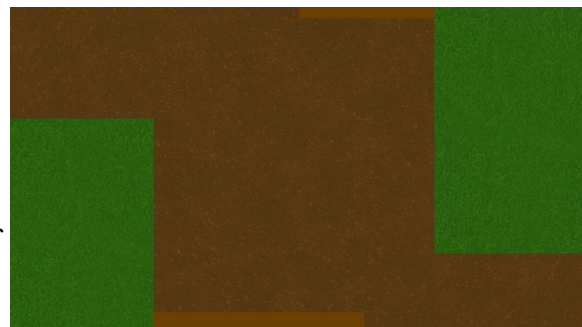

Figure 69: Final background

To create the image of the PIRATE that would go through the pipe maze, reference pictures of different versions of the real PIRATE were used. These pictures can be seen in figure 70.
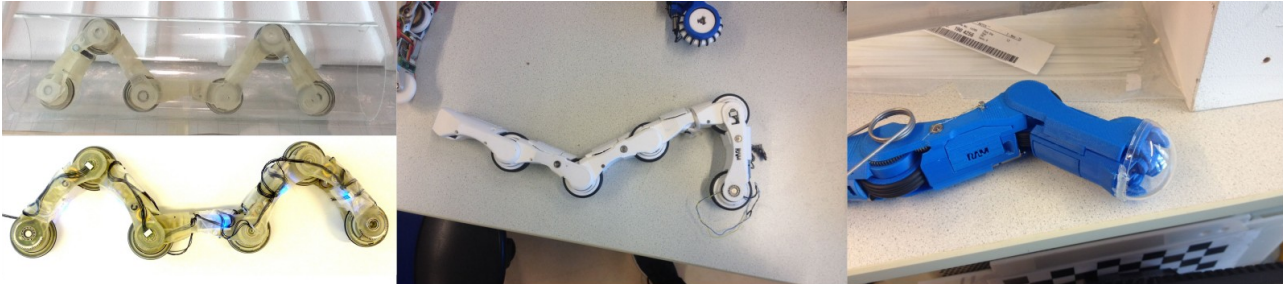

Figure 70: PIRATE reference pictures

With these references a digital drawing of the PIRATE was created in Sketchbook Pro. Every module of the pirate was put into a different layer of the drawing. This was done so that the position that the PIRATE is holding in the drawing is customizable. This was important because it was not clear yet how long the picture could be to still fit within the corner pieces of the pipe maze. If the picture needed to fit within the corner pieces because otherwise it would cause way more difficulty with the programming in processing.

To test out how long the picture needed to be, first a version was made where the PIRATE was stretched out similarly to how the 1:1 model is stretched out that is on top of the table, see figure 71.

Figure 71: PIRATE picture version 1

When this picture was placed inside the pipe maze it was clear that it was too long, see figure 72.

Figure 72: PIRATE picture version one inside pipe maze

By tweaking at the length of the picture of the PIRATE a version was created that was just small enough that it would perfectly fit within the corner pieces. This version, both it inside the pipes and the drawing, can be seen in figure 73.

Figure 73: PIRATE picture final version

Arduino code

The purpose of the Arduino code is to read and interpret when and which buttons are pressed. This is then sent to the processing code. The Arduino code checks the values of the pins which could be a 1 or a 0. When the value is a 1, the code translates this into a letter and continuously sends this to Processing as long as the button is pressed. This means that when two buttons or more are being pressed at the same time, the letters corresponding to these buttons are all being sent at the same time. When none of the buttons are being pressed this is translated to the letter G. To see which buttons are connected to which pin and translate to which letter, see table 8. The complete Arduino code can be seen in appendix D3.

Table 9: How the buttons translate to pins and letters

Button	Arduino pin	Letter
Start	2	A
Left	4	B
Up	6	C
Right	8	D
Down	10	E
Stop	12	F
No button	-	G

Processing code

The Processing code is significantly longer and more complicated than the Arduino code. Because of this the Processing code will be explained in five parts. These five parts are: initialising, serial processing, state handling, display, and debug for developers. The complete Processing code can be found in appendix D4.

Initialising

When the program starts the Processing code need to initialise. First the libraries that the program uses are imported. Secondly a lot of variables are created. A big part of those variables are the x and y coordinates as well as the width, and height in pixels. These were previously mentioned in the 'Aligning the visual digital parts of the table' part of this report. Where these coordinates are is visualised in figure 74. The letters in this figure correspond
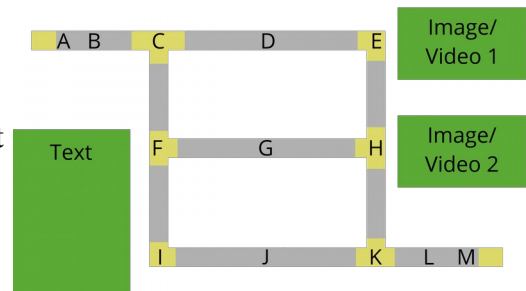

Figure 74: Visualisation of the coordinates

to the case letters which will be explained later in the report. Thirdly it is checked whether the Arduino is connected and it sets up the right communication channel. Lastly the information is imported. The way the importing of information works is pretty simple. The program tries to import an image from the data folder. If the program can not find the image, it tries to look for a video. If the program can not find the video the program will show an error message and will not start. Because of this it is important that there is always an image or video for the program to import. If it is desirable to not show an image or video at a point that it is required, a completely transparent picture is needed. This would be invisible to see for the user, but would prevent the program from having problems.

Serial processing

The serial processing consists of two parts. The first part is reading the letters from Arduino as integers. How these integers correspond to letters and buttons can be seen in table 9. The second part is translating these integers in order to interpret which button is being pressed.

Table 10: How buttons translate to letters and intergers

Button pressed	Translated letter by Arduino	Number send out by Arduino
Start	A	65
Left	B	66
Up	C	67
Right	D	68
Down	E	69
Stop	F	70
No button	G	71

State handling

The way the program reacts to the button presses is through state handling. This means that there are multiple states that the program can be in and that button presses can move the program through these states. In processing these states are called 'Cases'. The program has fifteen cases, of which each has a case, name and letter, see table 11. The last two cases in this table are the cases the program is in when the user has pressed the start or the stop button, the others correspond to a location on the screen.

Table 11: Case name and letter

Case name	Case letter
Begin_Case	A
Intro_Case	B
Corner1_Case	C
Move_Case	D
Corner2_Case	E
Corner3_Case	F
See_Case	G
Corner4_Case	H
Corner5_Case	I
Made_Case	J
Corner6_Case	K
Vopak_Case	L
End_Case	M
Changeblindness_Case	N
Gotostart_Case	O

How cases N and O interact with the other cases and with each other can be seen in the state diagram in figure 75. In this state diagram it can be seen that the start button always moves the program to state O. The stop button moves the program to state N except when the program is in case O. While the program is in the O case no button presses will have any effect until the program has moved on to case A. The last thing this state diagram shows is that the program automatically goes from case O to case A.
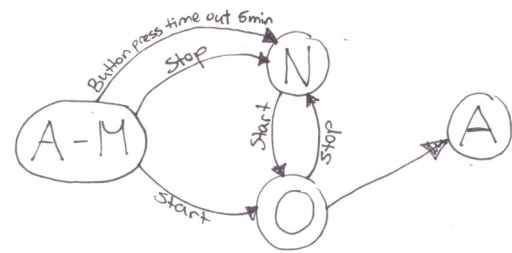

Figure 75: State diagram about interactions with case N and O

What figure 75 does not show is the interactions between cases A-M. The way that these cases interact can be seen in figure 76. The state diagram in this figure deliberately has the same formation as the pipe maze on the table. This is because these cases have to do with the locations in this pipe maze. As can be seen in this state diagram, these cases interact with each other though button presses of the navigation buttons. What is not shown in this diagram is that this navigation button press only influences the cases when the picture of the PIRATE has arrived at its destination and when a button has been released since this arrival. This is to prevent users from moving through the cases faster than the picture of the PIRATE visually moves through them and this is to prevent users from accidentally skipping a case because they did not let go of the button.
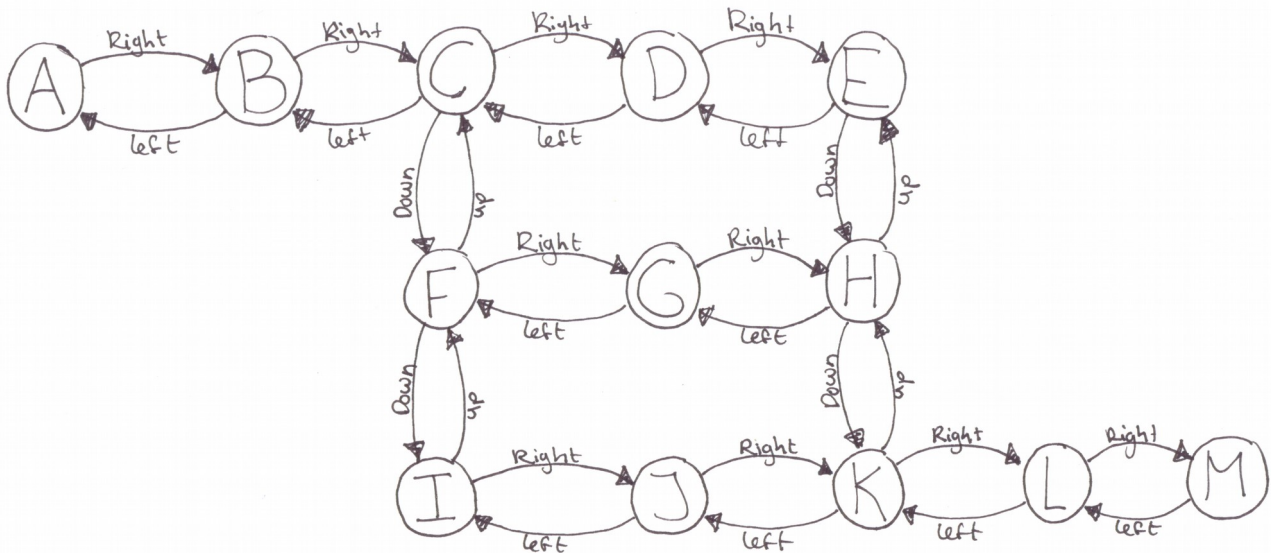

Figure 76: State diagram about interactions between cases A-M

Every case has a slightly different function. Something that is similar in every case is that they all visually move the picture of the PIRATE through the maze. All the cases, except case N, have a final destination for the PIRATE where the movement of the PIRATE stops, making it possible for the user to click another button. Case N is the Changeblindness_Case that the program goes to when the stop button is pressed. This case does not have a final destination for the PIRATE because the PIRATE continuously moves through the maze in this case. This is what creates the change blindness of the table to attract the attention of the passer by user. Case O is the Gotostart_Case. In this case the PIRATE does have a final destination because the whole function of this case is to move the PIRATE to its starting position at case A. While the PIRATE is moved to its starting position a small text is shown on the table informing the user that this is happening.

Once the picture of the PIRATE has arrived at the destination of the case, some cases show information. Which cases show which information can be seen in table 11.

Table 12: Case name, lettter, and its corresponding information

Case name	*Case letter*	*Information*
Begin_Case	A	-
Intro_Case	B	Introduction
Corner1_Case	C	-
Move_Case	D	How it moves
Corner2_Case	E	-
Corner3_Case	F	-
See_Case	G	How it sees
Corner4_Case	H	-
Corner5_Case	I	-
Made_Case	J	The inventors
Corner6_Case	K	-
Vopak_Case	L	Implementation Vopak
End_Case	M	-
Changeblindness_Case	N	-
Gotostart_Case	O	-

Display

The display part of the program layers the different pictures that are seen on the table. The first picture that is put down is the background picture of grass and dirt, see figure 77. Then the PIRATE is shown. This consists of the picture of the PIRATE, either horizontal or vertical depending on where the PIRATE is located in the maze, and the yellow circle that is faded in when the PIRATE is inside a corner. To make sure that the user can not see the PIRATE and the yellow circle in the information holes of the table, a foreground is then put on top of everything. This foreground is again a picture of the grass but with a see through part where the dirt of the background would be, see figure 78. On top of all of this the information can be displayed.
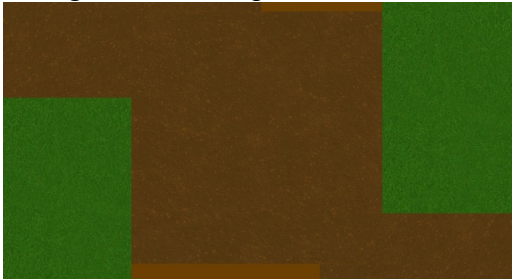

Figure 77: Program background

Figure 78: Program foreground

Debug for developers

This part of the Processing code is disabled when it is running inside the table but is not deleted in case it would be helpful when people are changing things about the table in the future. Which pieces of code need to be disabled and enabled have a comment near them in the code that clarifies this. There are two pieces of code that fall in this debug category. The first piece of code enables someone from using a keyboard to control the program instead of using the buttons in the table. The second piece of code visibly shows the coordinates of cases A-M on the screen.

Manual

Because the people at RaM will need to be able to change the information in the table and because the table will be owned by Vopak and will then be used by many different people, it is important that there is an easy to understand manual about how the table works. To make sure the manual was easy to understand for as many people as possible, it is both in Dutch and English. Every part of the manual is explained in easy to understand small steps with sometimes a helpful picture.

The manual explains the following things:
1. Turning on
2. Turning off
3. Lifting the top of the table off
4. Removing/replacing electronics
   - Laptop
   - Screen
   - Buttons
   - Arduino
5. Putting everything together
6. Moving
   - The passages are wider than 100cm
   - The passages are between 87cm and 100cm
7. Changing information
   - Text
   - Pictures
   - Videos
   - 1:1 model
   - Information signs
8. Often occurring problems
   - The buttons will not work
     - The 'Serial Monitor' only shows the letter G
     - The 'Serial Monitor' shows one or multiple different letters but G
     - The Arduino code gives the error 'Board at COM4 is not available'
   - The processing code will not run

It was tested if the way the finished manual was written was understandable. This was done by giving someone at RaM the manual and seeing if they understood how to turn on the installation. It was immediately clear that the manual worked well and would be perfect with some small language changes and added extra steps. Sometimes steps were not worded perfectly, so the entire manual was looked through and it was made sure that every step was easy to understand for anyone. For the full final manual in both Dutch and English, go to appendix D4.

Chapter 8: Evaluation

It is important to evaluate the realised table. To see what specifically needs to be evaluation it is important to look back at the specification phase in this report. In the specification phase it was stated that the table, then still called artifact, needs to get attention, be easy to figure out for the user, keep attention, be informative, and not annoying in order to be successful. Because these five points determine if the table is successful, they should be evaluated. Another important thing to evaluate is the satisfaction with both RaM and Vopak. How everything will be evaluated, why this method is chosen, how these evaluations went, and what the results were will be discussed in this part of the report.

How everything will be evaluated

The most logical way to test whether the table is easy to figure out is by doing a qualitative user test similar to the one that was done with the paper prototype in the specification phase. By adapting this qualitative user test to this final prototype and changing it a little bit, the points 'keeps attention' and 'is informative' would also be possible to test. 'Is informative' can not be tested perfectly however. This is because the table does not contain any real informative content yet. Despite this it can still be tested whether or not the subject of the table is clear. If the subject is unclear that means that the table failed to be informative, if the subject was clear there is a good possibility that the table could be a good informative tool. The only way to truly test if the table is a good informative tool is by testing the table on users once it has real information inside and figuring out how well the users understand and remember the information that is in the table, but due to the lack of real information this is impossible to do.

How the points 'get attention' and 'is not annoying' should be tested was a little bit harder to figure out. The best way to test these points would be to just place the table in the innovation lab and observe if it gets people's attention and if it is annoying to the people working there. Sadly, with the table being in Enschede and the innovation lab being in Rotterdam, it was not a feasible idea to drive it over there and back for this evaluation. Because of this the next best option was chosen for evaluation: talking to an expert.

The satisfaction of RaM and Vopak would be tested by talking to some employees at RaM and by talking to Mathijs Kossen from Vopak.

An overview of how everything will be evaluated can be seen in table 13.

Table 13: What need to be evaluated and how

What needs to be evaluated	*How it will be evaluated*
Gets attention	Expert evaluation
Easy to figure out for the user	User test
Keeps attention	User test
Is informative	User test
Is not annoying	Expert evaluation
Satisfaction RaM	Talk with employees at RaM
Satisfaction Vopak	Talk with Mathijs Kossen

Trial user test

Before doing the actual qualitative user test it was important to do a trial test. This was done to make sure that both the user test itself was not confusing or did not contain any big mistakes and this was done to make sure that there were no obvious and easy to fix mistakes in the interface itself.

The way the user test would go was as follows. First the user would read a short piece of text about the table itself and about what this test was going to be. This piece of text clearly stated that the user was free to withdraw from the study at any time without needing to give any reason. Because of this statement, the user group not being a vulnerable one, and that there would be no identifiable data collected during the study, there was no need for a consent form. After reading this piece of text the user would do four assignments. Both the piece of text and the assignments can be found in appendix E1. The user would read one assignment, carry out this assignment, read the next assignment, etc. While the user was doing the assignments, the researcher would be writing down observations. After all the assignments were finished the user would get a short questionnaire to fill out and then the user test would be done. Most of the questions in this questionnaire were on a scale from 1 to 5 while the questionnaire for the paper prototype had these questions on a scale from 1 to 3. The reason for this change was that it was stated by multiple users that a scale from 1 to 3 was too limited to give an accurate answer. The questionnaire made for this trial test can be found in appendix E2.

With the data collected from five participants there were some very clear things that could be concluded from this trial test. The first thing was that it was often unclear to the user what happened once they had pressed the start button. This was because half the time the PIRATE picture would already be moving towards the starting position when the user presses the start buttons, resulting in no visible feedback to the user which is very confusing. The second thing concluded from the trial test was that assignment two was written in an unclear way. Users interpreted the assignment as needing to literally look at the table without doing anything instead of moving the picture of the PIRATE to a place that would show information. This was because the assignment was poorly worded. Lastly it was seen that, besides these two very obvious problems during this test, users were overall still positive about, among other things, the design of the table and the interface itself. For the complete researcher's notes and the results with the complete analysis go to appendix E3 and E4.

Final user test

A few things needed to change in order to do the final user test. The first thing that needed to change was the wording of assignment two. The new version of the piece of text and the assignments can be found in appendix E5. The second thing that needed to change was what happened when a user pressed the start button. After changing this, pressing the start button resulted in the picture of the PIRATE speeding up and the screen showing the message 'The PIRATE is now heading towards the start position' at the spot that also shows the text information when needed. The last thing that needed to change was the questionnaire. While doing the trial questionnaire it was seen that one question was missing. This question was, on a scale from 1 to 5, 'The function of each button was clear'. For this final user test this question was added to the questionnaire, this questionnaire with the new question can be seen in appendix E2. After changing these things the final user test could be executed.

Figure 79: Final user test set up

This final user test had twenty participants. The way the user test was set up can be seen in figure 79. From these twenty participants many different things became clear. The complete researcher's notes, results, and analysis can be found in appendix E6 and E7.

When participants were asked their opinions about the test itself they were overall really positive. The assignments were clear, there were not too few or too many instructions provided, and all the assignments were easy to complete. The fact that the assignments were clear to the participants means that the change made to assignment two made this assignment not confusing any more. These results mean that the test itself was well structured and well made, making it a more reliable source for the conclusions that could be drawn from the test.

If the table was easy to figure out by the users was analysed by looking at how the users interacted with the interface. The first part of the interface that will be discussed is the buttons. It was obvious that the way the start button works had improved but it was not yet perfect. With this final user test one in twenty only needed some extra explanation, which is a big improvement on the four out of five from the trial test. That one person still needed some extra explanation though and four people were a little bit confused resulting in them clicking multiple buttons before figuring out how everything worked. For the start button to work perfectly no one should have any problems understanding what it does and how it works. One participant said that it might be beneficial to add instructions when the PIRATE has reached its starting position. This option has potential to improve the interface but if it would work perfectly is not yet clear because that would need to be tested. Another part of the interface that was important to test how easy it was to understand was the navigation buttons and the stop button. The result for the navigation buttons was really clear, overall the participants were really positive about how easy the navigation was to figure out. The buttons in general were clear to everyone. Something that was interesting to see was that participants had varied opinions about the necessity of the stop button, because they assumed that the table would press this button itself after a given time. Even though some participants questioned the necessity of this button, sixteen out of twenty participants decided to click it, proving that people would press the button if it was presented to them. Because of the four out of twenty that did not press the button it is important that the table indeed had this timer that would press the button automatically after a given time. All these results about the buttons, and the fact that participants said that the interface felt well designed, concludes that the button part of the interface is easy to figure out.

Another thing that was important about the interface was the placement of all the information and if the signs were good indicators. When participants got to choose what information they wanted to see no one seems confused about what information was where, making clear that the signs were good indicators. The big majority of participants went to look at 'how it moves' or 'how it sees'. When asked why they chose these most responses were either that the participant was interested in these pieces of information or that they were easiest to reach. These two information pieces, besides the introduction, are the most important ones for someone to look at in order to understand what the PIRATE is. That in combination with that many participants wanted to see these pieces of information means that it were logical choices to make the introduction a mandatory place to pass by and to make 'how it moves' and 'how it sees' the easiest to reach information pieces.

The last thing that was important about the interface was how easy it was to locate the PIRATE if it was hidden in a corner. To make this easier a yellow circle would fade in around the corner where the PIRATE would be located. What was interesting was to see that participants of the user test user multiple ways to find the PIRATE in a corner of which some were not anticipated. The one of the most used methods to find the PIRATE, with eight out of twenty participants, was to look at the yellow circle. This means that it was beneficial that the yellow circle was there. More importantly, none of the participants failed to find the PIRATE, meaning that everyone was always capable of finding the PIRATE.

Besides if the table is easy to figure out, it is important to look at how well it performs as an informative table. Because there was no real information inside the table, only place holders, the only thing that could be tested was if the subject of the table was clear to the participants. This was tested by asking the open question 'What was the subject of the artifact?'. The answers the participants gave were categorised on how specific they were about the subject. The best result would be if the participant names the PIRATE itself, the worst result would be if the participant said something that had nothing to do with the table or said that they had no idea. No participant fell in this worst result category meaning that for everyone the subject was at least a little bit clear. Half the participants even mentioned the PIRATE by name, which means that the subject is not just vaguely clear but actually completely clear to half the participants to the point that they remembered the name of the robot. These things combined means that the table was sufficient in getting the subject across. This means that there is a very high possibility that the table would be a good informative tool, but this would need to be tested when the table is filled with real information.

Another thing that was important to evaluate with this user test was if the table was good at keeping the attention of the user. The way that this was tested was by asking some questions and by writing down observations while the users were doing the assignments. From the questions it became clear that the participants felt like the artifact itself was visually pleasing, the participants did not feel frustrated while using the artifact, and everyone was comfortable while they were using the artifact. These three things combined mean that using the artifact was an overall pleasant experience. Because it was a pleasant experience the participants would be less likely to walk away from the table, which would mean that the table would lose the attention. From the notes made while the participants were completing the assignments it was also seen that many participants already started exploring the information in the table before they read assignment two. Multiple participants also started to look at more subjects inside the table after just completing assignment two. These things means that the table got people interested to see what information was inside. From all these things it can be concluded that the table kept the attention of the user sufficiently.

Next to the three subjects that were evaluated with this user test, there are still some interesting observations that were done with this user test that should be mentioned. The first thing is that a few participants mentioned that they thought it was a little bit weird that the PIRATE did not automatically drive through the corners that were no T corners. This was mentioned because these corners were not a place that provided the user with a choice besides going back or further. Changing this is something that could be looked into. Another thing that was mentioned by participants was that some felt like the text information looked a little bit boring with the black letters on a white background. Redesigning this is also something that could be looked into. The last thing that is interesting to mention is that almost all the people that casually passed through the hallway where the table was located during user testing noticed it in one way or another. These people all at least looked over their shoulder to see what the table was while many people even stop to look at it. A small amount of people even started interacting with the table by pushing the buttons. This is means that the table was very good at grabbing the attention of the people casually passing by the table in this hallway. But because the innovation lab is a very different setting than this hallway, this is not enough to conclude that the table would also be very good at grabbing the attention of a passer by in the innovation lab.

Expert evaluation
The aim of the expert evaluation was to figure out if the table gets attention and whether it is annoying or not. For this the right expert in the field of design would be needed. The expert chosen for this evaluation was Wouter Eggink. Wouter Eggink, teacher of design at the University of Twente, having worked in the design field, and having done research in the field of human-technology relations, was chosen for this expert evaluation. The way this expert evaluation was going to be an in depth conversation about the design of the table and whether the design choices made sense or if other options might have been better. The main topics would be if the table gets attention and if the table is annoying.

While talking to Wouter Eggink about if the table gets attention, the first thing he said was that it is indeed true that this is very dependent on the table's surroundings. After explaining to Wouter what the setting of the innovation lab was like he agreed that the way that the table was designed would probably grab attention in that setting. This would be due to its stand out colours of the table and the movement of the PIRATE when no one is interacting with the table. He did say that maybe the yellow on the corner pieces of the maze was not the best visual choice. After talking about that yellow was chosen because it represented underground gas and oil pipes he did recognize that this was a nice recognizable thing for people that might be working at Vopak or for someone from one of Vopak's clients because these people would more likely know about this. He also noticed that after looking at the table for a little bit longer that the yellow did not bother him any more and everything became more familiar to look at, making the yellow even less of a problem. The last thing that was discussed regarding the getting attention part of the design of the table was whether this part could be improved. Wouter said that it could be amplified with things like having the information signs physically moving or adding the previously planned possible mood light from the specification phase of this report. He did note himself though that having the signs move might be distracting to the user of the table, making the real message of the table less clear. The mood light would however be a really good idea as long as it would not be to bright and would only be directed at the 1:1 model on the table.

After having discussed the getting attention portion of the design, whether the table would be annoying was talked about. Wouter immediately mentioned that he did not expect this table could be distracting. This because the movement is so easy to get used to and because for the rest there are no changing parts of the table. The only way that the table would be annoying or distracting would be if it would have very abrupt changes happening every once in a while or if it would make working in the same space harder. It would make working in the same space harder if it were to make noise or if it would change the brightness or colour of the light in the room significantly, it does neither of these things.

While discussing these two subject Wouter did have two small design pointers that would make the table look a little bit nicer if implemented. The first thing is that the information spaces would look nicer and more finished if they had thin a boarder, like a photo frame. Now the edges are raw and this looks a little bit rushed. The second thing that was mentioned was the way that the written information is now presented in the table. It looks very flat and detached from the rest of the table, while it would look more integrated if, for example, the background was not just pure white.

After this conversation with Wouter Eggink it can be concluded that the table would be sufficient at grabbing attention in the innovation lab without being annoying to the people working there. Of course the only way to truly know if this is the case the table would need to be tested in the innovation lab itself, but for now this is a very clear and good outcome.

Talk with employees at RaM

To figure out if the Robotics and Mechatronics team was satisfied with the table, conversations were had with multiple employees at RaM, one of which was Johan Engelen. While talking with these employees everyone was very enthusiastic about the table. Some people even went as far as talking about ways to recreate the table so that they would have one for RaM itself as well. People did note that a few small changes might need to be made, like adding some nice frames around the information holes in the grass to make everything look a little bit finished. Overall everyone was really positive and happy with the result.

Talk with Mathijs Kossen

In order to find out about Mathijs's final opinion about the table he was contacted. Sadly it was not possible for him to come all the way over to Enschede and see the table himself so to have him know what the table was pictures were emailed and the way the table works was explained over the phone. After it was made clear what the final result is his opinion was discussed. He was a little bit disappointed that the table did not contain any real information yet, meaning it was not completely ready to go to Vopak's headquarters yet. It was then explained that adding the information would be done by the RaM team and was made as easy as possible. Everything concerning information is modular and easily changeable, which he did recognize as a very good thing. The second thing that he was a little disappointed about was how easy it would to transport the table. The table is too big to fit into a car for transportation, but he did say that the transportation was of course way less important than the final result. The rest of the conversation was positive. Mathijs was satisfied with the result, how it looked, and how it would work. He said that he thought the 1:1 model on top of the table was a very nice touch that would be really helpful for users to figure out how the PIRATE would work. He was also happy about the table not making noise, being easy to update, and felt like everything looked like it was well thought out. He was overall very positive and said that in his eyes the table was successful.

Chapter 9: Conclusion and recommendations

In this chapter all the conclusions from the evaluation will be combined to answer the main research question stated in the beginning of this report. Answering this research question will be done by looking back at the five factors stated in the specification phase of this report about what the artifact needed to do in order to be successful. It will then be discussed what still needs to be done in the future to either add to the research done in this report or to improve the artifact itself.

Conclusion

The main research question that is answered in this report is:

How should an informative, promotional, interactive artifact for Vopak about the RaM team, the University of Twente, and the PIRATE be designed?

From the background research done in this report it was found that the artifact needs to do five things. These five things are that the artifact:
- gets attention
- is easy to figure out
- keeps attention
- is informative
- is not annoying

To test this theory such an artifact was made. The artifact made is a table that is interactive through button presses and is informative/promotional through its content. When the user presses buttons they move a digital PIRATE through a track to choose from different information pieces the piece that interests them the most. It was then tested if this artifact did indeed do those five things succesfully. This was tested through user tests and an expert evaluation. The companies involved in the project were also asked whether they are satisfied with the results.

From these evaluations the following things can be said about those five things that the artifact needed to do. The artifact:
- gets attention: very likely
- easy to figure out: yes
- keeps attention: yes
- informative: very likely, it gets its message across
- not annoying: very likely

It can also be concluded that the companies involved are satisfied with the final artifact.

Because of these results it can be concluded that the artifact made has a high probability of being a succesful design to be an informative, promotional, interactive artifact for Vopak about the RaM team, the University of Twente, and the PIRATE.

Recommendations

Something that still needs to be done to confirm the research done in this report is testing out if the artifact that was made does the five things successfully in the innovation lab setting. Before this can be done two things need to happen to the artifact itself. The first thing is that the place holder information inside the table needs to be replaced with actual information. The second thing is optional and needs to be tested if it would improve the interface. This thing is that there might need to be a short message of instructions shown to the user when the digital PIRATE reaches its starting position after the user has pressed the start button.

Chapter 10: Personal reflection

In this final chapter of the report it will be discussed which things I personally feel like could have gone better and what I have learned from this. These things are regarding my planning and the building of the table itself.

Planning

Some mistakes were made while planning the course of the project. A lot of things took way more time then expected and this created some problems with trying to get everything finished in time. The main thing that was not planned well was the physical building of the table. This took at least twice as long as expected, resulting in less time for the digital parts of the table. Despite this the table did get finished, it would just have been less stressful if the planning had been more accurate. From this I have learned that it things often take longer than expected, especially when it comes to things with many variables like building a table.

The table

Because building the table took way longer then planned it resulted in some ideas getting scrapped. This could have been prevented if I had planned more time for the building part of the table but also if I had already anticipated that these ideas would probably not be able to become a reality due to lack of time. The ideas that were scrapped were the light underneath the 1:1 model of the PIRATE and the addition of a small LED inside the start button.

Next to this, a few mistakes were made while building the table. The first mistake is a small one. The velcro that connects the black piece of fabric to the table is not attached perfectly to the table. This is because it was assumed that stapling the velcro to the table would be enough to hold it there but it turns out that it is not. This would have been avoided if the velcro had been glued to the table. This is still something that can be done in the future if the velcro starts to come lose significantly. The second mistake is a bit bigger. A request from Vopak about the table was that they would have liked it if it were very easy to transport. Because of the mistake of forgetting to ask someone at Vopak how wide their hallways are, the frame of the table turned out to be too big to fit through the hallways. It would still fit if the table was taken apart and transported on its sides, but this is not ideal. It would have been better if the hallway measurements were taken into account earlier in the building phase of the table. This has thought me that it is always smart to check if you have all the information collected that is needed before you start doing irreversible things.

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Appendix A: State of the art

Appendix A1, installations at NEMO Science Museum
It was observed that the way most installations at NEMO get their information across is by trying to get the user to go through four stages with the installation. The installation gives the user the most information if the user reads the written text and understands its link to the installation. These steps are:

1. The installation grabs the user's attention.
2. The user figures out how to use the installation.
3. The user plays with the installation.
4. The user reads the written information.

Every installation that was observed at NEMO will be divided into groups based on how well they get the user to go through all four steps. The few installations that entirely miss one or more steps, and the installations that take a different direction to informing the user, are put in the category other. With every installation it will be briefly explained how it handled every step that is applicable and why this was or was not effective. If a technique is handled more than once, only at the first mentioned installation using that technique the reason of effectiveness will be explained.
When an installation does something interesting that does not fall within the four steps this will also be noted.

Pictures were taken with permission of NEMO, all the people in the pictures were asked for permission and know that the pictures are in this report.

<u>Successfully goes through all 4 steps</u>
Lightning spiral
Grabs attention with light [21] and movement [19, 20] of people [24] interacting with it.
Interaction is easily figured out with simple written instruction.
User plays with the installation because they want to try and get all the light panels to light up and they want to get the electric current as high as they can. This works because it makes the installation competitive.

Figure 80: Lightning spiral

The user reads the written text because they want to figure out why the current goes up. The installation shows something curious which makes the user wander how that works.

Mixing colours
Grabs attention with light [21].
Interaction is easily figured out through clear and big buttons with instant feedback.
User plays with the installation because there are multiple colours the user can create with it and the user gets curious how to create certain colours.
The user reads the written text because colour mixes in an unexpected way, differently from paint, and they want to know why.

Figure 81: Mixing colours

Battle against water

Grabs attention with the light [21] and subtle movement [25] created by the projected image, and with the amount of people gathered around the installation [24].

Figure 82: Battle against water

Interaction is easily figured out because the parts that can be interacted with stand out with colour, shape, and mostly texture.

User plays with the installation because there an almost infinite amount of different combinations of things can be created. Another thing adding to the reason users play with the installation is because the projection does not get annoying. This is because it is subtly changing instead of abruptly changing [25]. Because of these two reasons, users can play with the installation for a long time. Some children manage spend more than half an hour playing with this installation. This is also the reason that a crowd is formed.

The user reads the written text because they have spend a lot of time playing with the installation and would like to know more about what all the moveable parts represent.

Communicating with shapes

Grabs attention with colourful shapes and it grabs attention because it is the only installation in the room that it is located that is not inside of a see-through tent. The colourful shapes grab your attention because they do not instantly explain what the user should do with them. The tent grabs attention because it makes the installation different, and therefore stand out.

Figure 83: Communicating with shapes

Interaction is easily figured out because it is written down on the table in clear language.

User plays with the installation because the user can be creative with the shapes in an infinite amount of ways. There is also an element of curiosity involved for the player that has to recreate the other persons shape by listening to their instructions. The challenge involved at both ends of the communication makes the user want to get better at the game. It is also fun for the user that the installation learns them a new skill that can be used later in life.

The user reads the written text because they have spend a long time playing with the installation and would like to know more about how communicating works. The user might also already read the text when trying to figure out how to play the game.

Something that is interesting about this installation is that it uses no technology but it is still interactive in a way that has infinite options, is fun, and is informative.

Creating light through movement

Grabs attention with a light up screen.

Interaction is easily figured out through text on the screen with clear instruction on how to play the game.

User plays with the installation because they want to beat their opponent in the game. To encourage this even more the installation has a high score.

Figure 84: Playing how it was intended

The user reads the written text because they have been playing with the installation for a long time.

Something that is interesting about this installation is that the game can be easily cheated. Even though the installation is so easily cheated, this ads an extra element to the game of how to cheat well enough to beat the obviously cheated high-score. Even though this gets the user to play with the installation longer, it does take away from the information that the installation is trying to get across.

Figure 85: Cheating the installation

The machine
This installation was made up out of three parts that are all handled separately. Part 3 is in the group 'user stops after step 1'.
The way the machine gabs attention is with movement [19, 20] and sound. Sound grabs attention because, when a person hears something, they want to know what it is coming from.

Figure 86: The machine

Part 1
Interaction is easily figured out because of clear instruction on the screen, an easily recognizable way to interact with the joystick, and because the puzzles were easy to understand with the correspondence of colours. The joystick can be seen in figure 29.
User plays with the installation because they want to finish the puzzles and because the real-time movement of the robotic arm responding to the joystick is perceived as really cool. The robotic arm can be seen in figure 28.
The user reads the written text because they have played with the installation for a long time, either only one part or more, and they want to learn more about the production process that the installation is about.

Figure 87: Part 1

Part 2
Interaction is easily figured out because of clear instructions on the screen with icons and examples. Sometimes these instructions are to fast though, leaving the user confused with what they should do. This confusion is resolved with tips that are given through time. Something else that this installation does well on this part is that it gives clear feedback when something is done well with exploding stars coming from the solved puzzle.

Figure 88: Part 2

User plays with the installation because they want to finish the puzzles and because the puzzles are a little bit different every time they are played.
The user reads the written text because they have played with the installation for a long time, either only one part or more, and they want to learn more about the production process that the installation is about.

<u>User stops after step 3 – user is not interested enough to read the written text</u>
Dancing machine
Grabs attention with noise, movement [19, 20], and light [21].
Interaction is easily figure out because it is a very well known game to begin with.
User plays with the installation because it is competitive and together with someone else.
Does not get the user so far to read the written text because the

Figure 89: Dancing machine

installation does not give the idea that there is any extra information. The installation does not give this idea because it is such a well known game and this game has never had a written text with information next to it.

Peer pressure

Grabs attention with creating curiosity about what the installation does.

Interaction is easily figure out because of the clear place where every participant needs to place their had and because of easy to understand written instructions.

Figure 90: Peer pressure

User plays with the installation because of peer pressure. One person challenges others to dare to play with this installation.

Because of peer pressure the everyone joins in. Curiosity about how a tiny shock feels can also be the reason a user might play with the installation.

Does not get the user so far to read the written text because the information is both very far away and it is unclear that this game has any relation to any information.

Light up dress

Grabs attention with bright and subtle colour changing light [25].

Interaction is easily figure out because the way of interaction is with an easily recognizable button that even has some light in it so it stands out more.

User plays with the installation because they want to know what the buttons do and instantly see the colour and animation of the lights change when they press a button. The user also plays because the subtly changing light is not annoying to look at.

Does not get the user so far to read the written text because the information is hard to see. The room is dark and there is no light source directed at the written text.
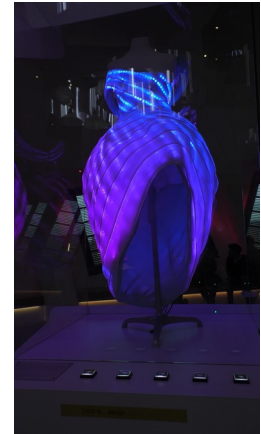
Figure 91: Light up dress

User stops after step 2 – user does not find the interaction interesting enough to play with

Magnetism

Grabs attention with being right next to the entrance of the museum. This results in many people walking past it and seeing it.

Interaction is easily figure out because it is clearly written in simple text on the installation.

Does not get the user to play with the installation because there is only one thing that can happen which is very short.

Figure 92: Magnetism

How magnets work

Grabs attention with the bright colour of the table and it being right next to the entrance of the museum.

Interaction is easily figure out because there is only one possible thing that can be done. The movable parts are restrained so they can not be taken away from where they can create an interaction.

Does not get the user to play with the installation because there is only one form of interaction which is hard to see. Not a lot happens with the interaction.
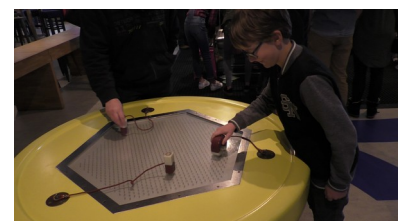
Figure 93: How magnets work

User stops after step 1 – user does not understand the interaction
Drop stopper
Grabs attention with how big it is in height and how dark it is. The fact that is is dark stands out from all the brightly coloured installations around it.
Interaction is hard to figure out because nowhere it is clearly stated what the user needs to do. There are two very clear buttons but if they are individually pushed nothing interesting happens. The green button drops one drop of water, the red button results in a quickly flashing light. If they are pressed at the same time you can see an illusion of a static falling drop of water. This problem of not recognizing how to let the interesting interaction happen could have been easily fixed by putting a one sentence explanation on the installation.

Figure 94: Drop stopper

Eyes in the back of your head
Grabs attention with being the first installation that a user walks into that is inside an orange curtain.
Interaction is hard to figure out because the interface on the computer is poorly done. The colours are distracting, text is hard to read and instructions are not clearly written. The instructions have confusing things like contradictions and strange sentences.

Figure 95: Eyes in the back of your head

The machine part 3
This is the third part of 'The machine' which was already partially discussed in 'Succesfully goes through all 4 steps'.
Interaction is hard to figure out because the button interface is confusing. One of the buttons says 'Start' but is also the 'OK' or 'Choose' button while the user is trying to play the game. This problem could have been easily avoided by changing the name of the button.

Figure 96: The machine part 3
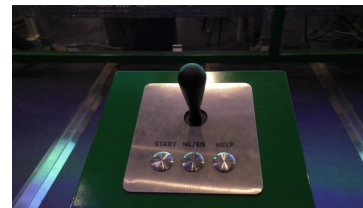
Figure 97: Button interface

User does not go through any steps – installation does not grab the attention of the user at all or not in a positive way.
Shadow wall
Does not grab attention because the installation is behind a wall, making the installation invisible. This problem could have easily been avoided by putting a big arrow on the wall pointing to where a user could get to the installation. Once the installation was found it was easy to figure out the interaction, because it happened by itself. The user kept playing with the installation because many different shadow

Figure 98: Shadow wall

shapes could be made, many possibilities of outcome. The user would read the written text because they want to figure out how the capturing of their shadow works.
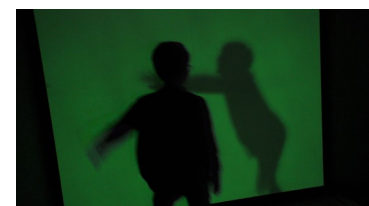
Noise cancellation

This installation does grab attention but it does it in an annoying way. This installation is about cancellation of noise. This results in the installation making loud noises that the user can hear from far away, but when when the user gets to the installation the noise gets less loud. This can be disorienting in finding the installation. The noises the installation makes are also very annoying repetitive noises, making it uninviting to take a closer look. This installation also does not get much attention because it is hidden in a corner.

Figure 99: Noise cancellation

Other

Toilet mirror

This installation is different because of its placement. This installation is located at the sink near the toilets and the installation is about water purification. The fact that the installation is located next to what it is actually about makes it very effective at relating its information.

Grabs attention through movement of the image on the mirror [19, 20].

Interaction is easily figured out because the interactivity happens when the tap is turned on. The user was going to do this anyway, even if no interactivity would happen from it.

This installation fails to get the user to play with it. But this is not a problem because this installation does not allow the user to play with it. The information is already effectively told without the user needing to do more than briefly interact with the installation.
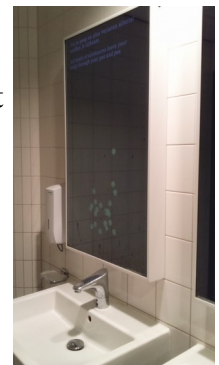
Figure 100: Toilet mirror

Bubbles

This installation is different because it is one of the only interactive installations at NEMO that is not obviously informative. This installation does not have any written text next to it. Because there is no written text the installation relies on older users to explain how the installation works to the younger users.

Grabs attention through familiarity. Every child has played with bubbles and associates it with fun. Interaction is easily figured out through familiarity as well.

User plays with the installation because there is the challenge of trying to blow the biggest bubble.

Figure 101: Bubbles

Figure 102: Bubbles

Figure 103: Bubbles

Appendix A2, notes from visit to NEMO Science Museum (In Dutch)

Speels leren

magneet tafel weinig interesse

Bellen veel interesse, echt heel druk

Sommige dingen niet self-explanitory maar eenmaal uitgelegd wel leuk (draaistoel met wiel)

fysiek zien gebeuren (elektriciteit opwekken draaitafel) weinig uitleg, zelf ontdekken, daarna achteraf uitleg op de grond

lichtgevende installaties meer aandacht

minder voor de hand liggende installaties minder aandacht, zoals druppel water (ook omdat weinig variatie wat je kan doen?? minder begrijpelijk wat er gebeurd?)

Afgezonderd minder aandacht

je blijft langer als variërende dingen mee kunt doen (sneller dan schaduw)

Geluid irriteert dus mensen snel weg (geluid ding hoek)

Als maar 1 iemand tegelijk kan minder animo (groepsdrang?)

watertafel! Veel dingen mee te doen, constant subtiele beweging, lang mee bezig kunnen zijn, mooie kleuren en simpele interactie waar geen uitleg voor nodig is.

De machine!

Stap 1 Beweging constant maar beetje afwisselend (kleuren ballen), geluid blijft lang niet irriteren maar op gegeven moment toch vervelend. 3 kanten samenwerking. Bewegende machines besturen is cool, zien bewegen. Puzzels oplossen leuk achievement, simpel snel begrepen interactie (joystick en touchscreen beide met directe feedback)

Stap 2 deel scanner lastig want soms anders dan verwacht. Niet volledig genoeg uitgelegd, soms moeilijker dan nodig (broek moest stukje omhoog voordat de pijpen eraan konden) eerst dingen slepen, daarna aanklikken is verwarrend. Vaas uitleg te snel, vinkje onduidelijk. Wel leuk elke keer anders. Terug koppeling ballen in rekje zoals in de machine is leuk gedaan. Tijd als challenge is leuk maar vooral handig, als iemand wegloopt zonder af te maken gaat het spel terug naar het start scherm als de tijd op is. 4 opties lijken niet te werken.

Stap 3 Start knop onduidelijk als keuze knop. Verder leuke terug koppeling naar de rest van de installatie.

Schok ding. Je blijft voor de uitdaging en komt uit nieuwsgierigheid en peer pressure.

Als spel te leuk dan zie je de informatie niet meer (dans machine)

dingen vangen is het spel het onderwerp, bij dans gaat het over dans maar vang test je reactie vermogen en gaat over reactie vermogen, werkt iets beter.

Ogen in rug. Interface niet duidelijk en lelijke kleuren. Het gordijn trekt aandacht en zondert af wat helpt met het artifact.

Vorm taal; Pattern Talk. Leuk want samen. Uitdaging. Creatief maken van iets, wat maakt de ander? Nieuwsgierigheid. Communicatie skills leren is leerzaam en leuk.

Mensen worden geleid door voetstap paden

Jurk 2 geen interactie, niemand kijkt er naar. Jurk 1 knoppen en ledjes feedback. Ledjes trekken aandacht knoppen houden het. Mensen kijken hier wel naar.

Energie opwekken met draaien 'licht is krachtig' leuk want competitie, zelfs highscores. Dan wil je vaker proberen, hoe overtref je de highscore? Duidelijke interactie. Maar hackable, dan toch nog steeds leuk.

Appendix B: Ideation

Appendix B1, mind map
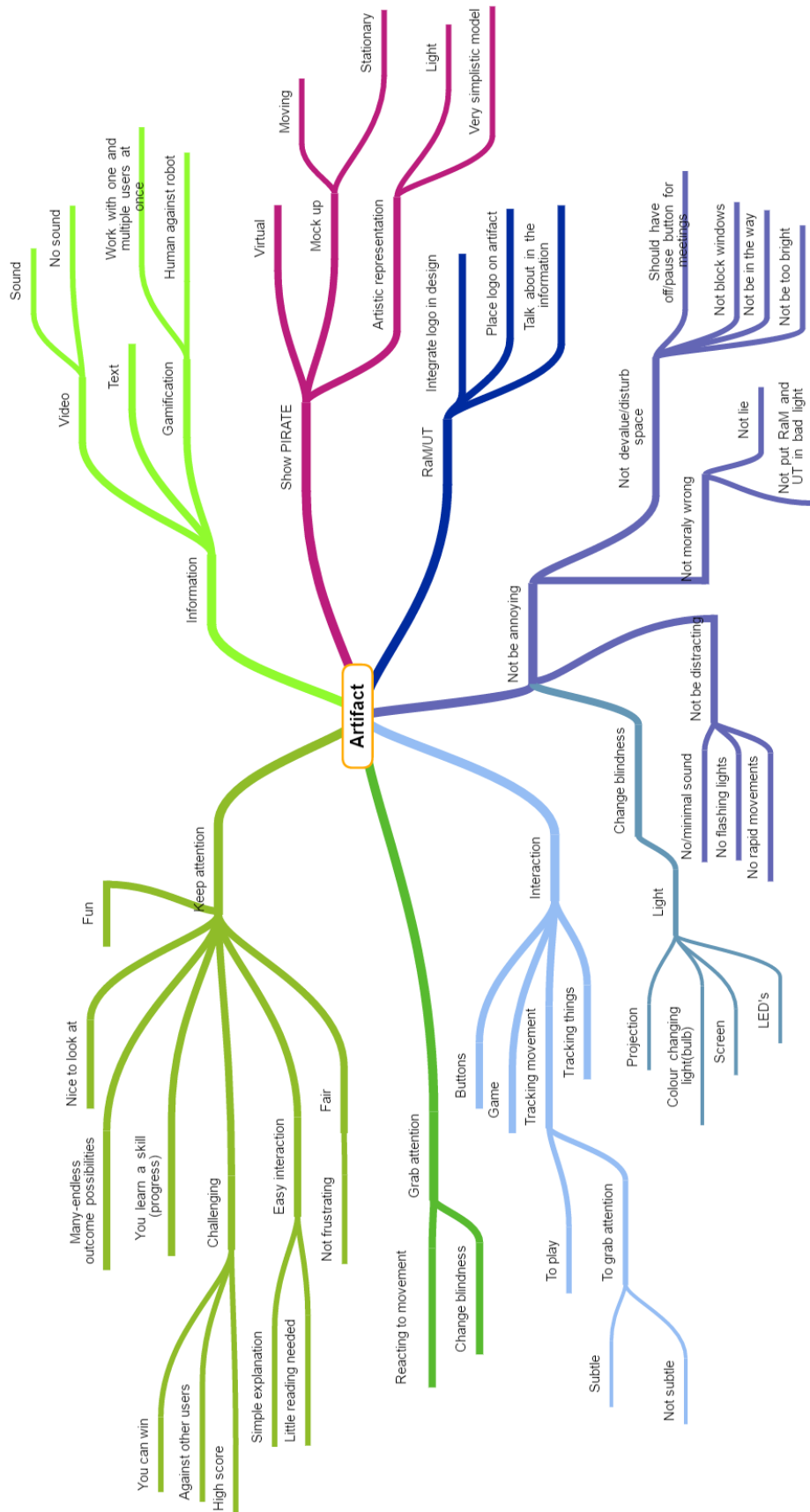
Appendix B2, notes from brainstorm meeting with Edwin Dertien (In Dutch)
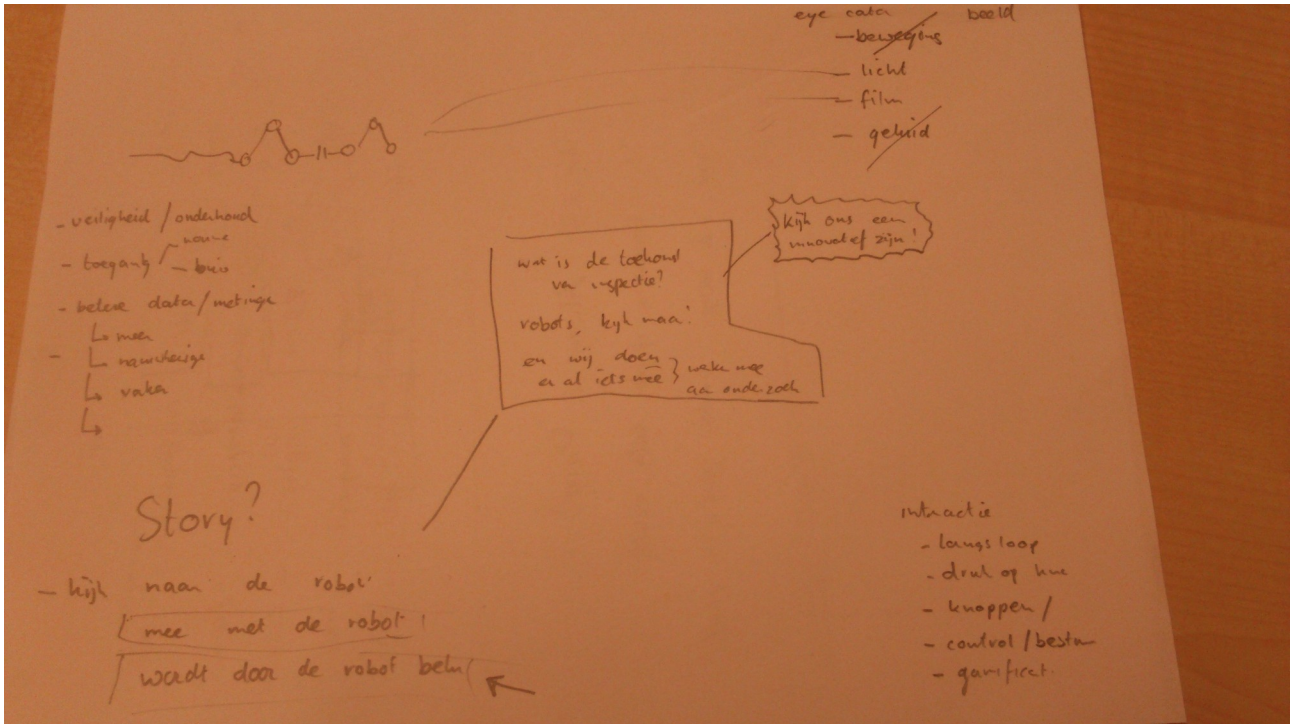
Figure 104: Brainstorming notes

Appendix B3, all generated ideas
Perspective 1: Looking at the robot
1.1. Choosing information 'game'
Small pipe 'maze' with a representation of the PIRATE that can ride through.
Each part of the maze shows some information about the PIRATE (exp. next to a sharp T-bend there is information about how the PIRATE would move through such a space)
The user chooses the PIRATE's direction, and with that the order of information they see.
There is a beginning and end to the maze. Beginning shows information about how the PIRATE would be put into the pipe's in a real life situation and the end will talk about the future of the PIRATE and how it will drive autonomously. When the PIRATE is at the end, it will then drive itself back to the beginning.

Many versions possible:
Representation of the PIRATE in pipes can be:
1. miniature printed version in small pvc pipes, the whole thing could possibly look like a small architectural model of a part of Vopak.
2. LED's representing both the pipe and PIRATE
3. projection
Presentation of information:
1. On one screen, video with text
2. Projected next to the pipe's/ small screens on the table
3. (if sound, provide headphones. Not ideal because then one or a limited amount of users can only hear the sound at once)
Maze:
1. 2D, on a table or against a board
2. 3D, in the air
Interaction:
1. Arrow buttons to move the PIRATE around, they could light up to show which are possible to click. Or a joystick
2. User builds the maze (only possible with the projected version of the PIRATE, or LED's)
RaM/UT:
1. Maze could be in shape of logo (can not when user builds the maze)
2. Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be)
3. Talk about in one of the information parts
1:1 model of PIRATE:
1. Could be placed at the same place as the RaM/UT logo (on the artifact), either half or full model.
2. Could function as a lamp
3. Could, itself, be interactive
Get attention:
• Reacting to movement
• Change blindness
Keep attention:
• With the interaction chosen
• By making it work well, no glitches
• By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.
• By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)

1.2. Simple 'push play' interaction

Small track that the PIRATE can move through while information is shown. Only interaction is that the user turns the artifact on, or 'pushes play' on the information and movement.

Many versions possible:

Representation of the PIRATE in pipes can be:

1. miniature printed version in small pvc pipes, the whole thing could possibly look like a small architectural model of a part of Vopak.
2. LED's representing both the pipe and PIRATE
3. projection
4. 1:1 model (if track is small)

Presentation of information:

1. On one screen, video with text
2. Projected next to the pipe's
3. (if sound, provide headphones. Not ideal because then one or a limited amount of users can only hear the sound at once)

Track:

1. 2D, on a table or against a board
   a) Simple
   b) Intricate
2. 3D, in the air
   a) Simple
   b) Intricate

Interaction:

1. On/play button and possible stop/pause buttons.
2. Turns on/starts by detecting movement

RaM/UT:

1. Track could be in shape of logo
2. Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be)
3. Talk about in one of the information parts

1:1 model of PIRATE:

1. Could be placed at the same place as the RaM/UT logo (on the artifact), either half or full model.
2. Could be the PIRATE that goes through the track if the track is simple enough.
3. Could function as a lamp
4. Could, itself, be interactive

Get attention:

- Reacting to movement
- Change blindness

Keep attention:

- By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)
- By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.

1.3. Race against other inspection options

The user controls one inspection options (human with dog/PIRATE/PIG/possibly more) and tries to beat the other options in speed, efficiency, movability, safety, possibly more. Multiple users could interact with the artifact at once, where each user can control one of the inspection options. With this method the benefits of using the PIRATE are clearly shown.

Many versions possible:

Representation of the PIRATE, and other inspection options:
1. miniature printed versions with small pvc pipes, the whole thing could possibly look like a small architectural model of a part of Vopak.
2. LED's representing both the pipe and the inspection options
3. projection

Presentation of information:
1. On one screen, video with text
2. Projected next to the pipe's
3. (if sound, provide headphones. Not ideal because then one or a limited amount of users can only hear the sound at once)

Track:
1. 2D, on a table or against a board
   a) Simple
   b) Intricate
2. 3D, in the air
   a) Simple
   b) Intricate

Interaction:
1. User(s) only push start button
2. User pushes a button rapidly to move the inspection option
3. User has to analyse the data that the option provides

RaM/UT:
1. Track could be in shape of logo
2. Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be)
3. Talk about in the information

1:1 model of PIRATE:
1. Could be placed at the same place as the RaM/UT logo (on the artifact), either half or full model.
2. Could function as a lamp
3. Could, itself, be interactive

Get attention:
• Reacting to movement
• Change blindness

Keep attention:
• With the interaction chosen
• By making it work well, no glitches. And by making it be fair.
• By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)
• By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.

1.4. Marble run

The PIRATE moves through a 'marble run' type of construction.

Many versions possible:
Representation of the PIRATE, and what is the marble run made out of:
1. Marble run is made out of pvc pipes, PIRATE is a small model with wheels so it can roll down through the marble run
2. Marble run is made out of pvc pipes with LED strips in them, PIRATE is a LED representation.
3. Marble run is made out of LED strips which are able to show a representation of the PIRATE on them.

Presentation of information:
1. On one screen, video with text. Either up right or on a table.
2. Written still text
3. (if sound, provide headphones. Not ideal because then one or a limited amount of users can only hear the sound at once)

Track:
1. 2D, on a table or against a board
   a) Simple
   b) Intricate
2. 3D, in the air
   a) Simple
   b) Intricate

Interaction:
1. User(s) only push start button to release the PIRATE from the top. User possibly also has to insert the PIRATE into the top.
2. The user has to get the PIRATE through the marble run by tilting it.

RaM/UT:
1. Track could be in shape of logo
2. Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be)
3. Talk about in one of the information parts

1:1 model of PIRATE:
1. Could be placed at the same place as the RaM/UT logo (on the artifact), either half or full model.
2. Could function as a lamp
3. Could, itself, be interactive

Get attention:
- Reacting to movement
- Change blindness

Keep attention:
- With the interaction chosen
- By making it work well, no glitches. And by making it be fair.
- By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)
- By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.

Perspective 2: Looking with the robot
2.1. Looking through the front piece
A very big version of the front piece of the PIRATE is attached to a screen, so you can look through the front piece and see the screen. This way the screen can show the inside of a pipe.

Many versions possible:
What the screen shows (1 or more):
1. The inside of the pipe
2. The data the PIRATE would collect
3. Information about the PIRATE

Presentation of information:
1. On the screen that also shows the inside of the pipe (could be scrolling text/ still tekst/ video with or without sound/ etc.)
2. On a separate screen
3. Printed next to/on the artifact

Interaction:
1. When the artifact detects movement it starts the video on the screen
2. When a button is pressed the video starts.

RaM/UT:
1. Logo could be on the side of the artifact (if it were to be a table of some sort)
2. Talk about in the information
3. Show on the screen

1:1 model of PIRATE:
1. Could be placed at the same place as the RaM/UT logo (when on the artifact), either half or full model.
2. On the side of the artifact
3. On top of the screen
4. Could function as a lamp

Get attention:
• Reacting to movement
• Change blindness

Keep attention:
• With the interaction chosen
• By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)
• By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.

2.2. Find the damage 'Game'

With the same set-up options as the previous idea, but with an added part on the/a screen showing the 'maze' of pipes. The user guides the PIRATE through the pipes to find if there is damage.

Many versions possible:

Interaction:

1. When the artifact detects movement it starts the video on the screen
2. User moves the PIRATE through the pipes using a joystick, or a set of buttons. To know which way to go, the pipe lay out is shown as a map on the screen. Where the user has been will turn a different colour. This could also be layed out with LED's but that is less versitile.

RaM/UT:

1. Logo could be on the side of the artifact (if it were to be a table of some sort)
2. Talk about in the information
3. Show on the screen

1:1 model of PIRATE:

1. Could be placed at the same place as the RaM/UT logo (when on the artifact), either half or full model.
2. On the side of the artifact
3. On top of the screen
4. Could function as a lamp

Get attention:

- Reacting to movement
- Change blindness

Keep attention:

- With the interaction chosen
- By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)
- The 'maze' could possibly be different every time. (only works when it is shown on the screen, not as LED's)
- By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.

Perspective 3: Robot looking at you

3.1. Robot coming from the pipe, inspecting you

PIRATE head coming from the pipe, moving around to look at its surroundings.

Many versions possible:

Representation of the PIRATE:
1. Printed version of the PIRATE (either 1:1, smaller, or bigger) with pvc pipes that are see through so you can see the entire PIRATE 'fake' clamping itself in place. Possible movement at the back end of the PIRATE could be shown.
2. Same but with a non see through pipe, making it easier to build

Presentation of information:
1. On one screen, video with text
2. Placed next to the PIRATE
3. (if sound, provide headphones. Not ideal because then one or a limited amount of users can only hear the sound at once)

Interaction:
1. A camera in the PIRATE head films what he sees and this is, in real time, shown on a screen or projected on the table the PIRATE would be on. (all other ideas could be combined with this one)
2. PIRATE moves its head towards the user to look at them, using a Kinect.
3. User(s) only push start button , to which the PIRATE starts randomly looking around. It could look at the space where the user 'would' stand to push the button for a longer time.
4. User moves the PIRATE head with a joystick

RaM/UT:
1. Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be)
2. Talk about in one of the information parts

1:1 model of PIRATE:
1. Could be the PIRATE that moves
2. Could be placed at the same place as the RaM/UT logo (on the artifact), either half or full model.
3. Could function as a lamp

Get attention:
• Reacting to movement
• Change blindness

Keep attention:
• With the interaction chosen
• By making it work well, no glitches.
• By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)
• By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.

3.2. Robot follows you through a maze

By tracking the movement of the user, because the PIRATE looks at them moving around, the PIRATE moves through a pipeline 'maze'. The PIRATE could even react to users that do not actively interact with the artifact.

Many versions possible:
Representation of the PIRATE in pipes can be:
1. miniature printed version in small pvc pipes.
2. 1:1 version of the PIRATE in a very simple pvc pipe maze.
3. LED's representing both the pipe and PIRATE

Presentation of information:
1. On one screen, video with text
2. Projected next to the pipe's
3. (if sound, provide headphones. Not ideal because then one or a limited amount of users can only hear the sound at once)

Maze:
1. 2D, on a table or against a board
2. 3D, in the air
3. One simple square or circle so the PIRATE can follow the user around.

RaM/UT:
1. Maze could be in shape of logo
2. Logo could be on the side of the artifact (if it were to be on a table, or it could be on the console where the buttons/joystick for interaction would be)
3. Talk about in one of the information parts

1:1 model of PIRATE:
1. Could be the PIRATE in the pipe maze
2. Could be placed at the same place as the RaM/UT logo (on the artifact), either half or full model
3. Could function as a lamp
4. Could, itself, be interactive

Get attention:
• Reacting to movement
• Might not need change blindness

Keep attention:
• With the interaction chosen
• By making it work well, no glitches
• By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.
• By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)

Perspective 4: Looking from the perspective of the designer
4.1. Disassembled PIRATE on the table that has to be re-assembled by the user.
The user gets an array of parts that can be put together to create an inspection robot. These parts are 1:1 based on the actual PIRATE and have been 3D printed to make them accurate. Parts are both the different parts of the outside shell and a simplified version of the electronics (that are also 3D printed)

Many versions possible:
Presentation of information:
1. On one screen, video with text
2. Placed next to the PIRATE
3. (if sound, provide headphones. Not ideal because then one or a limited amount of users can only hear the sound at once)

Interaction:
1. User has to build the PIRATE correctly
2. There are more versions possible to build, so different possible outcomes. The user could try to make the best robot, which would be the PIRATE how it is now.

RaM/UT:
1. Logo could be on the side of the artifact
2. Talk about in the information

1:1 model of PIRATE:
1. Could be the PIRATE that gets build, without an example PIRATE
2. Could be shown on a screen with the information, gets shown when the user thinks they have finished building the robot to show how it should look and why it is the best way.
3. Could be an example that the user can base its building on (which could be half, full, a lamp)

Get attention:
• Reacting to movement
• Change blindness

Keep attention:
• With the interaction chosen
• By making everything fit together well, not too hard to figure out.
• By making the information interesting and representing it in an interesting way (fast but not too fast, fun to look at, etc.)
• By making the artifact look nice, meaning a lot of detail and no bright light hurting the user's eyes etc.

Perspective 5: Robot looks with you
5.1. PIRATE looks at you interacting with the artifact.
While the user is interacting with the artifact, the PIRATE (1:1 printed version) keeps looking at them and reacting to what they are doing. The PIRATE moves its front module to look at the user.

This idea should be combined with one of the other ideas to work. Ideas this could work with are: 1.1, 1.3, 1.4, 2.2, and 4.1.

Two versions possible:
1. PIRATE only simply looks at the user's hands and face to give the idea that they are looking at them and what they are doing.
2. PIRATE has an emotion that is influenced by a colour changing light. While no one is interacting with the artifact, a light is constantly slowly changing colour, the moment the user starts interacting with the artifact the colour changing stops at 1 of 4 colours: yellow, red, green, or blue. (less than four could also be chosen if little time becomes a problem)
   a) Yellow = happy/enthusiastic. Excited, rapid movement of the front module. Possibly a little dance.
   b) Red: Angry/disapproving. Shacking of the front module in a 'no' motion of disapproval. Keeps looking away and up to indicate that it does not want to look at the user being a 'failure'.
   c) Green: Curious. Getting really close to what the user is doing, possibly even to the point of hindering them and then moving away to give the user more room again.
   d) Blue: Shy. Stays low and slowly looks around to rapidly move away again if it gets scared.

Keeps extra attention:
• by adding an extra interactive element to the artifact.

Perspective 6: Be the robot
6.1. Floor projection of a pipe maze that the user has to manoeuvre through.
The user is the PIRATE that has to find its way through a maze. The interaction is that the user physically walks through the projected maze.

- to childish, to little space

Appendix C: Specification

Appendix C1, paper prototype user test instructions
User interface testing
Artifact for Vopak about PIRATE

All over the world pipes are being used to transport liquids and gas. Nowadays all these pipes need to be inspected by people, which costs a lot of money and time. Right now a solution for this is being developed in the form of a pipe inspection robot called 'PIRATE'.
The company Vopak is very interested in this robot, seeing as they deal with transportation of liquids and gas.
Because PIRATE is still in development it is not yet clear what the PIRATE is, how it works, how it will benefit companies like Vopak, etc. An artifact is being made to explain the PIRATE to all the employees at Vopak, their customers, etc.

On the screen is a simplistic prototype of how the artifact will work when it is done. This means that there is no real information to be found yet, there are no animations shown, and there are no clear indicators of what each path will talk about. For this user test imagine that before you start interacting with the artifact there is an animation of the robot is driving around the track. Also, because there are no indicators of what each path talks about yet, here it is provided what each path is about:

Implementation at Vopak   How the robots hardware works

In short what this robot is

How the robot detects problems

Who made the robot

Assignment 1:
Whilest heading to a meeting you are casually passing by this artifact when grabbing a cup of coffee. As the artifact catches your eye, you walk up to it wondering how you can interact with it.
- Figure out how to get the robot in the starting position so you can interact with it further.

Assignment 2:
Because you are only casually grabbing some coffee, you only have a minute to spare looking at this artifact. Since you are an employee at Vopak are mostly interested in how this robot would help out Vopak.
- Get the robot as quickly as possible to the place that shows your desired information.

Assignment 3:
You get an email from your boss that the meeting you were heading too was cancelled. Given this extra time you are very interested in finding out more about the PIRATE.
- Ride the robot past all the available information.
- Finally, stop interacting with the artifact. Either stop clicking buttons or click the 'stop' button.

User interface testing
Artifact for Vopak about PIRATE

Date:_____ Test:_____

Feedback:

	Statement	*(no opinion: leave blank)* *Not agreeing – Neutral – Agreeing*
	The assignments were clear.	🙁 😐 🙂
	I could easily complete the assignments.	🙁 😐 🙂
	I felt like there were too few instructions.	🙁 😐 🙂
	I felt like there were too many instructions.	🙁 😐 🙂
	How I was supposed to navigate the robot was clear.	🙁 😐 🙂
	The skip button felt redundant.	🙁 😐 🙂
	The skip button was very useful.	🙁 😐 🙂
	The navigation buttons were easy to understand.	🙁 😐 🙂
	It would have been better if there as a joystick instead of buttons.	🙁 😐 🙂
	The interface was easy to understand.	🙁 😐 🙂
	The interface felt well designed.	🙁 😐 🙂
	I felt comfortable while using the artifact.	🙁 😐 🙂

Room for extra comments:

```
```

Appendix C3, paper prototype testing notes
Researcher's user interface test.

No comment: -

1.1. -
1.2. Took long, instructions unclear. Didn't notice the skip button.
1.3. -

2.1. Finds it weird that there is no animation (the robot jumps to starting position instead of drives)
2.2. Got there very fast, took two clicks to figured out navigation.
2.3. Used skip button once.

3.1. Finds it weird that there is no animation
3.2. Got there very fast, instantly figured out navigation.
3.3. -

4.1. Comments that it would be easier to understand if everything was mirrored (you read left-right, why is this from right-left)
4.2. Didn't completely read the assignment. Was thinking to far ahead (you need to know how something works before you can know how it will help you). I explained again that for this assignment you only have little time to find your desired information.
4.3. -

5.1. -
5.2. Drives around more than needed for fun.
5.3. -

6.1. -
6.2. Didn't completely understand the assignment/text. I had to give some extra explanation.
6.3. -

7.1. -
7.2. Tried to use the skip button but, because it didn't do anything when the robot is in the starting position, decided to just use the arrow buttons. Was pretty fast and understood the assignment perfectly.
7.3. -

8.1. -
8.2. It was not clear what information they needed to get to, so decided they wanted to know how the hardware worked.
8.3. -

9.1. Tried using arrows before figuring out the start button.
9.2. -
9.3. Did perfectly, drove around extra for fun.

10.1. -
10.2. -
10.3. had some navigational problems at the top left T.

User's notes user interface test.

1. Assignments were less clear, did not explain the context.

2. -

3. -

4. Limiting factor is environment used for prototype.

5. I don't think this is the easiest way to get information across.

6. -

7. -

8. Sometimes it was not clear why the robot couldn't move in a certain direction.

9. The empty middle tube was confusing (there was no information dupe shown) The bug of not turning left after going up on the left was confusing as well.

10. Did not think about what the skip button was for. Also did not feel like I needed it.

Appendix C4, paper prototype results analysis

User test results analysis: 1 is not agreeing, 2 is neutral, 3 is agreeing.

The assignments were clear:

Statistics

AssignmentsClear

N	Valid	10
	Missing	0
Mean		2.400
Mode		2.0
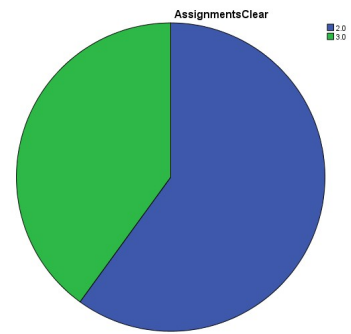
Conclusion: the assignments were mostly clear to everyone.

I could easily complete the assignments:

Statistics

AssignmentEasy

N	Valid	10
	Missing	0
Mean		3.000
Mode		3.0
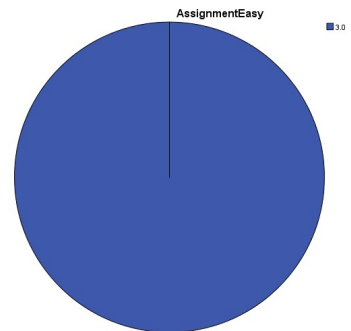
Conclusion: the assignment were easy to complete.

I felt like there were too few instructions:

Statistics

FewInstructions

N	Valid	10
	Missing	0
Mean		1.550
Mode		1.0
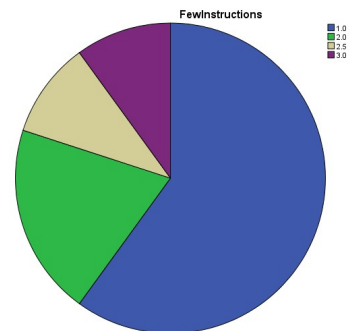
Conclusion: most people did not think/were neutral whether there were too few instruction.

I felt like there were too many instructions:

Statistics

ManyInstructions

N	Valid	10
	Missing	0
Mean		1.450
Mode		1.0
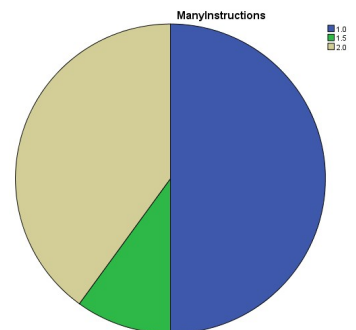
Conclusion: most people did not think/were neutral whether there were too many instruction.

How I was supposed to navigate the robot was clear:

Statistics

NavigationClear

N	Valid	10
	Missing	0
Mean		2.600
Mode		3.0
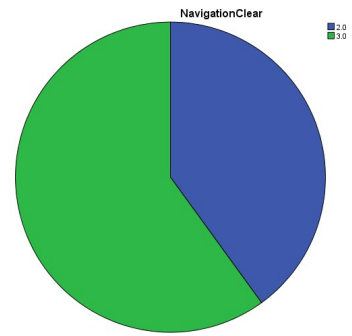
Conclusion: navigation was mostly clear to everyone.

The skip button felt redundant:

Statistics

SkipRedundant

N	Valid	10
	Missing	0
Mean		2.700
Mode		3.0
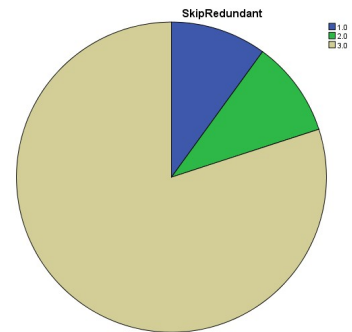
Conclusion: most people agreed that the skip button felt redundant.

The skip button was very useful:

Statistics

SkipUseful

N	Valid	10
	Missing	0
Mean		1.500
Mode		1.0
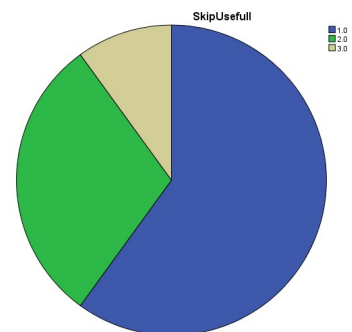
Conclusion: most people did not think/were neutral whether the skip button was useful.

The navigation buttons were easy to understand:

Statistics

NavigationEasyUnderstand

N	Valid	10
	Missing	0
Mean		2.800
Mode		3.0
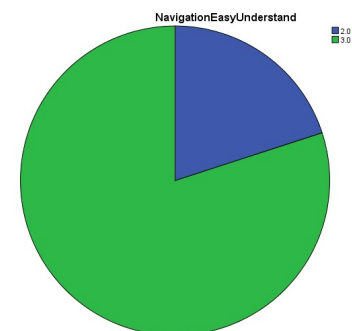
Conclusion: the navigation buttons were mostly easy to understand for everyone.

It would have been better if there was a joystick instead of buttons:

Statistics

JoystickBetterThanButtons

N	Valid	10
	Missing	0
Mean		2.300
Mode		3.0

Conclusion: most people agreed/were neutral about wether a joystick would work better.
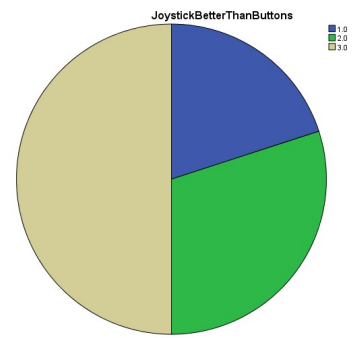
The interface was easy to understand:

Statistics

InterfaceEasyUnderstand

N	Valid	10
	Missing	0
Mean		2.850
Mode		3.0

Conclusion: most people found the interface easy to understand.
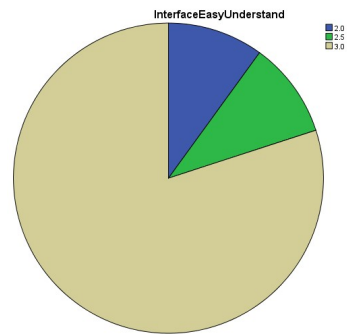
The interface felt well designed:

Statistics

InterfaceWellDesigned

N	Valid	10
	Missing	0
Mean		2.550
Mode		3.0

Conclusion: most people agreed/were neutral about the interface being well designed.
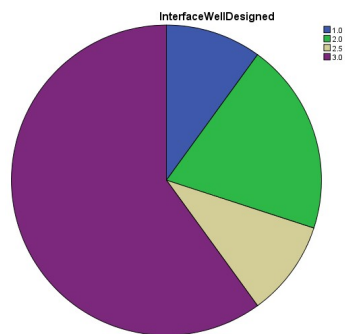
I felt comfortable while using the artifact:

Statistics

Comfortable

N	Valid	10
	Missing	0
Mean		2.850
Mode		3.0

Conclusion: most people felt comfortable while using the artifact.
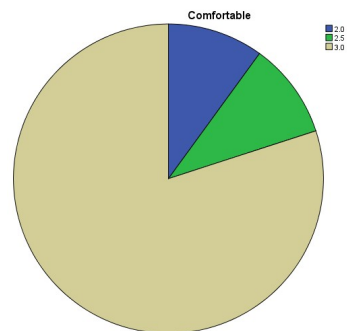
Appendix D: Realisation

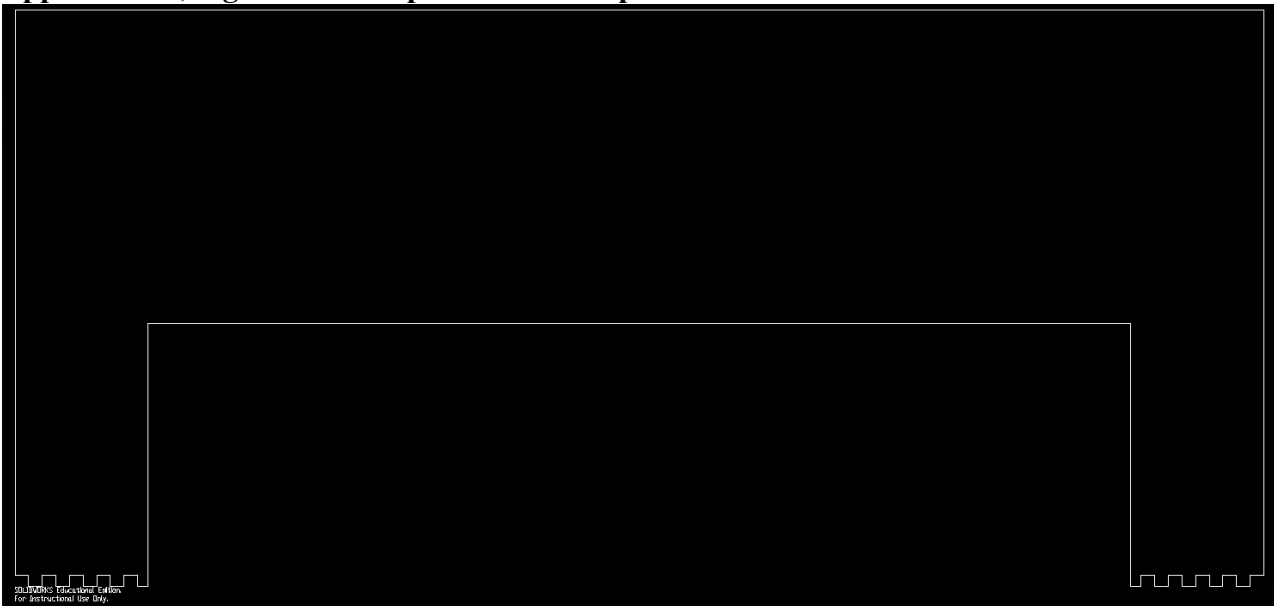## Appendix D1, digital lasercut pictures tabletop

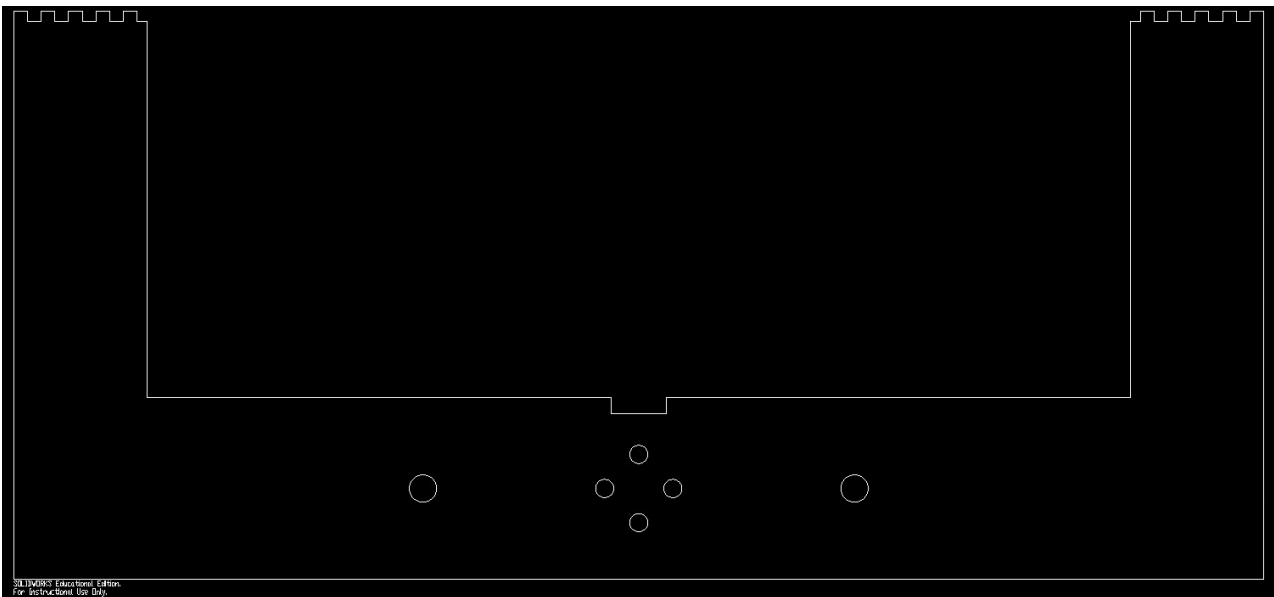*Figure 105: Digital lasercut picture back of tabletop*

Figure 106: Digital lasercut picture front of tabletop

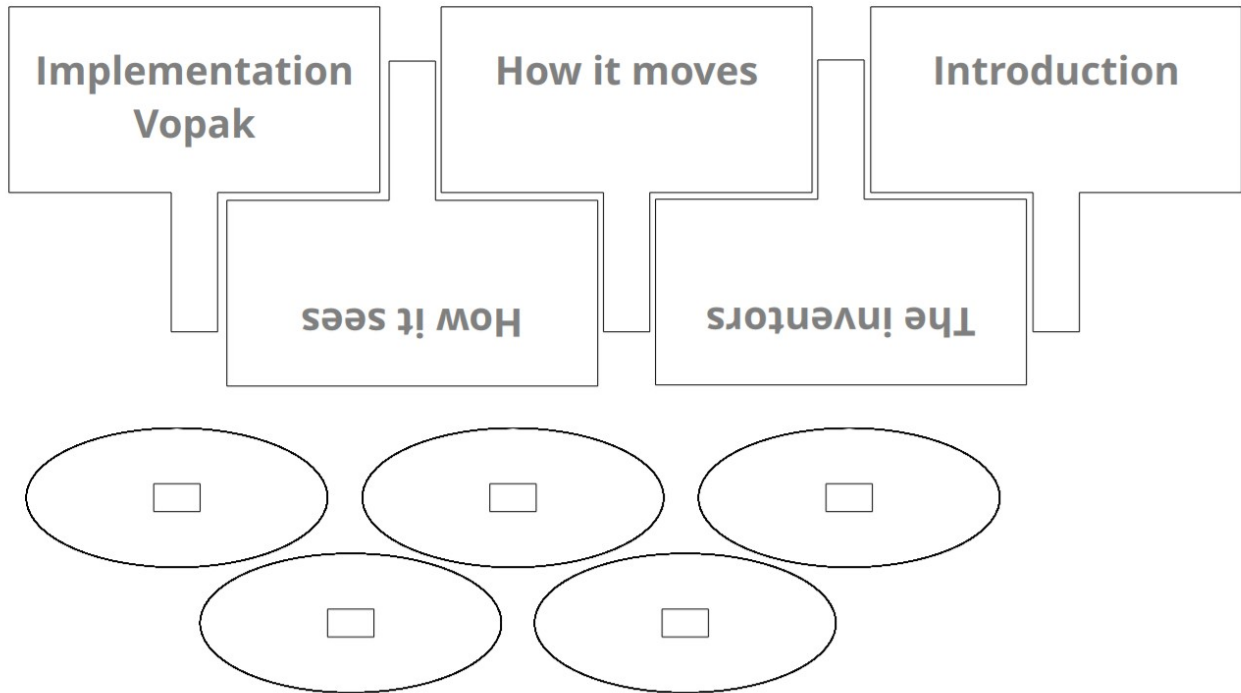**Appendix D2, digital lasercut picture indicator signs**

Implementation Vopak | How it moves | Introduction

How it sees | The inventors

Figure 107: Digital lasercut picture indicator signs

Appendix D3, digital lasercut picture Arduino box
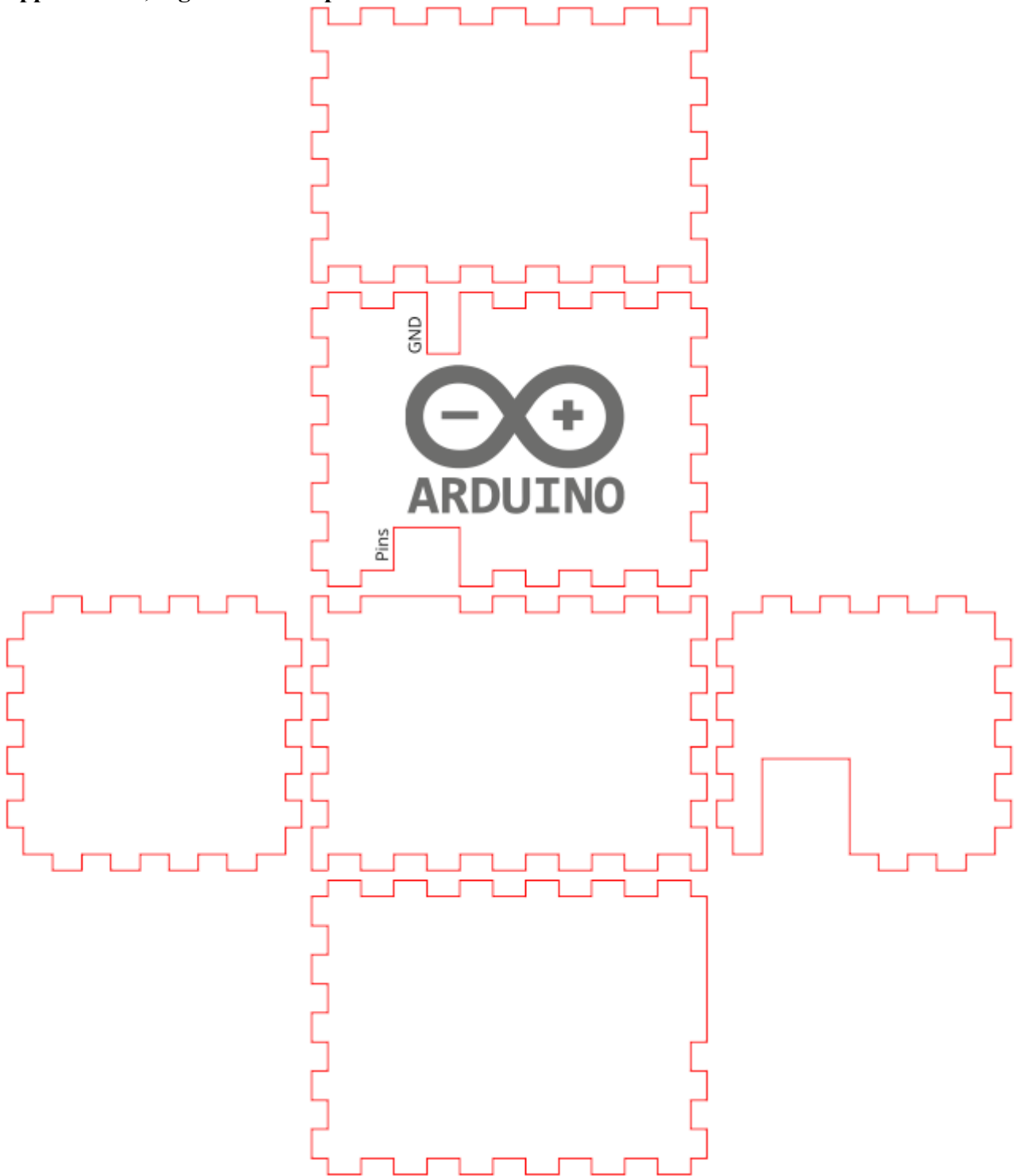
Figure 108: Digital lasercut picture Arduino box

Appendix D4, Arduino code

```
//Made by: Jasmijn de Vries
//Creative Technology bachelor project 2017

int StartPin = 2;
int LeftPin = 4;
int UpPin = 6;
int RightPin = 8;
int DownPin = 10;
int StopPin = 12;
int Start;
int Left;
int Up;
int Right;
int Down;
int Stop;

void setup() {
  Serial.begin(9600);
  pinMode(StartPin, INPUT);
  digitalWrite(StartPin, HIGH);
  pinMode(LeftPin, INPUT);
  digitalWrite(LeftPin, HIGH);
  pinMode(UpPin, INPUT);
  digitalWrite(UpPin, HIGH);
  pinMode(RightPin, INPUT);
  digitalWrite(RightPin, HIGH);
  pinMode(DownPin, INPUT);
  digitalWrite(DownPin, HIGH);
  pinMode(StopPin, INPUT);
  digitalWrite(StopPin, HIGH);
}

void loop() {
  Start = digitalRead(StartPin);
  Left = digitalRead(LeftPin);
  Up = digitalRead(UpPin);
  Right = digitalRead(RightPin);
  Down = digitalRead(DownPin);
  Stop = digitalRead(StopPin);
  if (Start == 1 || Left == 1 || Up == 1 || Right == 1 || Down ==
1 || Stop == 1) {
    if (Start == 1) Serial.print("A");
    if (Left == 1) Serial.print("B");
    if (Up == 1) Serial.print("C");
    if (Right == 1) Serial.print("D");
    if (Down == 1) Serial.print("E");
    if (Stop == 1) Serial.print("F");
  } else Serial.print("G");
  delay(15);
  }
```

Appendix D5, Processing code

```
//Made by: Jasmijn de Vries
//Creative Technology bachelor project 2017

//Libraries
import processing.serial.*;
import processing.video.*;

//Timer
int Delay;
int Time;
int Trans = 0;

//Arduino Input
Serial myPort;  // Create object from Serial class
String val;     // Data received from the serial port
int input;

//Knoppen
boolean Start = false;
boolean Stop = false;
boolean Left = false;
boolean Right = false;
boolean Up = false;
boolean Down = false;
boolean Idle = true;

//make sure to only continue to next state if button has been
released
boolean Released = false;
boolean Arrived = false;

//Changeblindness go to end and start
boolean LastEnd = false;

//Initial State
char Case = 'A';

//Pirate movement
boolean Horizontal = true;
int Speed = 4;
int StartSpeed = 6;

//Coordinates States
int Image1Xpos = 1438;
int Image1Ypos = 1;
int Image2Xpos = Image1Xpos;
int Image2Ypos = 404;
int ImageHeight = 273;
int ImageWidth = ImageHeight*16/9;
int TextXpos = 0;
```

```
int TextYpos = 457;
int TextWidth = 437;
int TextHeight = 623;

int PirateXpos = 110;
int PirateYpos = 124;

int BeginX = 110;
int BeginY = 124;
int Corner1X = 543;
int Corner1Y = BeginY;
int Corner2X = 1359;
int Corner2Y = BeginY;
int Corner3X = Corner1X;
int Corner3Y = 530;
int Corner4X = Corner2X;
int Corner4Y = Corner3Y;
int Corner5X = Corner1X;
int Corner5Y = 938;
int Corner6X = Corner2X;
int Corner6Y = Corner5Y;
int IntroX = 270;
int IntroY = BeginY;
int MoveX = 945;
int MoveY = BeginY;
int SeeX = MoveX;
int SeeY = Corner3Y;
int MadeX = MoveX;
int MadeY = Corner5Y;
int VopakX = 1633;
int VopakY = 935;
int EndX = 1810;
int EndY = VopakY;

//Images
PImage PirateH;
PImage PirateV;
PImage Background;
PImage Foreground;
PImage Intro1;
PImage Intro2;
PImage IntroText;
PImage Move1;
PImage Move2;
PImage MoveText;
PImage See1;
PImage See2;
PImage SeeText;
PImage Made1;
PImage Made2;
PImage MadeText;
```

```
PImage Vopak1;
PImage Vopak2;
PImage VopakText;
PImage StartText;

//Movies
Movie IntroM1;
Movie IntroM2;
Movie MoveM1;
Movie MoveM2;
Movie SeeM1;
Movie SeeM2;
Movie MadeM1;
Movie MadeM2;
Movie VopakM1;
Movie VopakM2;

void setup() {
  fullScreen(2);

  //  Disable the next two lines of code when not connected to
Arduino
  String portName = Serial.list()[1]; //change the 0 to a 1 or 2
etc. to match your port
  myPort = new Serial(this, portName, 9600);

  //Static images
  Background = loadImage("Background.png");
  Foreground = loadImage("Foreground.png");
  //Information images
  PirateH = loadImage("PirateH.png");
  PirateV = loadImage("PirateV.png");
  Intro1 = loadImage("Intro1.png");
  Intro2 = loadImage("Intro2.png");
  IntroText = loadImage("IntroText.png");
  Move1 = loadImage ("Move1.png");
  Move2 = loadImage ("Move2.png");
  MoveText = loadImage ("MoveText.png");
  See1 = loadImage ("See1.png");
  See2 = loadImage ("See2.png");
  SeeText = loadImage ("SeeText.png");
  Made1 = loadImage ("Made1.png");
  Made2 = loadImage ("Made2.png");
  MadeText = loadImage ("MadeText.png");
  Vopak1 = loadImage ("Vopak1.png");
  Vopak2 = loadImage ("Vopak2.png");
  VopakText = loadImage ("VopakText.png");
  StartText = loadImage ("StartText.png");

  //Information movies
  if (Intro1 == null) IntroM1 = new Movie(this, "Intro1.mov");
```

```
  if (Intro2 == null) IntroM2 = new Movie(this, "Intro2.mov");
  if (Move1 == null) MoveM1 = new Movie(this, "Move1.mov");
  if (Move2 == null) MoveM2 = new Movie(this, "Move2.mov");
  if (See1 == null) SeeM1 = new Movie(this, "See1.mov");
  if (See2 == null) SeeM2 = new Movie(this, "See2.mov");
  if (Made1 == null) MadeM1 = new Movie(this, "Made1.mov");
  if (Made2 == null) MadeM2 = new Movie(this, "Made2.mov");
  if (Vopak1 == null) VopakM1 = new Movie(this, "Vopak1.mov");
  if (Vopak2 == null) VopakM2 = new Movie(this, "Vopak2.mov");

  Delay = 300000;
  Time = millis();
}

void draw() {
  readSerial(); // Disable when not connected to Arduino
  ConvertInput(); // Disable when not connected to Arduino
  Display();
//  Debug(); // Enable when not connected to Arduino
  StateHandling();
//  Destinations(); // Enable when not connected to Arduino
}

void readSerial() {

  if (myPort.available () > 0) {
    val = myPort.readString();          // read it and store it in
val
    // println(val);

    if (val.length()<2) {
      input= val.charAt((val.length()-1));

   //   println(input);
    }

    if ( val.length() >= 2) {
      input = val.charAt((val.length()-2));
      //println(input);
    }
  }
}

void ConvertInput() {
  //A
  if (input == 65) Start = true;
  else Start = false;

  //B
  if (input == 66) Left = true;
  else Left = false;
```

```
  //C
  if (input == 67) Up = true;
  else Up = false;

  //D
  if (input == 68) Right = true;
  else Right = false;

  //E
  if (input == 69) Down = true;
  else Down = false;

  //F
  if (input == 70) Stop = true;
  else Stop = false;

  //G
  if (input == 71) Idle = true;
  else Idle = false;

  if (Idle == true && Arrived == true) Released = true;
}

void Display(){
  background(250,250,250);

  image(Background,0,0);
  Pirate();

    image(Foreground, 0, 0);
}

void Debug() {
  if (keyPressed) {
    Idle = false;

    if (key == 'd') Right = true;
    if (key == 'w') Up = true;
    if (key == 's') Down = true;
    if (key == 'a') Left = true;
    if (key == 'z') Start = true;
    if (key == 'x') Stop = true;
  } else {
    Idle = true;
    Right = false;
    Up = false;
    Down = false;
    Left = false;
    Start = false;
    Stop = false;
```

```
  }

  if (Idle == true && Arrived == true) Released = true;

  // The following four lines of code could be usefull while
debugging.
  // println(Case);
  // println("Start" + Start);
  // println("Right" + Right);
  // println("Left" + Left);
}

void StateHandling() {
  switch(Case) {

    // Begin
  case 'A':
    Begin_Case();
    break;

    // Intro
  case 'B':
    Intro_Case();
    break;

    // Corner 1
  case 'C':
    Corner1_Case();
    break;

    // Move
  case 'D':
    Move_Case();
    break;

    // Corner 2
  case 'E':
    Corner2_Case();
    break;

    // Corner 3
  case 'F':
    Corner3_Case();
    break;

    // See
  case 'G':
    See_Case();
    break;

    // Corner 4
```

```cpp
    case 'H':
      Corner4_Case();
      break;

      // Corner 5
    case 'I':
      Corner5_Case();
      break;

      // Made
    case 'J':
      Made_Case();
      break;

      // Corner 6
    case 'K':
      Corner6_Case();
      break;

      // Vopak
    case 'L':
      Vopak_Case();
      break;

      // End
    case 'M':
      End_Case();
      break;

      // Change Blindness Driving around between users
    case 'N':
      Changeblindness_Case();
      break;

      // Moving robot to start position
    case 'O':
      Gotostart_Case();
      break;
  }

  // After no button has been pressed for a specific amount of
time, go to case N (change blindness case)
  if (millis() > Time + Delay) {
    Case = 'N';
    Time = millis();
  }

  // If a button is pressed, reset the timer
  if (Idle == false) {
    Time = millis();
  }
```

```
}

void Begin_Case() {

  // Move Pirate
  if (Arrived == false) {
    if (PirateXpos > BeginX) PirateXpos -= Speed;
  }
  if (PirateXpos > BeginX-Speed && PirateXpos < BeginX+Speed &&
PirateYpos == BeginY) { //taking speed into account in case pirate
shoots over exact pos. Because this is a visible pos we don't move
the pirate into the right pos
    Arrived = true;
  } else Arrived = false;

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Right == true) {
      Case ='B';
      Released = false;
    }
  }
}

void Intro_Case() {

  // Move Pirate
  if (Arrived == false) {
    if (PirateXpos < IntroX) PirateXpos += Speed;
    if (PirateXpos > IntroX) PirateXpos -= Speed;
  }
  if (PirateXpos > IntroX-Speed && PirateXpos < IntroX+Speed &&
PirateYpos == IntroY) { //taking speed into account in case pirate
shoots over exact pos. Because this is a visible pos we don't move
the pirate into the right pos
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }
```

```
  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Right == true) {
      Case ='C';
      Released = false;
    }

    if (Left == true) {
      Case ='A';
      Released = false;
    }
  }

  if (Arrived == true) Information();
}

void Corner1_Case() {

  //move pirate
  if (PirateXpos < Corner1X) PirateXpos += Speed;
  if (PirateXpos > Corner1X) PirateXpos -= Speed;
  if (PirateYpos > Corner1Y) PirateYpos -= Speed;
  if (PirateXpos > Corner1X-Speed && PirateXpos < Corner1X+Speed
&& PirateYpos > Corner1Y-Speed && PirateYpos < Corner1Y+Speed)
{ //taking speed into account in case pirate shoots over exact
pos. Because this is not a visible pos we move pirate into the
right pos
    PirateXpos = Corner1X;
    PirateYpos = Corner1Y;
  }
  if (PirateXpos == Corner1X && PirateYpos == Corner1Y) {
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
```

```
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true && Arrived == true) {

    if (Right == true) {
      Case ='D';
      Released = false;
    }

    if (Left == true) {
      Case ='B';
      Released = false;
    }

    if (Down == true) {
      Case ='F';
      Released = false;
    }
  }
}

void Move_Case() {

  //move pirate
  if (Arrived == false) {
    if (PirateXpos < MoveX) PirateXpos += Speed;
    if (PirateXpos > MoveX) PirateXpos -= Speed;
  }
  if (PirateXpos > MoveX-Speed && PirateXpos < MoveX+Speed &&
PirateYpos == MoveY) { //taking speed into account in case pirate
shoots over exact pos. Because this is a visible pos we don't move
the pirate into the right pos
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }
```

```
  //movement when direction button is pressed
  if (Released == true) {

    if (Right == true) {
      Case ='E';
      Released = false;
    }

    if (Left == true) {
      Case ='C';
      Released = false;
    }
  }

  if (Arrived == true) {
    Information();
  }
}

void Corner2_Case() {

  //move pirate
  if (PirateXpos < Corner2X) PirateXpos += Speed;
  if (PirateYpos > Corner2Y) PirateYpos -= Speed;
  if (PirateXpos > Corner2X-Speed && PirateXpos < Corner2X+Speed
&& PirateYpos > Corner2Y-Speed && PirateYpos < Corner2Y+Speed)
{ //taking speed into account in case pirate shoots over exact
pos. Because this is not a visible pos we move pirate into the
right pos
    PirateXpos = Corner2X;
    PirateYpos = Corner2Y;
  }
  if (PirateXpos == Corner2X && PirateYpos == Corner2Y) {
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }
  //movement when direction button is pressed
  if (Released == true) {
```

```
      if (Down == true) {
        Case ='H';
        Released = false;
      }

      if (Left == true) {
        Case ='D';
        Released = false;
      }
    }
}

void Corner3_Case() {

  //move pirate
  if (PirateXpos > Corner3X) PirateXpos -= Speed;
  if (PirateYpos < Corner3Y) PirateYpos += Speed;
  if (PirateYpos > Corner3Y) PirateYpos -= Speed;
   if (PirateXpos > Corner3X-Speed && PirateXpos < Corner3X+Speed
&& PirateYpos > Corner3Y-Speed && PirateYpos < Corner3Y+Speed)
{ //taking speed into account in case pirate shoots over exact
pos. Because this is not a visible pos we move pirate into the
right pos
    PirateXpos = Corner3X;
    PirateYpos = Corner3Y;
  }
  if (PirateXpos == Corner3X && PirateYpos == Corner3Y) {
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Right == true) {
      Case ='G';
      Released = false;
    }
```

```
    if (Up == true) {
      Case ='C';
      Released = false;
    }

    if (Down == true) {
      Case ='I';
      Released = false;
    }
  }
}

void See_Case() {

  //move pirate
  if (Arrived == false) {
    if (PirateXpos < SeeX) PirateXpos += Speed;
    if (PirateXpos > SeeX) PirateXpos -= Speed;
  }
  if (PirateXpos > SeeX-Speed && PirateXpos < SeeX+Speed &&
PirateYpos == SeeY) { //taking speed into account in case pirate
shoots over exact pos. Because this is a visible pos we don't move
the pirate into the right pos
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Right == true) {
      Case ='H';
      Released = false;
    }

    if (Left == true) {
      Case ='F';
      Released = false;
```

```
    }
  }
  if (Arrived == true) {
    Information();
  }
}

void Corner4_Case() {

  //move pirate
  if (PirateXpos < Corner4X) PirateXpos += Speed;
  if (PirateYpos < Corner4Y) PirateYpos += Speed;
  if (PirateYpos > Corner4Y) PirateYpos -= Speed;
  if (PirateXpos > Corner4X-Speed && PirateXpos < Corner4X+Speed
&& PirateYpos > Corner4Y-Speed && PirateYpos < Corner4Y+Speed)
{ //taking speed into account in case pirate shoots over exact
pos. Because this is not a visible pos we move pirate into the
right pos
    PirateXpos = Corner4X;
    PirateYpos = Corner4Y;
  }
  if (PirateXpos == Corner4X && PirateYpos == Corner4Y) {
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Up == true) {
      Case ='E';
      Released = false;
    }

    if (Down == true) {
      Case ='K';
      Released = false;
    }
```

```
    if (Left == true) {
      Case = 'G';
      Released = false;
    }
  }
}

void Corner5_Case() {

  //move pirate
  if (PirateXpos > Corner5X) PirateXpos -= Speed;
  if (PirateYpos < Corner5Y) PirateYpos += Speed;
  if (PirateXpos > Corner5X-Speed && PirateXpos < Corner5X+Speed
&& PirateYpos > Corner5Y-Speed && PirateYpos < Corner5Y+Speed)
{ //taking speed into account in case pirate shoots over exact
pos. Because this is not a visible pos we move pirate into the
right pos
    PirateXpos = Corner5X;
    PirateYpos = Corner5Y;
  }
  if (PirateXpos == Corner5X && PirateYpos == Corner5Y) {
    Arrived = true;
  } else Arrived = false;


  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Up == true) {
      Case ='F';
      Released = false;
    }

    if (Right == true) {
      Case ='J';
      Released = false;
    }
  }
```

```cpp
}

void Made_Case() {

  //move pirate
  if (Arrived == false) {
    if (PirateXpos < MadeX) PirateXpos += Speed;
    if (PirateXpos > MadeX) PirateXpos -= Speed;
  }
  if (PirateXpos > MadeX-Speed && PirateXpos < MadeX+Speed &&
PirateYpos == MadeY) { //taking speed into account in case pirate
shoots over exact pos. Because this is a visible pos we don't move
the pirate into the right pos
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Right == true) {
      Case ='K';
      Released = false;
    }

    if (Left == true) {
      Case = 'I';
      Released = false;
    }
  }
  if (Arrived == true) {
    Information();
  }
}

void Corner6_Case() {

  //move pirate
  if (PirateXpos < Corner6X) PirateXpos += Speed;
```

```
  if (PirateXpos > Corner6X) PirateXpos -= Speed;
  if (PirateXpos > BeginX-Speed && PirateXpos < BeginX+Speed)
PirateXpos = Corner6X; //taking speed into account in case pirate
shoots over exact pos. Because this is not a visible pos we move
pirate into the right pos.
  if (PirateXpos == Corner6X && PirateYpos < Corner6Y) PirateYpos
+= Speed;
  if (PirateXpos == Corner6X && PirateYpos > Corner6Y) PirateYpos
-= Speed;
  if (PirateYpos > Corner6Y-Speed && PirateYpos < Corner6Y+Speed)
PirateYpos = Corner6Y; //taking speed into account in case pirate
shoots over exact pos. Because this is not a visible pos we move
pirate into the right pos. Because of strange VopakY moving X and
Ypos need to be seperate
  if (PirateXpos == Corner6X && PirateYpos == Corner6Y) {
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Up == true) {
      Case ='H';
      Released = false;
    }

    if (Right == true) {
      Case ='L';
      Released = false;
    }
    if (Left == true) {
      Case = 'J';
      Released = false;
    }
  }
}

void Vopak_Case() {
```

```
  //move pirate
  PirateYpos = VopakY;
  if (PirateXpos < VopakX) PirateXpos += Speed;
  if (PirateXpos > VopakX) PirateXpos -= Speed;
  if (PirateXpos > VopakX-Speed && PirateXpos < VopakX+Speed &&
PirateYpos == VopakY) { //taking speed into account in case pirate
shoots over exact pos. Because this is a visible pos we don't move
the pirate into the right pos
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Right == true) {
      Case ='M';
      Released = false;
    }
    if (Left == true) {
      Case = 'K';
      Released = false;
    }
  }
  if (Arrived == true) {
    Information();
  }
}

void End_Case() {

  // Move Pirate
  if (Arrived == false) {
    if (PirateXpos < EndX) PirateXpos += Speed;
  }
  if (PirateXpos > EndX-Speed && PirateXpos < EndX+Speed &&
PirateYpos == EndY) { //taking speed into account in case pirate
shoots over exact pos. Because this is a visible pos we don't move
```

```
the pirate into the right pos
    Arrived = true;
  } else Arrived = false;

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;
  }

  //if stop is pressed the Pirate starts driving around on its own
in the changeblindness case
  if (Stop == true) {
    Case = 'N';
    Released = false;
  }

  //movement when direction button is pressed
  if (Released == true) {

    if (Left == true) {
      Case ='L';
      Released = false;
    }
  }
}

void Changeblindness_Case() {

  //go to case to move pirate to begin if start is pressed
  if (Start == true) {
    Case ='O';
    Released = false;

  }


  if (LastEnd == false) {
    if (PirateXpos > Corner5X-Speed && PirateXpos < Corner5X+Speed
&& PirateYpos < Corner5Y) {
      PirateXpos = Corner5X;
      PirateYpos += Speed;
    }
    if (PirateXpos < Corner2X && PirateXpos != Corner5X &&
PirateYpos != Corner5Y) PirateXpos += Speed;

    if (PirateYpos < EndY && PirateXpos > Corner2X-Speed &&
PirateXpos < Corner2X+Speed) {
      PirateXpos = Corner2X;
      PirateYpos += Speed;
    }
```

```
    if (PirateXpos < Corner6X && PirateYpos > Corner6Y-Speed &&
PirateYpos < Corner6Y+Speed) {
        PirateYpos = Corner6Y;
        PirateXpos +=Speed;
    }
    if (PirateXpos < EndX && PirateXpos >= Corner6X && PirateYpos
> Corner6Y-Speed && PirateYpos < Corner6Y+Speed) PirateYpos =
EndY;
    if (PirateXpos < EndX && PirateYpos == EndY) PirateXpos +=
Speed;
    if (PirateXpos > EndX-Speed && PirateXpos < EndX+Speed &&
PirateYpos == EndY) {
        PirateXpos = EndX;
        LastEnd = true;
    }
  }

  if (LastEnd == true) {

    if (PirateXpos > Corner2X-Speed && PirateXpos < Corner2X+Speed
&& PirateYpos > Corner2Y) {
        PirateXpos = Corner2X;
        PirateYpos -= Speed;
    }
    if (PirateXpos > Corner5X && PirateXpos != Corner2X &&
PirateYpos != Corner2Y) PirateXpos -= Speed;

    if (PirateYpos > BeginY && PirateXpos > Corner5X-Speed &&
PirateXpos < Corner5X+Speed) {
        PirateXpos = Corner5X;
        PirateYpos -= Speed;
    }
    if (PirateXpos > Corner1X && PirateYpos > Corner1Y-Speed &&
PirateYpos < Corner1Y+Speed) {
        PirateYpos = Corner1Y;
        PirateXpos -=Speed;
    }
    if (PirateXpos > BeginX && PirateXpos <= Corner1X &&
PirateYpos > Corner1Y-Speed && PirateYpos < Corner1Y+Speed)
PirateYpos = BeginY;
    if (PirateXpos > BeginX && PirateXpos <= Corner1X &&
PirateYpos == BeginY) PirateXpos -=Speed;
    if (PirateXpos > BeginX-Speed && PirateXpos < BeginX+Speed &&
PirateYpos == BeginY) {
        PirateXpos = BeginX;
        LastEnd = false;
    }
  }
}

void Gotostart_Case() {
```

```
   Information();;
   if (PirateXpos > Corner2X-StartSpeed && PirateXpos <
Corner2X+StartSpeed && PirateYpos > Corner2Y) {
     PirateXpos = Corner2X;
     PirateYpos -= StartSpeed;
   }
   if (PirateXpos > Corner5X && PirateXpos != Corner2X &&
PirateYpos != Corner2Y) PirateXpos -= StartSpeed;

   if (PirateYpos > BeginY && PirateXpos > Corner5X-StartSpeed &&
PirateXpos < Corner5X+StartSpeed) {
     PirateXpos = Corner5X;
     PirateYpos -= StartSpeed;
   }
   if (PirateXpos > BeginX && PirateYpos <= Corner1Y) {
     PirateYpos = BeginY;
     PirateXpos -=StartSpeed;
   }
   if (PirateXpos > BeginX-StartSpeed && PirateXpos <
BeginX+StartSpeed && PirateYpos == BeginY) {
     PirateXpos = BeginX;
     Case = 'A';
   }
}

void Information() {

  //fill content based on case
  if (Case == 'B') {
    if (Intro1 != null) {
      image(Intro1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    } else {
      IntroM1.play();
      if (IntroM1.available()) {
        IntroM1.read();
      }
      image(IntroM1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    }

    if (Intro2 != null) {
      image(Intro2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    } else {
      IntroM2.play();
      if (IntroM2.available()) {
        IntroM2.read();
      }
      image(IntroM2, Image2Xpos, Image2Ypos, ImageWidth,
```

```
ImageHeight);
    }

    image(IntroText, TextXpos, TextYpos, TextWidth, TextHeight);
  } else {
    if (Intro1 == null) IntroM1.stop();
    if (Intro2 == null) IntroM2.stop();
  }

  if (Case == 'D') {
    if (Move1 != null) {
      image(Move1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    } else {
      MoveM1.play();
      if (MoveM1.available()) {
        MoveM1.read();
      }
      image(MoveM1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    }

    if (Move2 != null) {
      image(Move2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    } else {
      MoveM2.play();
      if (MoveM2.available()) {
        MoveM2.read();
      }
      image(MoveM2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    }

    image(MoveText, TextXpos, TextYpos, TextWidth, TextHeight);
  } else {
    if (Move1 == null) MoveM1.stop();
    if (Move2 == null) MoveM2.stop();
  }

  if (Case == 'G') {
    if (See1 != null) {
      image(See1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    } else {
      SeeM1.play();
      if (SeeM1.available()) {
        SeeM1.read();
      }
      image(SeeM1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
```

```
    }

    if (See2 != null) {
      image(See2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    } else {
      SeeM2.play();
      if (SeeM2.available()) {
        SeeM2.read();
      }
      image(SeeM2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    }

    image(SeeText, TextXpos, TextYpos, TextWidth, TextHeight);
  } else {
    if (See1 == null) SeeM1.stop();
    if (See2 == null) SeeM2.stop();
  }

  if (Case == 'J') {
    if (Made1 != null) {
      image(Made1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    } else {
      MadeM1.play();
      if (MadeM1.available()) {
        MadeM1.read();
      }
      image(MadeM1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    }

    if (Made2 != null) {
      image(Made2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    } else {
      MadeM2.play();
      if (MadeM2.available()) {
        MadeM2.read();
      }
      image(MadeM2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    }

    image(MadeText, TextXpos, TextYpos, TextWidth, TextHeight);

  } else {
    if (Made1 == null) MadeM1.stop();
    if (Made2 == null) MadeM2.stop();
  }
```

```
  if (Case == 'L') {
    if (Vopak1 != null) {
      image(Vopak1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    } else {
      VopakM1.play();
      if (VopakM1.available()) {
        VopakM1.read();
      }
      image(VopakM1, Image1Xpos, Image1Ypos, ImageWidth,
ImageHeight);
    }

    if (Vopak2 != null) {
      image(Vopak2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    } else {
      VopakM2.play();
      if (VopakM2.available()) {
        VopakM2.read();
      }
      image(VopakM2, Image2Xpos, Image2Ypos, ImageWidth,
ImageHeight);
    }

    image(VopakText, TextXpos, TextYpos, TextWidth, TextHeight);

  } else {
    if (Vopak1 == null) VopakM1.stop();
    if (Vopak2 == null) VopakM2.stop();
  }
  if (Case == 'O') {
    image(StartText, TextXpos, TextYpos, TextWidth, TextHeight);
  }
}

void Pirate() {

  if (PirateXpos == Corner1X || PirateXpos == Corner2X) {
    Horizontal = false;
  } else Horizontal = true;

  if (Horizontal == true) { // If Pirate is moving horizontally,
show the horizondal picture of the pirate at the right location
    image(PirateH, PirateXpos-101, PirateYpos-36, 202, 73);
  }

  if (Horizontal == false) { // If Pirate is moving vertically,
show the vertical picture of the pirate at the right location
    image(PirateV, PirateXpos-36, PirateYpos-101, 73, 202);
```

```
  }

  // If the Pirate is in a corner, fade in a yellow circle around
the corner
  if (PirateXpos == Corner1X && PirateYpos == Corner1Y ||
PirateXpos == Corner2X && PirateYpos == Corner2Y || PirateXpos ==
Corner3X && PirateYpos == Corner3Y || PirateXpos == Corner4X &&
PirateYpos == Corner4Y || PirateXpos == Corner5X && PirateYpos ==
Corner5Y || PirateXpos == Corner6X && PirateYpos == Corner6Y) {
    if (Case != 'N' && Case != 'O') {
      fill(255, 255, 0, Trans);
      noStroke();
      ellipse(PirateXpos, PirateYpos, 300, 300);
      if (Trans < 50) Trans += 1;
    }
  }

  if (Arrived == false) Trans = 0;
}

void Destinations(){
  // this shows the coordinates of the cases, can be very helpfull
while debugging
  noFill();
  stroke(0);
  ellipse(Corner1X, Corner1Y, 20, 20);
  ellipse(Corner2X, Corner2Y, 20, 20);
  ellipse(Corner3X, Corner3Y, 20, 20);
  ellipse(Corner4X, Corner4Y, 20, 20);
  ellipse(Corner5X, Corner5Y, 20, 20);
  ellipse(Corner6X, Corner6Y, 20, 20);
  ellipse(BeginX, BeginY, 20, 20);
  ellipse(IntroX, IntroY, 20, 20);
  ellipse(MoveX, MoveY, 20, 20);
  ellipse(SeeX, SeeY, 20, 20);
  ellipse(MadeX, MadeY, 20, 20);
  ellipse(VopakX, VopakY, 20, 20);
  ellipse(EndX, EndY, 20, 20);
}
```

Handleiding: Informatieve tafel over de PIRATE

Manual: Informative table about the PIRATE

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Creative Technology
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Inhoud
Table of contents

<u>English</u>

Nederlandse verzie

Aanzetten
1. Stop de kabels van zowel de laptop als het scherm in een stopcontact. Zorg ervoor dat de laptop goed aan de oplader hangt, anders valt hij misschien uit.
2. Doe de laptop aan.
3. Doe het scherm aan d.m.v. de afstandsbediening. De ontvanger zit aan de onderkant van het scherm in het midden. Het scherm gaat aan als hij het Philips logo laat zien.
4. Start de Arduino code. Dit doet u door op de laptop het mapje 'Arduino code' te openen en daarin dubbel te klikken op het programma.
5. Open de Processing code. Dit doet u door op de laptop het mapje 'Processing code' te openen en daarin dubbel te klikken op 1 van de processing mapjes. Het maakt hierbij niet uit op welke u klikt.
6. Run de Processing code. Klik hiervoor op de 'play' knop links bovenin, zie het plaatje rechts.
7. De tafel staat aan. Als iets het niet doet zie 'Veel voorkomende problemen'.

Uitzetten
1. Zet het scherm (d.m.v. de afstandsbediening) en de laptop uit.
2. De tafel staat uit. U kunt eventueel de stekkers uit het stopcontact halen maar dit is niet nodig.

Bovenkant van de tafel er af tillen
Dit zou gedaan moeten worden als de tafel zijwaarts verplaatst moet worden of als er iets met de elektronica moet gebeuren.
1. Haal het zwarte stof los en leg het in de tafel.
2. Til het gaas uit de schroefjes aan de achterkant van de tafel.
3. Til het 1:1 model en zijn omhulsel uit de tafel.
4. Maak de connectors los die tussen de knoppen en de Arduino zitten.
5. De bovenkant van de tafel is nu los en kan er voorzichtig af worden getild.

Elektronica verwijderen/vervangen

Laptop
1. Zet de laptop uit.
2. Haal de laptop los van de oplader, de Arduino, en het scherm.
3. De laptop kan nu verwijderd/vervangen worden.

Scherm
1. Til de bovenkant van de tafel er af. (zie 'Bovenkant van de tafel er af tillen')
2. Haal de stroom kabel uit de muur en de HDMI kabel uit de laptop.
3. Het scherm kan nu voorzichtig uit de tafel worden getild zodat hij verwijderd/vervangen kan worden.

Knoppen
1. Haal de connectors los.
2. Draai de knoppen los van de tafel.
3. De knoppen kunnen nu verwijderd/vervangen worden.

Arduino
1. Haal de bovenkant van het Arduino doosje eraf.
2. Verwijder voorzichtig het blauwe snoer uit de Arduino.
3. Haal nu voorzichtig de rode en het zwarte kabeltje uit de Arduino.
4. De Arduino is nu los en kan verwijderd/vervangen worden.

In elkaar zetten
1. Plaats alle eventueel verwijderde elektronica, behalve de knoppen, terug in de tafel.
2. Leg de bovenkant van de tafel op zijn plek, vanwege de spalkjes valt hij met een beetje schuiven vanzelf op zijn plek.
3. Schroef nu de eventueel verwijderde knoppen terug in de bovenste plank van de tafel.
4. Doe de kabeltjes van de knoppen door het gat voorin de tafel.
5. Doe de connectors weer vast. Op de labeltjes van de kabels staat aangegeven welke aan elkaar moeten.
6. Zet het 1:1 model en zijn omhulsel weer terug in de tafel.
7. Hang het gaas weer op aan de schroefjes.
8. Span de stof weer om de tafel aan het klittenband.
9. De tafel zit nu weer in elkaar.

Verplaatsen

De doorgangen zijn breder dan 100cm
1. Haal de zwarte stof los en leg het in de tafel.
2. Haal de wieltjes van hun slot.
3. Rol de tafel voorzichtig en langzaam naar zijn nieuwe plek. Soms zal te tafel over een drempeltje getild moeten worden, het is hierdoor belangrijk dat u de tafel niet alleen verplaatst.
4. Als de tafel op de nieuwe bestemming is aangekomen:
    1. Zet de wieltjes weer op slot
    2. Span de stof weer om de tafel aan het klittenband.

De doorgangen zijn tussen de 87cm en 100cm
1. Til de bovenkant van de tafel eraf. (zie 'Bovenkant van de tafel er af tillen')
2. Verwijder de laptop en het scherm van de tafel. (zie 'Elektronica verwijderen/vervangen' kopjes 'Laptop' en 'Scherm'.)
3. Haal de wieltjes van hun slot.
4. Zet de tafel voorzichtig op zijn kant.
5. Til de tafel naar zijn nieuwe bestemming. Dit moet door minstens 2 mensen gedaan worden.
6. Als de tafel op de nieuwe bestemming is aangekomen:
    1. Zet de tafel weer voorzichtig rechtop.
    2. Zet de wieltjes op slot.
    3. Zet de tafel weer in elkaar. (zie 'Tafel in elkaar zetten')

Als de doorgangen kleiner zijn dan 87cm zal de tafel helemaal uit elkaar geschroefd moeten worden.

Vervangen informatie

Tekst
1. Maak een nieuw stuk tekst, gebruik hierbij het lettertype Open Sans. Dit moet worden omgezet in een PNG van 437 x 263px
2. Geef het nieuwe tekst vlak de juiste naam. Zie hiervoor de tabel 'Naam van de files in de data map'.
3. Verwijder het oude tekst vlak van het mapje 'data' op de laptop in de tafel.
4. Zet het nieuwe tekst vlak in het mapje 'data' op de laptop in de tafel.
5. Het tekstvlak is nu vervangen.

Plaatjes
1. Maak een nieuw plaatje. Deze moet 1920 x 1080px zijn (of verhouding 16/9) en een PNG bestand zijn.
2. Geef het nieuwe plaatje de juiste naam. Zie hiervoor de tabel 'Naam van de files in de data map'.
3. Verwijder het oude plaatje van het mapje 'data' op de laptop in de tafel.
4. Zet het nieuwe plaatje in het mapje 'data' op de laptop in de tafel.
5. Het plaatje is nu vervangen.

Videos
1. Maak een nieuwe video. Deze moet 1920 x 1080px zijn (of verhouding 16/9) en een MOV bestand zijn.
2. Geef de nieuwe video de juiste naam. Zie hiervoor de tabel 'Naam van de files in de data map'.
3. Verwijder de oude video van het mapje 'data' op de laptop in de tafel.
4. Zet de nieuwe video in het mapje 'data' op de laptop in de tafel.
5. De video is nu vervangen.

Let op!
Als u geen plaatje of video wilt laten zien op een informatie moment in de tafel moet er nog wel een plaatje in de data map zitten. Om er voor te zorgen dat er niks wordt laten zien maakt u dit plaatje compleet transparant.

Naam van de files in de data map			
Plaats in de tafel	*Tekst*	*Plaatje/Video vlak 1*	*Plaatje/Video vlak 2*
Introduction	IntroText	Intro1	Intro2
How it moves	MoveText	Move1	Move2
How it sees	SeeText	See1	See2
The inventors	MadeText	Made1	Made2
Implementation Vopak	VopakText	Vopak1	Vopak2

1:1 model
1. Trek voorzichtig het 1:1 model van de PIRATE uit elkaar zodat hij uitrekt en los komt van zijn omhulsel.
2. Verwijder voorzichtig het 1:1 model uit het omhulsel.
3. Er kan nu een nieuw 1:1 model in het omhulsel worden gezet.

Informatie bordjes
1. Til de bordjes die u wilt vervangen uit de tafel.
2. Het CorelDRAW bestand van de bordjes staat op de laptop die in de tafel zit, gebruik dit bestand op een computer met CorelDRAW om de bordjes aan te passen.
3. Lasercut nieuwe bordjes uit 6mm dik hout dat geschikt is voor lasercutten.
4. Plaats de nieuwe bordjes op de tafel.

Veel voorkomende problemen

De knoppen doen het niet
Klik op de 'Serial Monitor'. Zie het plaatje rechts.
Er zijn 3 dingen die nu kunnen gebeuren:
   a) De 'Serial Monitor' laat alleen de letter G zien.
   b) De 'Serial Monitor' laat één of meerdere andere letters dan G zien.
   c) De Arduino code geeft de foutmelding 'Board at COM4 is not available'.

a) De 'Serial Monitor' laat alleen de letter G zien
   1. Alle knoppen zouden het moeten doen. Probeer processing opnieuw op te starten.

b) De 'Serial Monitor' laat één of meerdere andere letters dan G zien
   1. Bekijk welke letters er worden doorgegeven. Kijk in de tabel 'Knop met corresponderende letter en Arduino pin'.
   2. Controleer of de kabels van de corresponderende knoppen wel goed contact maken in de Arduino. Als er nog steeds geen letter G wordt doorgegeven ga dan door naar de volgende stap.
   3. Controleer of de connectors van de knoppen wel goed contact maken. Als de connectors vast zitten moet u misschien voorzichtig even aan de connectors draaien tot de 'Serial Monitor' de letter G door geeft.
   4. Als dit allemaal niet werkt is een kabeltje, connector, of knop stuk en moet deze worden vervangen.

c) De Arduino code geeft de foutmelding 'Board at COM4 is not available'
(zie plaatje rechts onder)
   1. De Arduino is niet aangesloten aan de laptop of zit in de verkeerde USB port. Stop de Arduino in een andere USB port en klik opnieuw op de 'Serial Monitor' net zolang tot u de juiste USB port heeft gevonden.
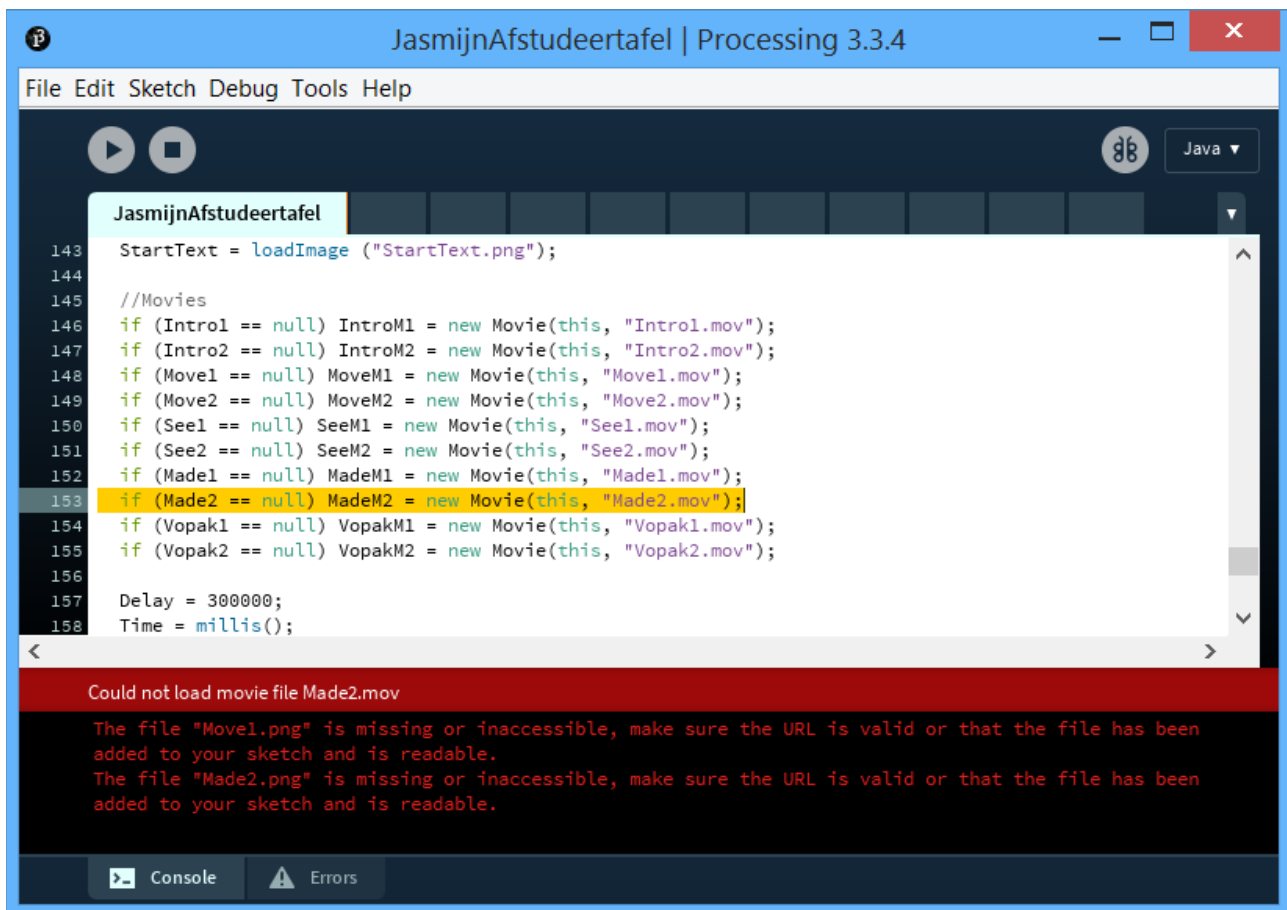
Knop met corresponderende letter en Arduino pin		
Knop	*Letter in de 'Serial Monitor'*	*Arduino pin*
Start	A	2
Links	B	4
Omhoog	C	6
Rechts	D	8
Omlaag	E	10
Stop	F	12
Geen knop	G	-

De processing code wil niet runnen

Het meest waarschijnlijk als de processing code niet wil runnen is dat er een fout zit in de data folder. Processing geeft dan de foutmelding 'Could no load movie file __.mov', zie het plaatje lager op deze pagina. In deze foutmelding staat de naam van de file waar een probleem mee is. Foutmeldingen dat PNG's missen geven geen problemen dus kunnen genegeerd worden. Deze foutmelding kan veroorzaakt worden door:

a) De informatie file heeft de verkeerde titel.
       Los dit op door de titel van de file te verbeteren. Kijk voor de juiste file namen in de tabel op pagina 6.

b) Er mist een informatie file.
       Los dit op door een informatie file toe te voegen, of door een transparant plaatje in de data file te stoppen met de juiste file naam. Kijk voor de juiste file namen in de tabel op pagina 6.

English version

Turning on

1. Put both the cables of the laptop and the screen in a power socket. Make sure that the laptop is efficiently connected, otherwise it might turn off on its own.
2. Turn the laptop on.
3. Turn the screen on using the remote. If the screen is turning on it will show the Philips logo.
4. Start the Arduino code. Do this by opening the folder 'Arduino code' on the laptop and then double clicking on the program.
5. Open the Processing code. Do this by opening the folder 'Processing code' on the laptop and then double clicking on 1 of the Processing files. It does not matter which file you click.
6. Run the Processing code. For this you have to click the 'play' button that is at the top left of the program, see the picture to the right.
7. The table is now on. If something isn't working go to 'Often occurring problems'.
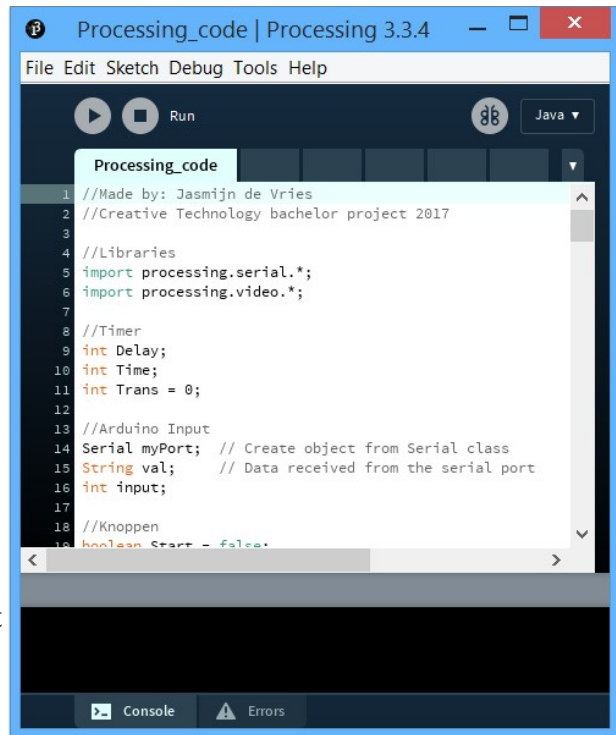
Turning off

1. Turn of the screen (using the remote) and turn of the laptop
2. The table is now turned off. You could take the cables out of the power sockets but this is not a necessity.

Lifting the top of the table off

This is necessary if the table needs to be transported sideways or if something needs to happen with the electronics.

1. Remove the black fabric from the table, until it is only connected to the right back corner of the table, and place it inside the table.
2. Lift the mesh fabric off the screws that are at the back of the table.
3. Lift the 1:1 model and its stand out of the table.
4. Detach the connectors that are between the buttons and the Arduino.
5. The top of the table is now lose and can be carefully lifted off the table.

Removing/replacing electronics

Laptop
1. Turn the laptop of.
2. Take the charger out of the laptop, take the Arduino cable out of the laptop, and take the HDMI cable out of the laptop.
3. The laptop is now free to be removed/replaced.

Screen
1. Lift the top of the table off. (See 'Lifting the top of the table off')
2. Take the cable out of the power socket and the HDMI cable out of the laptop.
3. The screen can now be carefully lifted out off the table so it can be removed/replaced.

Knoppen
1. Detach the connectors.
2. Screw the buttons lose from the table.
3. The buttons can now be removed/replaced.

Arduino
1. Remove the top of the Arduino box.
2. Carefully detach the blue cable from the Arduino.
3. Now carefully remove the red and blue cabled from the Arduino.
4. The Arduino is now free to be removed/replaced.

Putting everything together
1. Put all the possible removed electronics, except the buttons, back into the table.
2. Put the tabletop back on the table, because of the splints a little shuffling should be enough to have the tabletop fall in its place.
3. Screw the possible removed buttons back into the tabletop.
4. Place the cable of the buttons back through the hole inside the front of the table.
5. Reconnect the connectors. All the cables have been labeller to show how everything should be connected.
6. Place the 1:1 model and its stand back into the table.
7. Hang the mesh fabric back up on the screws.
8. Tightly place the black fabric back around the table on the velcro.
9. The table has now been put back together.

Moving

The passages are wider than 100cm
1. Remove the black fabric from the table, until it is only connected to the right back corner of the table, and place it inside the table.
2. Unlock the wheels.
3. Carefully and slowly roll the table to its new location. Sometimes the table will need to be lifted over something like a threshold. Because of this it is important that at least two people are moving the table.
4. When the table has reached its new destination:
   1. Lock the wheels.
   2. Tightly place the black fabric back around the table on the velcro.

The passages are between 87cm and 100cm
1. Carefully lift the tabletop off of the table.
2. Remove the laptop and the screen from the table. (see 'Removing/replacing electronics' sections 'Laptop' and 'Screen'.)
3. Unlock the wheels.
4. Carefully place the table on its side.
5. Lift the table to its new destination. This needs to be done by at least two people.
6. When the table has reached its new destination:
   1. Carefully place the table back on its wheels.
   2. Lock the wheels.
   3. Put the table back together. (see 'Putting everything together')

If the passages are smaller that 87cm the table will need to be completely deconstructed.

Changing information

Text
1. Create a new piece of text, use the font Open Sans for this. This piece of text then needs to be converted to a PNG of 437 x 263px.
2. Give the new piece of text the right file name. For the right file name see table 'File names in the data folder'.
3. Remove the old text file from the data folder on the laptop that is inside the table.
4. Put the new text file inside the data folder.
5. The text file has now been changed.

Pictures
1. Create a new picture. This picture needs to be 1920 x 1080 (ratio 16/9) and it needs to be a PNG file.
2. Give the new picture the right file name. For the right file name see table 'File names in the data folder'.
3. Remove the old picture file from the data folder on the laptop that is inside the table.
4. Put the new picture file inside the data folder.
5. The picture file has now been changed.

Videos
1. Create a new video. This video needs to be 1920 x 1080px (ratio 19/6) and it needs to be a MOV file.
2. Give the new video the right file name. For the right file name see table 'File names in the data folder'.
3. Remove the old video file from the data folder on the laptop that is inside the table.
4. Put the new video file inside the data folder.
5. The video file has now been changed.

Beware!

If you don't want to show a picture or video at an information spot in the table, you need to still put a picture inside the data folder. To have the table not show anything this picture needs to be completely transparent.

File names in the data folder			
Place inside the table	*Text*	*Picture/Video space 1*	*Picture/Video space 2*
Introduction	IntroText	Intro1	Intro2
How it moves	MoveText	Move1	Move2
How it sees	SeeText	See1	See2
The inventors	MadeText	Made1	Made2
Implementation Vopak	VopakText	Vopak1	Vopak2

1:1 model
1. Carefully pull on both ends of the 1:1 model of the PIRATE so the model will stretch out and become lose from the stand.
2. Carefully remove the 1:1 model from the stand.
3. A new 1:1 model can now be put inside the stand.

Information signs
1. Lift the signs that you want to change out of the table.
2. The CorelDRAW file for the signs is on the laptop that's inside the table. Use this file on a computer that has CorelDRAW to adjust the signs.
3. Lasercut the new signs out off 6mm thick wood that is suitable for a lasercutter.
4. Place the new signs on the table.

Often occurring problems

The buttons don't work

Click on the 'Serial Monitor'. See the picture on the right. There are three possible things that can happen:

a) The 'Serial Monitor' only shows the letter G
b) The 'Serial Monitor' shows one or multiple different letters but G.
c) The Arduino code give the error 'Board at COM4 is not available'.

The 'Serial Monitor' only shows the letter G

1. All buttons should be working fine. Try restarting the processing code.

The 'Serial Monitor' shows one or multiple different letters but G.

1. Look at which letters are being shown. Look in the table 'Button with corresponding letter and Arduino pin'.
2. Check if the cables of the corresponding buttons are making a connection in the Arduino. If the 'Serial Monitor' is now still not sending the letter G, go to the next step.
3. Check if the connector are making a connection. If the connectors are connected, try carefully turning them until the 'Serial Monitor' shows the letter G.
4. If all of this fails a cable, connector, or button is broken and needs to be replaced.
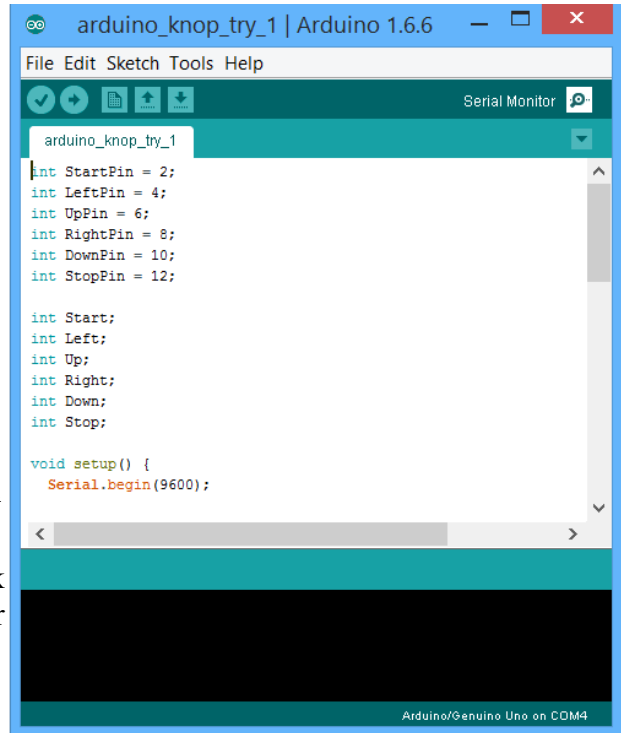
The Arduino code gives the error 'Board at COM4 is not available'

(see the picture to the bottom right)

1. The Arduino isn't connected to the laptop at all or is connected to the wrong USB port. Put the blue cable from the Arduino in a different USB port and click on the 'Serial Monitor' again. Keep trying different USB ports until the error isn't shown any more.

Button with corresponding letter and Arduino pin		
Button	*Letter in the 'Serial Monitor'*	*Arduino pin*
Start	A	2
Left	B	4
Up	C	6
Right	D	8
Down	E	10
Stop	F	12
No button	G	-

The processing code won't run

The most likely reason why the Processing code won't run is because there is something wrong in the data folder. If this is the case, Processing will show the error 'Could no load movie file ___.mov', see the picture placed lower on this pace. The name of the file that is the problem will be in this error. Errors regarding missing PNG's won't give any problems and should be ignored. This movie error could be caused by the following:

a) The information file has the wrong title

  Fix this by correcting the file name. For the correct file name you can look in the table on page 11.

b) There is a missing information file.

  Fix this by either adding an information file or a transparent picture with the correct name to the data folder. For the correct file name you can look in the table on page 11.
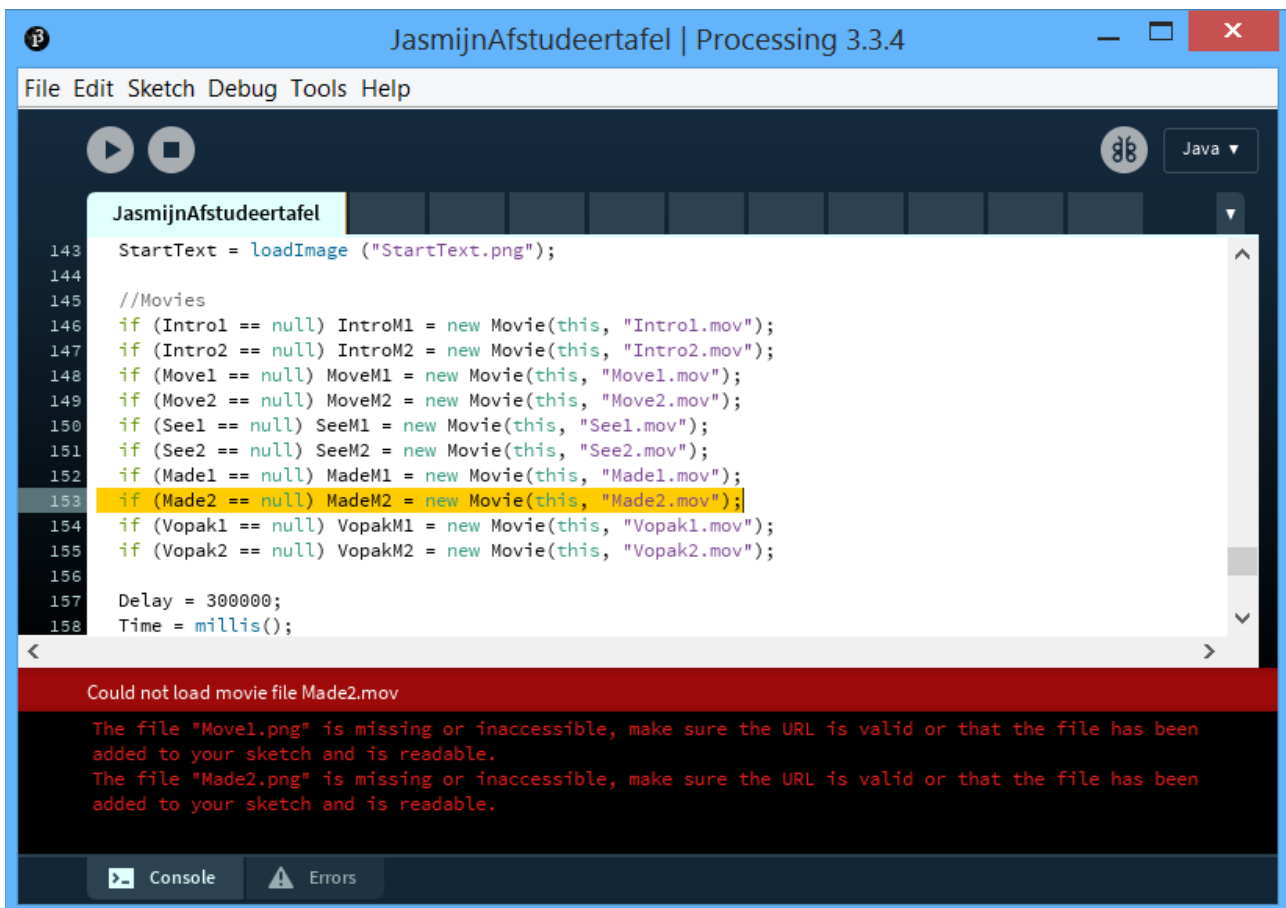
Appendix E: Evaluation

Appendix E1, trail user test instructions

User test Bachelor project
Informative artifact for Vopak

Introduction
For this bachelor project the company Vopak contacted the University of Twente about wanting a new informative artifact for their innovation lab.

Vopak is the biggest company in the world that operates bulk liquids storage terminals. To stay competitive in the market, Vopak is constantly innovating the way they work. They are very proud of this and have therefore established an innovation lab. This innovation lab is located in Vopak's headquarters in Rotterdam. Besides showcasing innovations, the innovation lab is also used as an office and a meeting room.

To create the informative artifact the design process for Creative Technology was used. Research, ideation, specification, and realisation have already been completed. This has resulted in the artifact that you will be testing to contribute to the evaluation phase of this project.

This study
The aim of this study is to collect data on how people interact with, and perceive, the created artifact. While you are interacting with the artifact observations will be written down by the researcher. All the observations will be carefully written down so it is impossible for people to identify who they are about. There will be no identifiable data collected in this study. When you're done interacting with the artifact there will be a short questionnaire.
If you want to withdraw from this study at any time, you are allowed to stop without giving any reason.

Because this bachelor project is only about creating the informative artifact and not about creating the information, the artifact will be filled with stakeholders instead of proper information.

While doing the assignments, imagine that you are an office worker at Vopak.

Assignment 1:
While you are heading to a meeting you feel like grabbing a cup of coffee. On your way to the coffee machine the artifact catches your eye so you walk up to it.
- • Figure out how to begin interacting with the artifact.

Assignment 2:
Because you were only planning on grabbing some coffee, you only have a minute to spare looking at this artifact.
- • Look at one information part that interests you the most.

Assignment 3: (please turn around while reading this assignment)
You leave to go to your meeting. When the meeting is done you are still very curious about what other information the artifact holds so you walk back to it. However, when you look at the artifact, the navigational tool shaped like a robot is not in the same place you left it.
- • Figure out where the robot is located.

Assignment 4:
Because you don't have anything scheduled for the next few minutes you have enough time to explore as much information as you want.
- • Look at all the information parts.
- • When you are done interacting with the artifact, stop interacting with it in a way that seems natural to you

Appendix E2, trial and final user test questionnaire
Both these questionnaires were google forms. The only difference between the trial and final user test questionnaire is the addition of one question. This question has 'only in final user test' in brackets behind the question.

User test Bachelor project

Date

..-..-...

Test subject number (filled in by the researcher)

____

What was the subject of the artifact?

____

Which information did you look at for assignment 2?
O Introduction
O How it moves
O How it sees
O The inventors
O Implementation Vopak

Why did you go to this particular information?

____

The assignments were clear

	1	2	3	4	5	
Not agreeing	O	O	O	O	O	Agreeing

I could easily complete the assignments

	1	2	3	4	5	
Not agreeing	O	O	O	O	O	Agreeing

I felt like there were too few instructions

	1	2	3	4	5	
Not agreeing	O	O	O	O	O	Agreeing

I felt like there were too many instructions

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

The artifact felt well designed

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

The artifact looked visually pleasing

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

How I was supposed to navigate the robot was clear

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

The navigation buttons were easy to understand

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

The interface was easy to understand

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

The interface felt well designed

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

The function of each button was clear *(only in final user test)*

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

I felt frustrated while using the artifact

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

I felt comfortable while using the artifact

	1	2	3	4	5	
Not agreeing	○	○	○	○	○	Agreeing

Do you have any extra comments? This can be explaining some of your previous answers and comments in general.

_____

Thank you very much for doing this user test! It is greatly appreciated.

Appendix E3, trial user test notes
Researcher's notes trial user test.

No comment: -

1.1. -
1.2. Assignment bit vague
1.3. Sees circle
1.4. Clicks stop

2.1. Because PIRATE already moving towards start it is confusing that there is no feedback when start is pressed. Therefore clicks all buttons to try and make something happen.
2.2. -
2.3. Clicks start
2.4. Already does this before reading that this was the assignment. Clicks Stop

3.1. No immediate feedback when start is pressed leaves user confused and randomly clicking buttons.
3.2. Needs extra explanation for this assignment
3.3. Clicks a navigation button
3.4. Walks away

4.1. No immediate feedback leaving user confused again.
4.2. -
4.3. Sees circle
4.4. Clicks stop

5.1. No immediate feedback, confusion again
5.2. -
5.3. Sees circle
5.4. Clicks stop

Appendix E4, trial user test results analysis
Analysis from the researcher's notes

No one: -

Assignment 1:
1 = Needed extra explanation
2 = Clicked more buttons than just start but figured it out on their own
3 = Went perfectly

1: 4
2: -
3: 1

Assignment 3:
1 = Can not find it
2 = Looks inside the corners
3 = Clicks start
4 = Clicks navigation button
5 = Sees circle

1: -
2: -
3: -
4: 2
5: 3

Assignment 4:
1 = Clicks stop
2 = Walks away

1: 4
2: 1

Results and analysis from the questionnaire

Results:

What was the subject of the artifact?

5 responses

Explaining what the robot does and the use at the company.

The artifact provides information about the Pirate.

robots moving in pipes

information about the robot

The PIRATE inspection Robot

Analysis:

Type of answere	Amount of answeres
Has no idea	0
Mentions one of the sub subjects but not the main subject	0
Mentions a robot	1
Mentions a robot and something extra like pipes, navigation, or Vopak	2
PIRATE	2

Results:

Which information did you look at for assignment 2?

5 responses

- Introduction
- How it moves
- How it sees
- The inventors
- Implementation Vopak
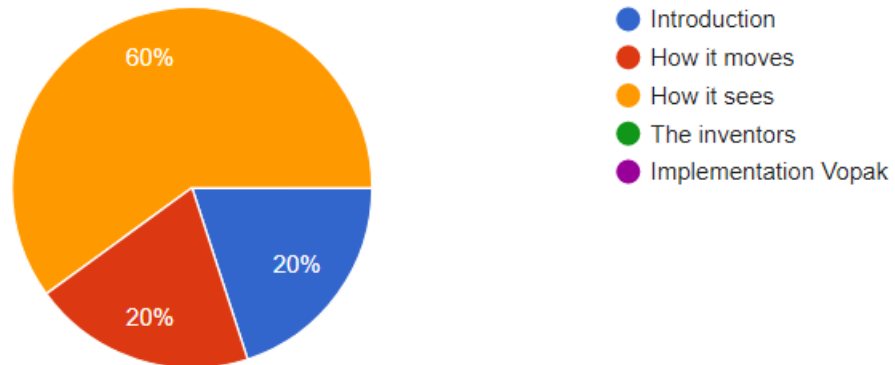
Why did you go to this particular information?

5 responses

Since it seemed the most interesting information.

I pressed Start.

I suspected it sees with cameras but wanted to check it

I was curious about how it sees. i could understand how it moves from seeing it in the table pipe display thingy

No reason at all, just seemed a fun path to take with the buttons

Analysis:

Type of answere	Amount of answeres
Because of interest	3
Because of how the maze is laid out	1
Other	1

Results and analysis of the questions on a scale from 1-5

The assignments were clear
5 responses
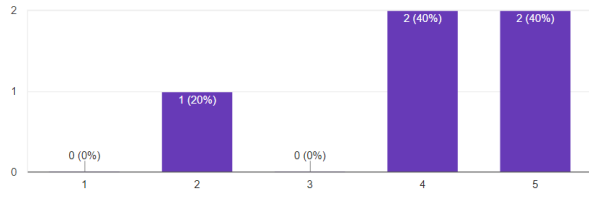
I could easily complete the assignments
5 responses
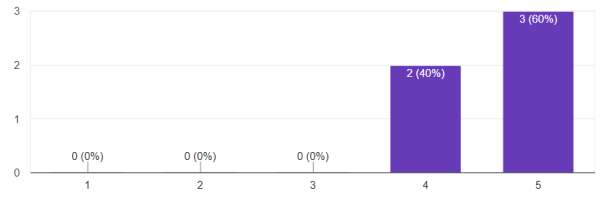
I felt like there were too few instructions
5 responses
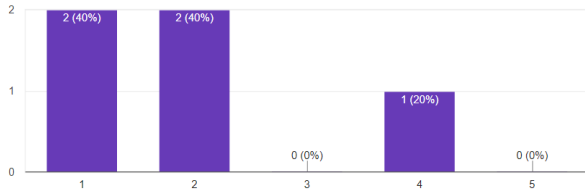
I felt like there were too many instructions
5 responses
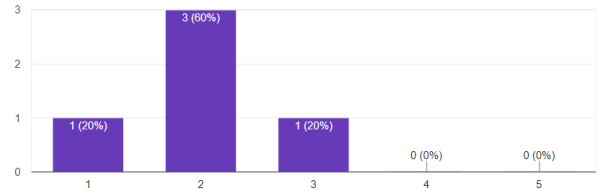
The artifact felt well designed
5 responses
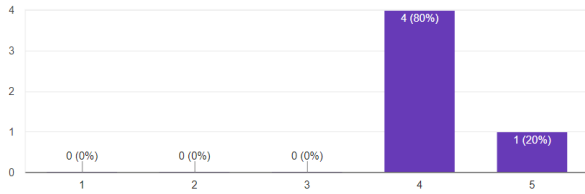
The artifact looked visually pleasing
5 responses
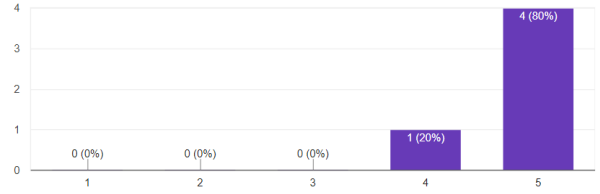
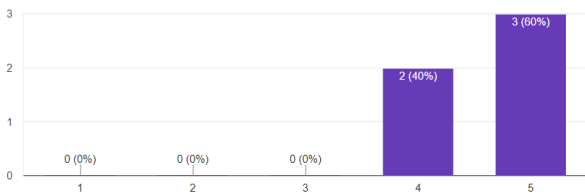
How I was supposed to navigate the robot was clear
5 responses
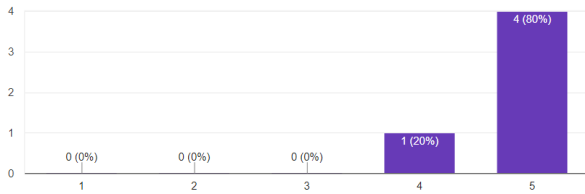
The navigation buttons were easy to understand
5 responses
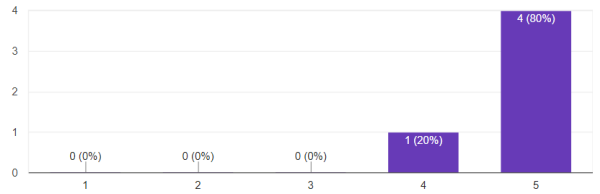
The interface was easy to understand
5 responses

The interface felt well designed
5 responses
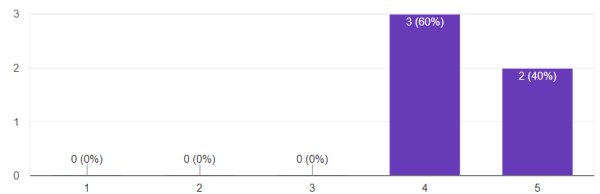
I felt frustrated while using the artifact
5 responses
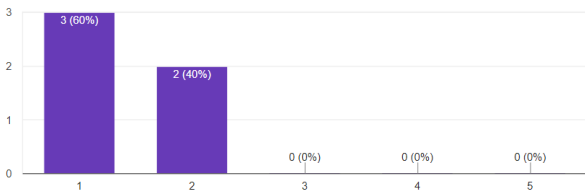
I felt comfortable while using the artifact
5 responses
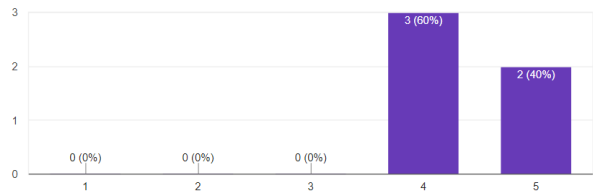
Results:

Do you have any extra comments? This can be explaining some of your previous answeres and comments in general.

3 responses

Clarify what Start and Stop do.
Starting was hard.
Good work, awesome project!

Analysis:
Start needs to change!

Appendix E5, final user test instructions

User test Bachelor project
Informative artifact for Vopak

Introduction
For this bachelor project the company Vopak contacted the University of Twente about wanting a new informative artifact for their innovation lab.

Vopak is the biggest company in the world that operates bulk liquids storage terminals. To stay competitive in the market, Vopak is constantly innovating the way they work. They are very proud of this and have therefore established an innovation lab. This innovation lab is located in Vopak's headquarters in Rotterdam. Besides showcasing innovations, the innovation lab is also used as an office and a meeting room.

To create the informative artifact the design process for Creative Technology was used. Research, ideation, specification, and realisation have already been completed. This has resulted in the artifact that you will be testing to contribute to the evaluation phase of this project.

This study
The aim of this study is to collect data on how people interact with, and perceive, the created artifact. While you are interacting with the artifact observations will be written down by the researcher. All the observations will be carefully written down so it is impossible for people to identify who they are about. There will be no identifiable data collected in this study. When you're done interacting with the artifact there will be a short questionnaire.
If you want to withdraw from this study at any time, you are allowed to stop without giving any reason.

Because this bachelor project is only about creating the informative artifact and not about creating the information, the artifact will be filled with stakeholders instead of proper information.

While doing the assignments, imagine that you are an office worker at Vopak.

Assignment 1:

While you are heading to a meeting you feel like grabbing a cup of coffee. On your way to the coffee machine the artifact catches your eye so you walk up to it.
- Figure out how to begin interacting with the artifact.

Assignment 2:

You notice that there are multiple subject matters within the artifact. Because you were only planning on grabbing some coffee, you only have a minute to spare looking at these subjects.
- Look at one subject matter that interests you the most.

Assignment 3: (please turn around while reading this assignment)

You leave to go to your meeting. When the meeting is done you are still very curious about what other information the artifact holds so you walk back to it. However, when you look at the artifact, the navigational tool shaped like a robot is not in the same place you left it.
- Figure out where the robot is located.

Assignment 4:

Because you don't have anything scheduled for the next few minutes you have enough time to explore as much information as you want.
- Look at all the information parts.
- When you are done interacting with the artifact, stop interacting with it in a way that seems natural to you

Appendix E6, final user test notes
Researcher's notes final user test.

No comment: -

1.1. -
1.2. - Additionally wants to look at the inventors
1.3. Clicks navigation button
1.4. Walks away

2.1. Clicks start twice but no major confusion
2.2. -
2.3. Sees circle
2.4. Clicks stop

3.1. -
3.2. -
3.3. Clicks navigation button
3.4. Clicks stop

4.1. -
4.2. -
4.3. Clicks navigation button
4.4. Clicks stop

5.1. -
5.2. -
5.3. Sees circle
5.4. Walks away

6.1. - Notes that maybe it would make it more clear if the table would say people can start
interacting when the robot has arrived at the start position
6.2. -
6.3. Sees circle, clicks navigation button to make sure
6.4. Clicks stop

7.1. -
7.2. -
7.3. Sees circle
7.4. Clicks stop

8.1. -
8.2. -
8.3. Sees circle
8.4. Clicks stop

9.1. -
9.2. -
9.3. Clicks navigation button
9.4. Clicks stop

10.1. First clicks stop, then start
10.2. Presses start between every movement
10.3. Clicks start
10.4. Clicks stop

11.1. Clicks start twice
11.2. -
11.3. Clicks navigation button
11.4. Clicks stop

12.1. Clicked Start, ← , Stop, so needed to get some extra explanation
12.2. -
12.3. Clicks navigation button
12.4. Walks away

13.1. Clicks down, start, right
13.2. -
13.3. Clicks start
13.4. Walks away

14.1. -
14.2. -
14.3. Sees circle
14.4. Clicks stop

15.1. -
15.2. -
15.3. Sees circle
15.4. Clicks stop

16.1. - Says that some extra instructions at the start position would have been nice
16.2. -
16.3. Sees circle. Notes that if the circle was pulsing, if there were moving arrows around the corner, or if the circle was brighter it would have been easier to find)
16.4. Clicks stop. Notes that at corner 2 and 5 the robot would not need to stop moving.

17.1. -
17.2. -
17.3. Clicks navigation button. Notes that maybe the circle should pulse to be easier to see.
17.4. Clicks stop

18.1. -
18.2. - Notes that the buttons are really nice to click
18.3. Clicks the navigation buttons
18.4. Clicks stop

19.1. -
19.2. -
19.3. Clicks start
19.4. Clicks stop

20.1. -
20.2. -
20.3. Looks inside the corners. Notes that the circle should maybe pulse to be easier to see
20.4. Clicks stop

Notes not connected to particular participants:

Many participants already start exploring the information inside the table before reading assignment 2.
Multiple participants already started to look at more subjects after finishing assignment 2 before they read assignment 3.
Almost everyone that walks by the table at least looks over their shoulder. Many people even stop to look at it while some even start clicking the buttons.

Appendix E7, final user test results analysis
Analysis from the researcher's notes

No one: -

Assignment 1:
1 = Needed extra explanation
2 = Clicked more buttons than just start but figured it out on their own
3 = Went perfectly

1: 1
2: 4
3: 15

Assignment 3:
1 = Can not find it
2 = Looks inside the corners
3 = Clicks start
4 = Clicks navigation button
5 = Sees circle

1: -
2: 1
3: 3
4: 8
5: 8

Assignment 4:
1 = Clicks stop
2 = Walks away

1: 16
2: 4

Results and analysis from the questionnaire

Results:

What was the subject of the artifact?

20 responses

Pipe robot
A robot that can move through pipes
the robot
The Pirate robot from Vopak
How a pirate moves through pipes
The PIRATE robot and it's uses within VOPAK.
Checking out pipelines to look for any defects
a robot navigation system
Providing information on a crawling robot
PIRAtE, a robot designed for VOPAK
bulk storage of liquids
A pirate that crawls through pipelines
pirate robot
Pirate
The pipe exploring robot
A pipe inspection robot
Pirate/VOPAK
PIRATE
Edwins robot
Tunnel evaluating robot

Analysis:

Type of answere	Amount of answeres
Has no idea	0
Mentions one of the sub subjects but not the main subject	2
Mentions a robot	2
Mentions a robot and something extra like pipes, navigation, or Vopak	6
PIRATE	10

Results:

Which information did you look at for assignment 2?

20 responses

- 🔵 Introduction
- 🔴 How it moves
- 🟠 How it sees
- 🟢 The inventors
- 🟣 Implementation Vopak
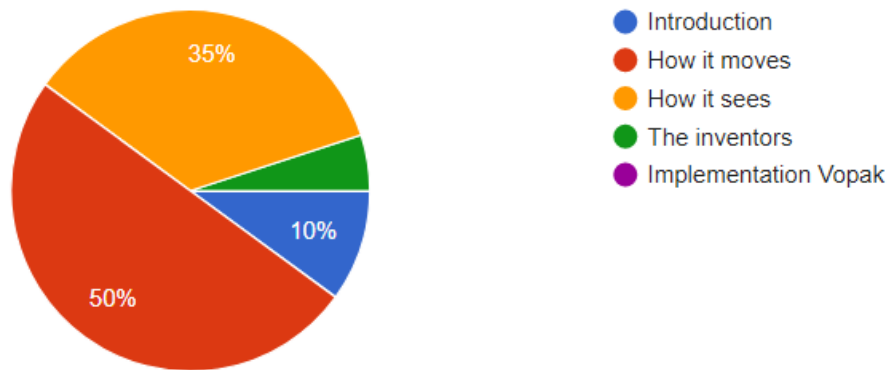
Why did you go to this particular information?

20 responses

I found it interesting to know how the robot sees its environment.

Was closest by

As a technical person, I like technical stuffs

I didn't really look at the signs, but just pushed the buttons randomly

Because that seemed the most interesting

I was just exploring the installation and how it worked; at this point I wasn't looking for specific information yet.

i was interested because it looks like it would move like a snake

That was the thing about the robot I didn't know about

Because it has a very interesting shape, it's hard to see immediately how it would work so it draws attention.

I pressed start

because it was after the introduction the first interesting subject , and i thought the others would be an explaination after that one.

was placed in the middle

because it was in the middel

Cause it was close

Because I was interested whom started the project and their reason for doing so.

Because it was the fastest to reach

Pressing start and using arrows

I already knew how it moves, so I wanted to know how it sees.

because I wanted to know what it is

Just to explore something that was close to the start

Analysis:

Type of answere	Amount of answeres
Because of interest	9,5
Because of how the maze is laid out	6,5
Other	3

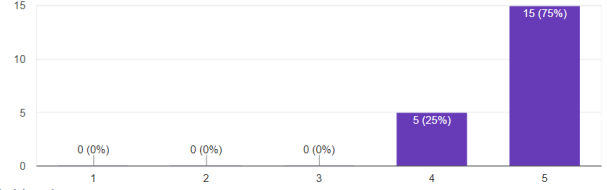# Results and analysis of the questions on a scale from 1-5

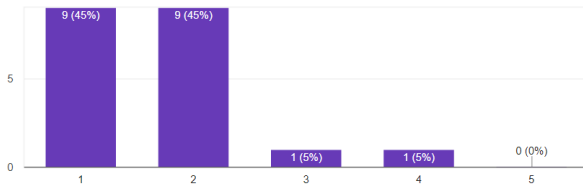**The assignments were clear**
20 responses
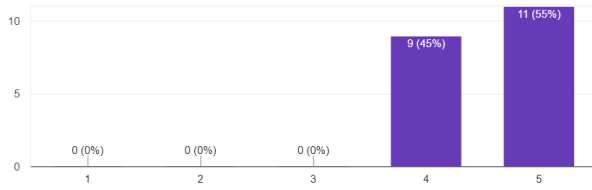
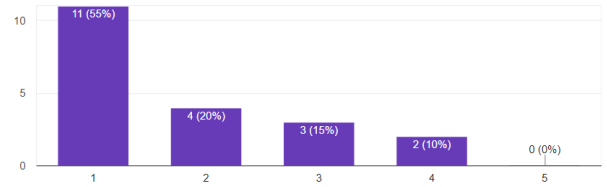

I could easily complete the assignments
20 responses

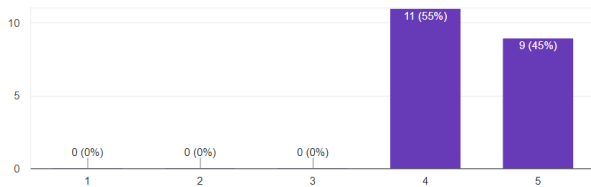**I felt like there were too few instructions**
20 responses

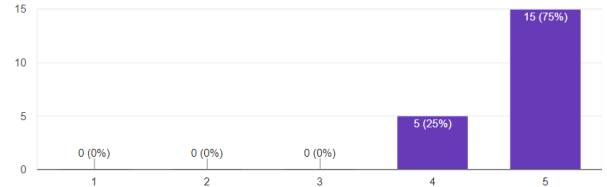**I felt like there were too many instructions**
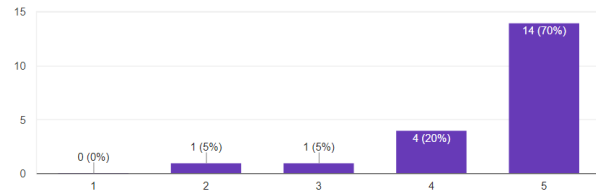20 responses

The artifact felt well designed
20 responses
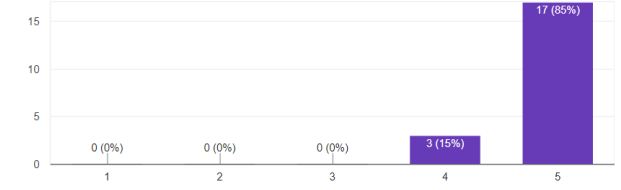

The artifact looked visually pleasing
20 responses

How I was supposed to navigate the robot was clear
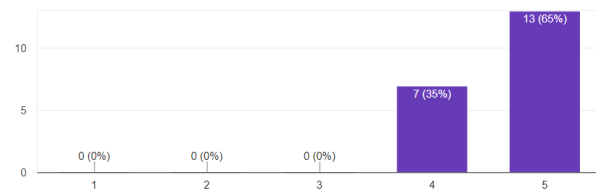20 responses

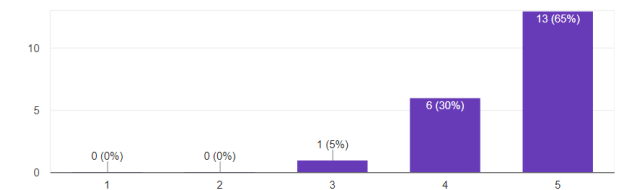**The navigation buttons were easy to understand**
20 responses

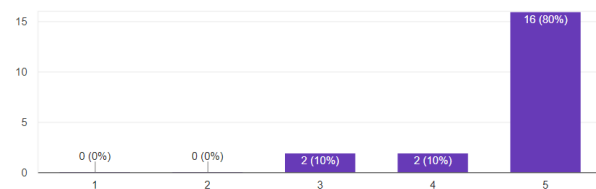**The interface was easy to understand**
20 responses

The interface felt well designed
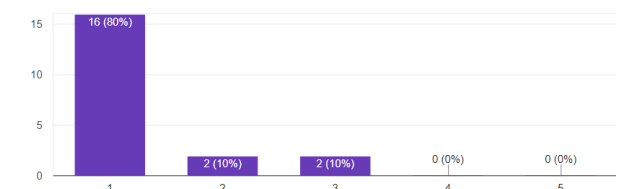20 responses

The function of each button was clear
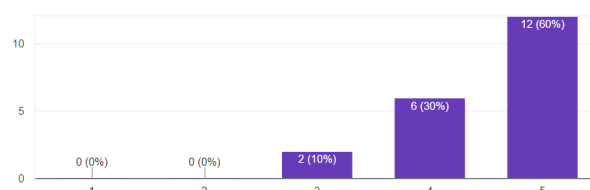20 responses

I felt frustrated while using the artifact
20 responses

I felt comfortable while using the artifact
20 responses

Results:

Do you have any extra comments? This can be explaining some of your previous answeres and comments in general.

20 responses

No (2)

- (2)

Cool installation. I think this would be a nice addition to a work environment.

Start makes the thing go to the start position, but it feels like it should start the whole thing. I didn't know I had to use the arrows to make the thing move for the first time, instead I tried to press start for the second time.

I felt respected while using the artifact! <3

Goed bezug Jasmijn! Succes nog ;)

It was not clear to me that I had to start moving the robot myself after it had gone to the starting position.

The interface was very clear to understand

It stops in one-directional corners! it should just continue!

The screens on the right are a bit far away for the viewer, it wasn't immediately obvious where to look for more information besides the screen on the left.

nope!

Looked and worked very well

no

The text info looks a little boring, other than that this is 200% awesome confirmed hell yes

The robot moved quite slowly, I would like it to move up to twice as fast.

It worked ok, but there was room for improvement. A lot of the functions could be made more clear.

The movement when being idle felt a bit uncomfortable, it looks a bit fake because it's so fluent yet the body is so static. I don't have this feeling when I have to push a button to let it move.

It wasn't directly clear what the stop button did

Analysis:

Type of answere	Amount of answeres
Compliment	5
Pointer about start	2
Other pointer	7
Nothing	6

Interesting pointers:
Text info looks a bit boring
Robot moved too slowly
The robot should not stop in corners 2 and 5

Appendix E8, expert evaluation notes (in Dutch)

Trekt aandacht:
Hangt af van omgeving. (moet anders zijn/afsteken)
Kleuren vallen waarschijnlijk in de setting op.
    Geel misschien niet de beste keus voor de hoekpunten, misschien was een rustigere kleur beter geweest.
    Het design van de tafel wordt wel snel vertrouwelijk, dus het geel is daarbij blijkbaar geen hinder. Het steekt ook niet heel erg af van de rest van de tafel en maakt het ook niet kitsch.
Dat de beweging aandacht zal trekken klopt.
Misschien dat meer beweging toevoegen of meer beweging, zoals het laten bewegen van de informatie bordjes, meer aandacht zou trekken. Dit zou alleen wel af kunnen leiden van het meer belangrijke deel van de tafel, de informatie. Wouter was het er wel over eens dat de toevoeging van een mood light waarschijnlijk positief zou zijn, zolang dit light niet te fel zou zijn.

Niet irritant/afleidend:
Was het eigenlijk met alle keuzes eens. De mensen in het innovatie lab zouden idd wennen aan de rustige beweging terwijl voorbijlopende het nog wel op zou kunnen vallen.

Andere design opmerkingen:
Schermpjes zouden mooier afgewerkt mogen zijn. Nu een beetje een surprise gevoel met de grove randjes. Een net foto lijstje of ijzer randje zou het mooi afwerken.
De manier waarop de geschreven informatie wordt laten zien is ook niet erg mooi en zou misschien beter zijn als het niet zo zwart op wit was maar wat meer doorzichtig bijvoorbeeld.
Verder erg positief over hoe alles er uit ziet!