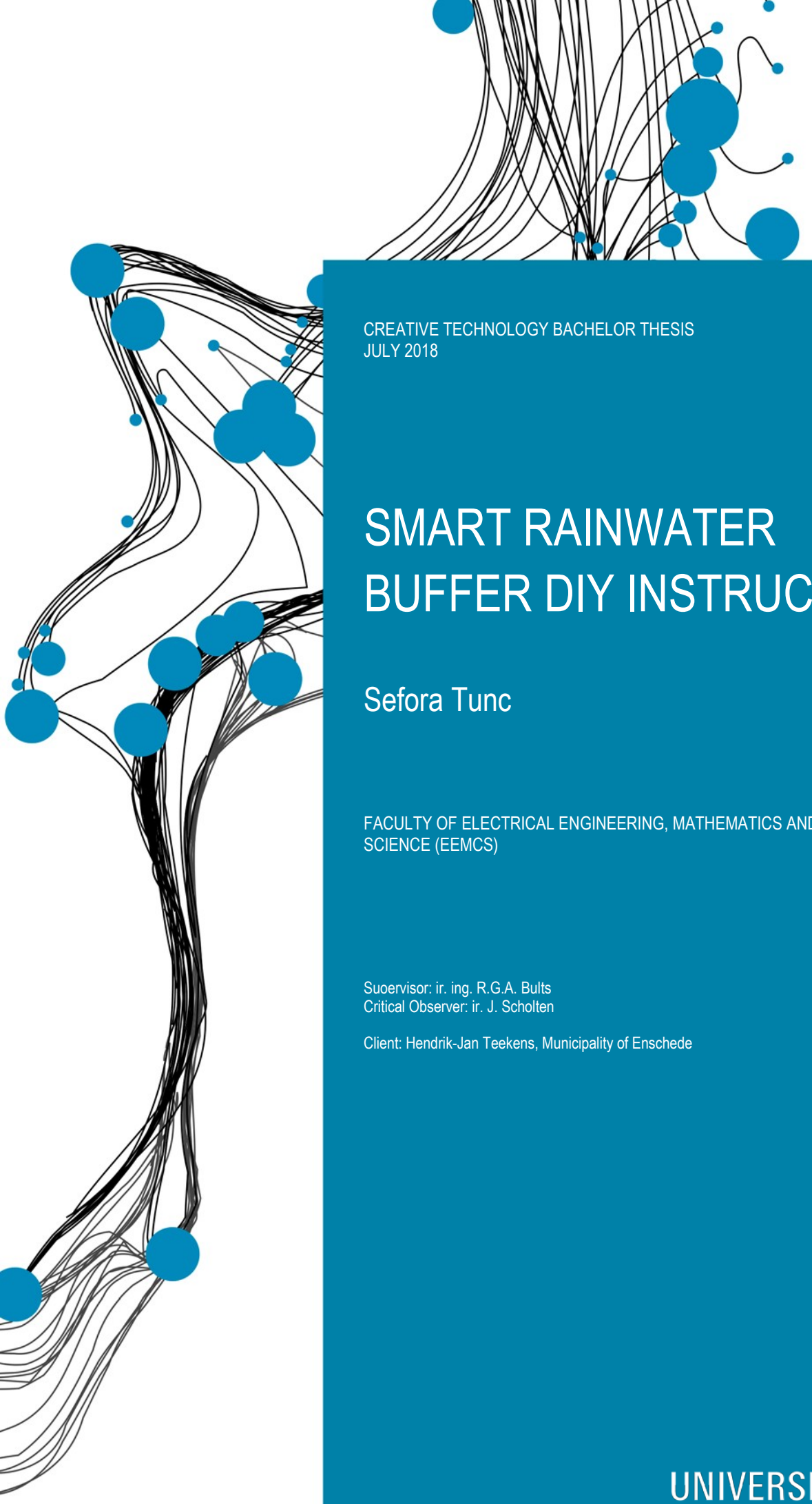

CREATIVE TECHNOLOGY BACHELOR THESIS
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SMART RAINWATER BUFFER DIY INSTRUCTIONS

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Abstract

Due to the impact of climate change, Enschede is affected by flooding, leading to severe damage and high risks for the inhabitants. To fight this problem, a solution called the *Smart Rainwater Buffer* was developed. If it was deployed on a large scale it could buffer sufficient water, preventing the city from flooding. Therefore, research was conducted on deployment opportunities and it was found that a DIY-approach, as known from IKEA, was the most affordable and best-accepted approach of distributing the SRB amongst the inhabitants of Enschede. Consequently, this initiated the research of this bachelor thesis: developing a DIY-solution enabling large-scale deployment of the SRB for every SRB-user.

Following the Creative Technology Design process, a state of the art research was conducted on existing work, yielding results on variations of instruction methods as well as guidelines on best practices. These have been used as a reference to develop concepts relating to the SRB. Using an iterative approach, a detailed DIY-solution concept has been specified in collaboration with stakeholders, resulting in requirements that must be incorporated in the definitive DIY-solution.

Summarizing these requirements, it has been specified that a combination of an instruction manual consisting of text and illustrations as well as an expert opinion video are the most promising approaches for a DIY-solution. In combination they can transfer the information of how to assemble and maintain the SRB to a diverse audience. Evaluating this DIY-solution with different potential users, it has confirmed this thesis and either one of the instruction methods was able to communicate the information successfully. However, limitations to this study are the fact that it has not been tested whether users feel comfortable utilizing electronic tools, hole saws for instance. As it is part of the DIY-solution, this must be subject to further research.

Token of Appreciation

Several people have contributed to my success and deserve a token of appreciation. Without you this would have not been possible.

Firstly, I want to thank the teaching staff of Creative Technology for broadening my horizon in many subjects and directions. I have learned a lot in every module and always felt that Creative Technology was the right choice for me. Secondly, I want to thank Richard Bults and Hans Scholten for guiding me during this bachelor thesis when it was my turn to become an expert rather than learning something existing. The knowledge and expertise you shared with me helped to deliver a project I am proud of. I want to thank my friends, Betina Markova and Niels van Huizen, who have made the years at the UT even more enjoyable.

And lastly, I want to thank my parents, my aunt, my siblings and my boyfriend for supporting me throughout my academic career. Thank you for supporting the choices I have made, thank you for helping me when I needed you and thank you for being there from the start until the end.

Table of Contents

Appendices

1. Introduction

As an introduction to the present bachelor thesis, this chapter will act as a description of the current situation relating to Smart Rainwater Buffers in Enschede (Netherlands), define the challenges, elaborate on the resulting research questions and finally, it will give an outline on how the answers will be embraced over the complete thesis.

1.1 Situation

Since 26% of the Netherlands are below sea level [1], the country has developed deep knowledge and experience in relation to water and water systems to protect citizens from its threats, e.g. flooding [2] and to take advantage of it, e.g. in the tourism sector [3]. However, global warming has caused new challenges in water management, resulting from an increase in rainfall. In the last 108 years, an increase of 27% - from 695mm to 880mm - of the overall rainfall was documented in the Netherlands, with an ongoing trend [4], which the Dutch sewerage system is not designed to deal with [5]. This leads to flooded streets and buildings, damaging property and injuring people, being a costly and dangerous situation for Dutch communities.

As for the geographical situation of Enschede, the city is located on a hill, causing the excessive rainwater to flow downwards in direction of the city centre, flooding the West of the city. To relieve the pressure on the sewerage system in the city of Enschede, the University of Twente has developed a prototype of a Smart Rainwater Buffer (SRB) [6] [7]. Placing one in every household in Enschede potentially creates a buffer-effect designed to prevent the city from being flooded and engages the use of rainwater in a more sustainable manner. Even though there is a working prototype, final touches need to be made for a pilot-run and the official launch.

The SRB is a system created in cooperation with the city of Enschede. It is only working on a large scale, opposing difficulties in its distribution over the city with regards to the willingness of people to install it. Therefore, the SRB must be re-designed, making it more useful and more affordable for the largest possible amount of people, to prove effective and solve the problems mentioned.

1.2 Challenges and Objectives

Based on previous research conducted by Dico Defize [8], a DIY-approach has been identified as the most affordable solution, which was well-accepted by participants in his study. This principle saves production and delivery costs as it arrives fragmented and compactly packaged, ready to be set-up by the user. However, the DIY-instructions must be well-planned and prepared to allow a successful and efficient assembly, leaving the user with a positive experience.

Since these instructions do not exist yet, it is the objective of this bachelor thesis to create DIY-instructions that are understood by a wide range of people with different demographic backgrounds, as it is the case in Enschede. The exact amount of parts, materials and packaging must be identified and packaged in a manner guaranteeing a successful an efficient assembly, keeping the user engaged and motivated. The DIY cannot be a factor that discourages people to make use of the SRB and prevent a successful distribution.

1.3 Research Question

Resulting from the described situation and challenges in section 1.1 and 1.2, this bachelor thesis will deal with the research question: "*How to develop a DIY solution for all SRB-users to enable large scale deployment of SRBs?*"

For a more elaborate answer sub-questions were identified:

1. How to develop SRB DIY-instructions, suitable for people without technical background?
2. How to design DIY-instructions that encourage users to execute them?

Answering the sub-questions will lead to a solution that allows every possible user of the SRB to assemble it successfully. Furthermore, it supports the deployment when adding a motivational factor to the instructions. Based on the findings for the sub-questions, instructions will be developed and tested to find an answer for the main-question, creating an optimized DIY-experience.

1.4 Outline

The introduction of the bachelor thesis will be followed by a chapter covering background research on the SRB and on DIY-solution. It contains a state of the art review to validate the novelty of the research question and serves as a source of inspiration for the development of concepts. After that, methods will be introduced to describe how the SRB DIY-solution will be developed. Consequently, different phases of

the development will form the next chapters, being the ideation, specification, realisation and evaluation of the DIY-solution. The bachelor thesis is finalized in a conclusion chapter where the answer to the research question is given in form of a DIY-solution design and further recommendations are summarized.

2 State of the Art

This section covers the background research on the situation in the city of Enschede, introduces the concept of the Smart Rainwater Buffer and continues with a literature research on DIY-instruction production guidelines. It presents different methods of DIY assembly instructions and illustrates examples of DIY Rainwater Buffers. This is followed by methods for DIY-instructions production and ends with a conclusion on the novelty of the research question to be covered in this bachelor thesis.

2.1 Smart Rainwater Buffer Concept

Hendrik-Jan Teekens works as a 'Water Designer' in Enschede and is responsible for the water management projects in the city [10]. As he represents the main stakeholder - the city of Enschede - he was interviewed on 15th March 2018 to gain further insight into the challenges and solutions that the city is dealing with and what the SRB is supposed to achieve. His information served as a foundation to enrich with further research as summarised in this section.

2.1.1 Challenges: Waterstress in Enschede

Enschede is located on a Moraine, a hill that has a grown-in water source system, entailing constant supply of water [11]. In the past, this property has allowed Enschede to grow to the largest textile producer of the Netherlands, by making constant use of the groundwater without gravely side-effects [12]. However, along with the decay of the textile industry in the 1960s, water problems emerged due to rising groundwater levels [11] [13]. Moreover, considering the effects of climate change, such as more excessive rainfall, effects of the problems were enhanced [11] [14]. Especially since the city is situated on a hill with 44m difference between the highest point (Enschede East) and the lowest point (Enschede West), the lower parts of the city have become vulnerable to flooding as rain will flow down the hill [11].

An area considered at special risk is the shopping district located at de Heurne and Oldenzaalstraat [15]. The geographical situation is flat and public buildings allow penetration without resistance due to the absence of doorsteps. These floodings do not only damage property, cause moisture in houses and apartments but also endanger the inhabitants. Therefore, Hendrik-Jan Teekens has introduced several projects that are supposed to lower the mentioned risks and simplify living with excessive rainfall [13].

2.1.2 Solutions: Activities for Improvement of the Situation

Multiple projects have been introduced by the municipality of Enschede to fight the flooding problem, such as brooks, wadis, green roofs and the groene linie. Ideas and functions of each project will be briefly described in this section to provide an overview of why the utilization of an SRB is different and how it adds value to decreasing rainwater problems in Enschede.

Brook [16]

As mentioned earlier, Enschede has been the largest textile producer in the Netherlands. Due to textile factories needing groundwater, ponds dried out and were transformed into open sewers. The city of Enschede, however, wants them to return to their old state and recreates the ponds in order to achieve a method to drain the water slowly, that else would flow too fast to lower parts of Enschede and flood the city. Additionally, ponds do cool the city during hot, dry times. Successful examples are the “Beek aan de Zuiderval”, “Beek ’t Zwering”, “Beek Auke Vleerstraat” and “de Stadsbeek”.

Wadis [17]

A wadi is a lower area where water is accumulated and then infiltrates. As a result, it forms a buffer during excessive rainfall and contributes to the purification of water. Additionally, wadis prevent high groundwater via drainage. Wadis were invented in Enschede in 1993 and are used throughout the Netherlands ever since.

Green Roofs [18] [19]

Green roofs are roofs covered with plants. They contribute to a healthy environment by regulating CO_2 emission as well as the consequences of climate change, such as reducing heat stress in cities and buffer water during excessive rainfall. Moreover, they cool buildings, increase the biodiversity and offer an extended isolation of roof coverings.

Groene Linie [20]

Underneath the Oldenzaalstraat in the shopping district of Enschede, that is considered to be at a high flooding risk, a long, deep ’tube’ is being constructed. This increases the capacity of water collection. Furthermore, a green line is incorporated which include wadis that give an additional support, improving the drainage of the water.

Smart Rainwater Buffer [6] [7]

Being affected by flooding due to excessive rainfall as a result of climate change, a 20Creathon themed "Waterstress and Climate Change in the City of the Future" was organized by the University of Twente, Kennispark, waterboard Vechtstromen and the municipality of Enschede in November 2015. As a solution to the postulated problem, the Ensketon Smart Rainwater Buffer became subject for several graduation projects, pursued by Steeghs [21], Rindt [22], Vetter [23] and Defize [8] in 2017.

A rainwater buffer functions by accumulating the rainwater during rainfall, reducing strain on the sewerage system and avoiding flooding. The implementation of sensors and actuators allow remote monitoring of e.g. occupied capacity or remote control, automatic drainage for instance. Steeghs [21] and Rindt [22] realized a prototype of an SRB with different functionalities for both the users of the SRB (inhabitants of Enschede) and the municipality. The prototype is connected to the internet and has insight on the rain forecast. When it is supposed to rain in two hours, the buffer empties itself slowly, maximizing buffer capacity during rainfall. An interface allows the monitoring of the buffer by the inhabitants and the municipality. These functions are summarized in figure 2.1.

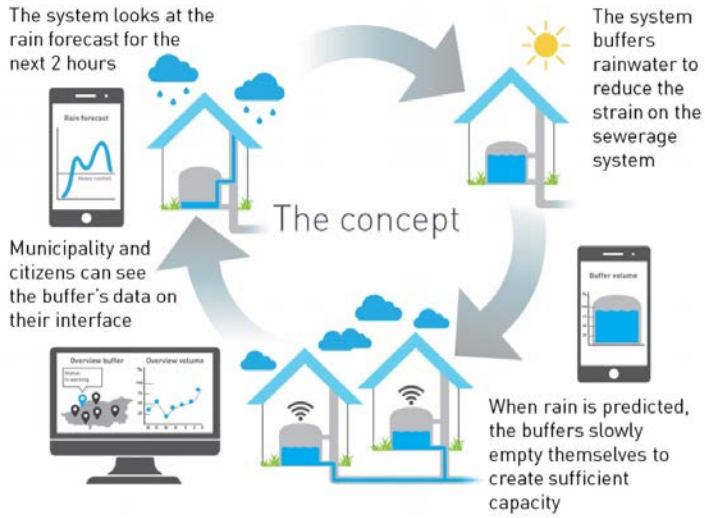


Figure 2.1 Functions of a SRB visualized in an infographic by Gelieke Steehgs [21]

To save costs and raise awareness, the SRB was chosen as a bottom-up approach, that uses the initiative of including inhabitants of Enschede to work on the problem. However, this approach poses a lot of barriers that must be overcome in order to make people use the SRB. After Vetter introduced four different designs, which were a water fence, water barrel, IBC tank and an underground tank [23], Defize

continued his research by adding the option of a DIY-kit, concluding in his research that a DIY-kit was posed as the most favourable solution [8]. Based on further findings of Defize [8], the prototype has to be developed into a DIY-concept in order to be accepted and tested by early adopters. This research lays the foundation of this Bachelor Thesis, aiming to create DIY-instructions for a modularized SRB.

2.1.3 Conclusion: What the SRB still lacks and needs to be optimized

To conclude from this section, the Smart Rainwater Buffer proves to be a different kind of approach than other projects the city of Enschede has introduced. It relieves the stress of the city by utilizing the help of the inhabitants. However, to be successful with this project, the necessities of the municipality and inhabitants must be determined, and the project must be tailored to match these. This has been done partly by identifying that a modularized DIY-solution is an approach that may be accepted by the inhabitants. Nonetheless, to create this modularized DIY-solution more information has to be collected in order to further develop the idea in a user-centred design approach. Only latter can guarantee the development of a successful product.

2.2 Literature Research on DIY-instructions Guidelines

Due to avoidance of cognitive overload and simple production, it has been established that images are more suitable than video and text to present assembly instructions. Supporting this opinion, [46] states that the use of text is less cost-effective since it creates language barriers and thus is not universally applicable without translation. Moreover, [48] establishes in their research that the use of text requires increased cognitive demand that can be reduced by visualizing the components and assembly process through video and images. Nonetheless, [47] claims the best method is to use images that are supported by text, whereas [50] points out that the use of images with single steps is sufficient. Compared with video instructions, [51] demonstrates that sequenced images have the same effect and videos do not offer any additional benefit. Referring to internationally successful companies that offer DIY kits, IKEA's assembly instructions consist of sequenced images without the use of text being compliant with previously mentioned aspects. Consequently, sequenced images are proven to be the best media to present DIY instructions.

Still, there are factors influencing the comprehensibility of sequenced images, such as the need of a coherent design. To begin with, [49] points out that changes of perspectives must be avoided, which is

supported by [50]. This is the case as multiple angles tend to confuse the user since it aggravates the assembly process. In addition, [48] advises to guide the user during the assembly process and the inclusion of an image that displays the finished product. [50] emphasizes this aspect as well. The visual representation of the finished product gives the user an impression on how he or she should assemble it. Furthermore, numbers and zoom help the user understand which step he or she has to take in order to complete the task at hand [48]. Considering the previous example, IKEA applies these supportive measures to their manuals also. Hence, the use of a consistent point of view, supported by numbers and zoom, leads to a more pleasant assembly experience.

The images themselves, however, should consist of simplistic pictures, representing the object without redundant information to further decrease the cognitive effort. Therefore, [52] argues that illustrations are more suitable than photographs since the presented information becomes more easily accessible. Both, [49] and [50] agree as illustrations only display relevant details. Moreover, [50] emphasizes utilising different line weights to illustrate the product. This is the case, as line weights highlight important aspects within the image. Another way to distinguish between sections and components is the use of different colours, as described by [46] and [52]. Continuing with the example of IKEA, all aspects are incorporated besides the use of colour. Accordingly, the most important aspects to consider are the use of illustrations with different line weights and a sparingly use of colour.

Besides the actual DIY assembly manual, personal drivers also participate in completing the product. These can become visible in different ways. As [53] explains, building something successful by oneself leads to a higher valuation of the product. This results from the fact that it was not bought ready-made but effort was invested in order to complete it. An example is the autonomous completion of furniture that leaves the user more satisfied due to the experienced effort and the thought of saving costs with one's own labour. In contrast to this principle, a personal driver can also be initiated by the author of the manual self. As [47] introduces the principle of rhetoric during instructions, meaning that an own narrative how obstacles were overcome, can motivate users to follow the process. This is achieved by giving them a main character they can identify themselves with and takes away concerns by illustrating the own experience. To conclude, users can be motivated by instructions that include a personal narrative and are engaging or, by instructions, cost them some effort and, i.e. have to be slightly challenging to have this effect. This latter principle is confirmed using Schell's Rule of Gamification [54], stating that the difficulty has to be nuanced in order to keep the user encouraged.

Concluding from these findings, it becomes apparent that different guidelines on the correct design of DIY instructions exist. However, none of them exactly answer the research question on how to design non-technical user-friendly instructions by themselves. Overall, the main goal of the guidelines is to reduce the cognitive load of the user in order to allow him a simple assembly without encountering difficulties. As the DIY SRB is a product that has to be distributed on a large scale, it is important to obey to these rules and achieve the simplest assembly possible. However, it is still arguable whether images are the best approach to present a DIY since the motivational aspect regarding the narrative may have a better effect during a video with expert opinion. This is object to further research to be explored throughout this Bachelor Thesis.

2.3 Modular Systems

Systems which use a design approach that decomposes them into individual parts (modules) are called "modular systems". These modules are created independently, are interchangeable without affecting the rest of the system and allow simple assembly and maintenance. TVs, Computers and cars are examples of modular systems [24]. While these come readily assembled, other companies like LEGO or IKEA use modularized DIY-kits.

2.3.1 LEGO A/S

LEGO A/S is a Danish company [25] and largest toy producer in the world. It is famous for its modularized DIY-kits, consisting of LEGO blocks that are used to build objects based on provided assembly instructions.

The company produces a variety of sets with different themes for different target groups. A selection can be found in figure 2.2. The DIY-kits are ordered from youngest (2 years) to oldest (12 years <) target group and show rising complexity and number of parts [26] [27] [28] [29]. In addition, the size of the parts decreases with rising recommended age. Considering their assembly instructions, with rising age instructions become longer and more complex.

What becomes apparent from LEGO's concept, and is a relevant factor for this project, is that more modules mean increased difficulty for the user. Also, despite the simple and tool-less assembly,

instructions must be very detailed and show every step in an individual image in order to comprehend the instructions correctly. To conclude, great detail in instructions allows the assembly of complex objects.

Figure 2.2 DIY-kits by LEGO [26] [27] [28] [29] ordered by age and page numbers.

2.3.2 IKEA

Being a company that built its foundation on flatpack furniture, IKEA is the largest distributor of DIY-furniture-kits [30]. The Swedish company uses the flatpack principle to save labour and shipping costs. Everything besides tools is included for a successful assembly. Buyers assemble the furniture based on provided instructions or may find instructions with or without expert opinions online. These are either published officially by IKEA or by private instances. To illustrate these different methods of assembly instructions applied, two pieces of furniture were chosen: the corner sofa bed “Friheiten” and the chest of drawers “Malm”. While there have been found two videos with expert opinions for the corner sofa bed, there was one animated instructions video for the chest of drawers.

Corner Sofa Bed “Friheiten”

The corner sofa bed “Friheiten” is one example of IKEA’s diverse offer. It comes with 6 modules, 65 additional parts for assembly and instructions [31]. The 20 assembly steps are explained on 20 pages using only line-art images. Text is avoided and symbols are used for communication. The instruction design resembles the most findings in section 2.2, such as using line-art with different line-weight for emphasis without distracting details, making use of sequenced images, zoom and numbers for better understanding and listing all components that are necessary.

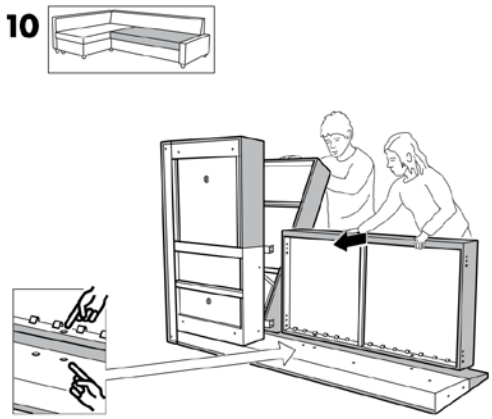


Figure 2.3 PP FlatPack assembly instructions [33]. *Figure 2.4 IKEA assembly instructions example [31].*

In contrast to these provided instructions, videos of the assembly process including expert opinions are published on online platforms, making constant use of words to verbalize explanations and recommendations. An example is the YouTuber *PP FlatPack* [32] whose video instructions for "Friheiten" take 11 minutes and show him assembling the sofa bed [33]. He makes use of time lapses and voice-overs minimizing the video-length and maximizing valuable insights, like in 1:30 "*Key is, to put the corners on the corner*" while showing the correct application of the sofa's fabric.

These privately recorded instruction videos may result from the lack of availability of videos including an expert opinion by the company itself. However, since IKEA is an international company, this does not apply to every country. While IKEA USA [34] only provides instructional videos without an expert opinion, IKEA Espana [35] has dedicated their channel to professionally recorded and edited videos with expert opinions [36]. What may add value to their videos, which is missing in PP FlatPack's case, is the sterile environment putting the focus on the to be assembled object, a timeline on the left that allows to skip to the section of interest and animations and drawings that indicate the necessary components and create a relation to the original printed instructions manual. Nonetheless, a language barrier does exist for people not speaking Spanish, that takes away the insights on the expert opinion that may be overcome by PP FlatPack using English as a widely spoken standard.

Considering this, it is Important to mention that the video has 15.000 views and PP Flatpack's whole channel is dedicated to IKEA furniture, meaning that there is demand for more elaborate explanations than the ones provided by IKEA. Despite disobeying the instruction design guidelines (section 2.2) such as amongst others utilizing sequenced images rather than video and using illustrations instead of real-life

footage, it supports the finding that people are more motivated to do DIY if these are enriched with personal experiences. This phenomenon must be examined throughout this Bachelor Thesis to determine the most suitable DIY instructions method for people without technical background.

Chest of Drawers “Malm”

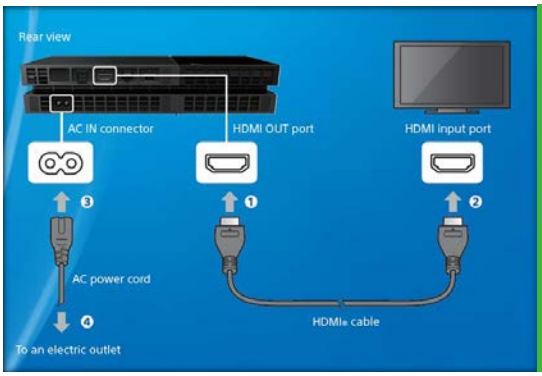
The “Malm” Chest of Drawers is another modularized piece of furniture in IKEA’s offer. It comes with 11 modules, 111 additional parts for assembly and instructions [37]. Using only sequenced line-art images, the 29 assembly steps are explained on 24 pages, including warnings and a listing of components. Overall, the instructions delivered with the components follow the same structure as the instructions for the corner sofa bed “Friheiten” and in similar fashion as previously mentioned, it is possible to find additional instruction-material online. For example, instructions with an expert opinion by PP Flatpack have been found, but besides videos with or without expert opinions, a 23-minutes animation video visualizing the assembly process was discovered [38].

In comparison with other instruction-methods, the video does not give further insights into what to consider during the assembly process, nor does it feature a subject assembling the chest with drawers. It rather emphasizes the process as a whole and can be contemplated as an extension of the provided instructions by IKEA, adding transitions between the sequenced images. Consequently, on the one hand it supports the comprehension and lowers the cognitive load by making fluent transitions, but on the other hand, it does not add further value to the original instructions and the creation of the instructions poses to be an increased workload for the producer.

2.3.3 Sony Playstation and Microsoft Xbox

Founded in 1946, Sony [39] has grown to one of the largest Japanese companies retailing consumer electronics. In 1996 Sony published a home entertainment system called PlayStation 1 [40], consisting of the console, power cables, controllers, memory cards and different games. Due to the interchangeability of each component, the PS1 can be considered a modular system that was already introduced in the 90s. In 2002, however, Microsoft joined the console market with the Xbox [41] having a similar structure as the PlayStation. Throughout the past, many additional modules were introduced to be connected to the systems, such as the Sony EyeToy Camera or the Microsoft Xbox Kinect, microphones and steering wheels and many improved versions of the consoles have been published.

The most recent versions of the consoles are the PS4 Pro and Xbox One. By default, the consoles come in a box with their power cables, one controller and their instructions [42] [43]. Despite being very extensive, both instruction manuals have only one page dedicated to the actual assembly. Both companies use an exploded view where all parts are associated with each other at once. This may result from the fact that there are not many parts, making an exploded view more suitable than sequenced images or a video with expert opinion. Looking at the components, it also becomes apparent that they are designed to fit only in one place, so mistakes of plugging the cables in wrongly can be avoided.



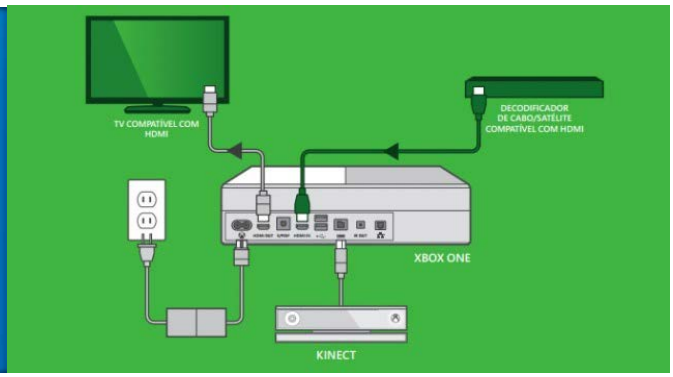


Figure 2.5 Playstation Assembly instructions [42] *Figure 2.6 Xbox assembly instructions [43]*

2.3.4 RainGrid Inc.

The company RainGrid Inc. [44] is considered the leading company in stormwater management since 1996. In 2002 it has introduced a rain barrel called *RainGrid Cistern* [45] that works similarly to the previously introduced Smart Rainwater Buffer in section 2.1.2. However, in contrast to the SRB, it is not smart and has to be operated manually. The main function of the RainGrid Cistern is buffering rainwater during storms in order to relieve the stress on sewerage systems and prevent flooding. It is a modularized system consisting of 9 modules that can be scaled up to a larger system.

The RainGrid Cistern comes in a DIY-kit with instructions. The instruction manual of the RainGrid Cistern is a combination of illustrations and text. It summarizes the components in text and adds numbered images to refer to. The assembly is explained in multiple steps using text accompanied by representative images. Four steps with each 3 - 6 points lead to the completed assembly process. It is all summarized in one A4 page with additional information about maintenance and warning notice on the backside. Although it offers a quick overview on all the components and how they are interconnected, visualizing the process more explicitly may give a better insight into the correct assembly than text. The depicted

images do not give valuable insight into the assembly process self and would not work without text. Especially since text may not be universally understood due to cultural differences. Still, the text acts as an aid to understand the images, adding value to the instructions when being able to understand it.

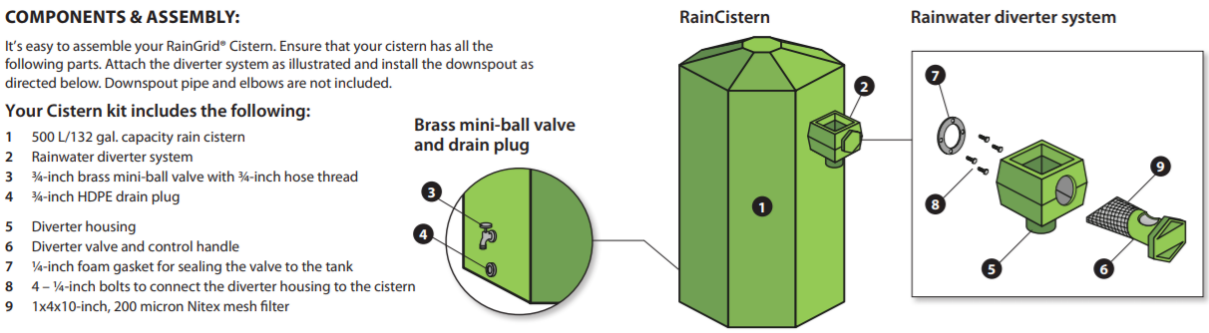


Figure 2.7 Instructions for the Rainwater System RainGrid Cistern [45]

2.3.5 Conclusion

Different conclusions can be drawn from these examples. Firstly, information about the average user is presented. Secondly, important aspects of instruction design are emerging when inspecting the presented products. And lastly, certain style and number of components are more suitable to be presented by certain instruction methods.

As all these examples originate from famous and successful companies supplying modularized products to be assembled by their customers, it becomes apparent on what technical level the average person can master component assembly tasks. To summarize, the average person can handle standard tools such as screwdrivers, bolts and nuts and can connect cables to a module in the correct way when explicitly stated where each cable belongs to. This means that these skills can be expected from the user when designing the SRB-modules and instructions. Other aspects to be considered during the module-design are, e.g. with increasing components and decreasing size, the difficulty of the assembly increases. Hence, as many components as possible should be summarized into one, so the component number decreases and the size increases.

Another insight these examples provided is that there are several approaches to design DIY-assembly instructions for modularized systems. Each has their own advantages and disadvantages, which are summarised in *table 2.1*. Depending on the final modularized SRB, the most suitable DIY-instructions-

method can be chosen when considering the findings. However, most companies do not rely on one instruction method but offer multiple options, such as illustrations and videos. As their customers consist of a wide range of different people, each has their own preference. Therefore, having multiple kinds of instructions fits the preference of a larger portion of people.

Instructions Method	Advantages	Disadvantages
LEGO: Sequenced Photographs	+ Simplified notion of parts due to association with real-life + Distinction between parts enhanced by color + Step-by-step increased comprehensibility	- More details allow more distraction from what is essential - Sequenced images are not useful when there is a small amount of parts
IKEA: Sequenced Line-Art Images	+ Emphasis on essential parts + No distraction by details + Step-by-step increased comprehensibility	- No use of color increases difficulty of distinction between parts - Sequenced images are not useful when there is a small amount of parts
IKEA Espana: Expert Opinion	+ Provide help and tips while assembling + Clean environment allows to focus on the assembly process + Timeline indicates what parts are going to be assembled + Relation to line-art instructions provide additional help + Subject allows identification with oneself as motivational factor	- Language barriers - Assembly in own pace is not possible unless pausing the video after each step - Only works in connection with initially delivered IKEA instructions
IKEA: Animated Video	+ No distraction by other factors + Focus on the assembly process self + Transitions are made by visualization and do not have to be made by oneself	- No additional value to sequenced images other than transitions - Production has higher workload than images
Sony + Microsoft: Exploded View	+ Fast and easy to produce + Fast and easy recognition of relations when low amount of parts	- Not suitable for many connections - Not suitable when using similar components that may be mixed up
RainGrid Inc: Line-Art Images with Text	+ Better understanding of images + More detailed explanation	- Language may not be understood universally - Images are not meaningful without text

Table 2.1 Summary of advantages and disadvantages of DIY assembly instruction methods.

Insights that do not relate to the instruction method itself but rather to the sections that are included in instructions are a summary of components that are delivered, warnings and other relevant information, such as maintenance of the purchased product. Combining these findings to create instructions, these will allow a simple assembly possibly leading to a large-scale deployment of the SRB.

2.4 Review: DIY Rainwater Harvesting/Buffering Systems

Having examined instructions of products from e.g. IKEA [30] and Lego [25] to gain insight on best practices of leading companies, general knowledge has been obtained that could be put in association with results from scientific research. Nonetheless, it is also relevant to conduct research on similar products of less renowned companies, i.e. rainwater buffering or harvesting systems to understand how they design their instructions. Hence, a selection of four different systems with an own interpretation of instructions will be reviewed and conclusions on their approaches will be drawn.

2.4.1 Second Rain [107]

Second Rain founded their business based on garden furniture that can act as a rainwater harvesting system. To be more precise, their offer includes a cube covered in durable wood with a plastic lining inside collecting water. These cubes can be combined with each other, resulting in a diversity of furniture such as tables, benches or a bar. As it is a modularized system that can be individualized by their customers, the furniture coms in a DIY-kit with instructions. These consist of images accompanied with texts on how to assemble it (see figure 2.8).

The images are renders from 3D-modelled objects resembling the components included in the DIY-kit. They feature close-ups and different perspectives to explain the assembly process. What is not clear is the division of space for the images and the order of steps. Furthermore, the text is not written in an objective manner “you’ll see why in a sec.” as it is expected from explanatory documents. In other words, the presented instructions have room for improvement. However, besides these instructions, Second Rain has uploaded animation videos of the 3D-objects that can be seen in their instructions, showing the assembly process in a time-lapse without text- or audio-explanations. These may improve the assembly experience by clearly indicating the process as well as having a smooth transition between images, allowing a better understanding of the different perspectives presented in the printed instructions.

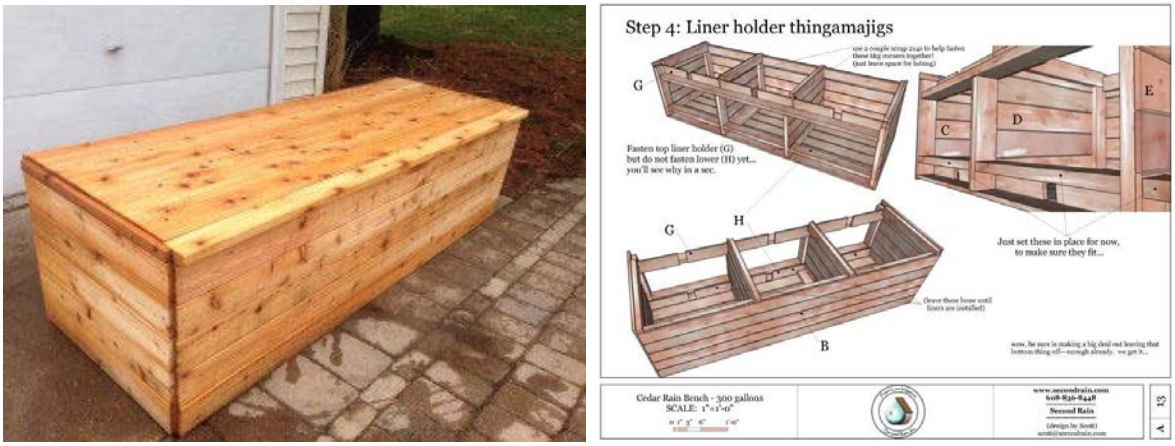


Figure 2.8 Second Rain furniture rainwater tank and instructions.

2.4.2 Rain Saucer [108]

Different than Second Rain, Rain Saucer does not sell a container to harvest water but a DIY-kit to upgrade regular barrels for an improved rainwater harvesting experience. In other words, they allow a simple installation of a spigot for the simplified use of harvested water. The company achieves this by selling a universal solution that can be applied to any container. Their set of components comes with text instructions that have a few images to aid in the installation process (see figure 2.9). Overall, the instructions are well-structured and the steps are easy to identify and follow. They are very extensive and precise, i.e. it is possible to follow them without visual aid. Nonetheless, images do raise the quality of instructions as they are more meaningful than words. Using more images could have reduced the number of words significantly, making the instructions more appealing and allowing the user to comprehend the steps faster. Also, they do reference a source for more images, but these are not in form of instructions and therefore do not enhance the quality of the provided text.

3. **Installing the spigot:** Drill a 1 ¼" hole, 1-8 inches from the bottom of your barrel. If your barrel will be going on a stand or blocks, the hole should be as low possible to maximize water pressure. If your barrel will be going on dirt, grass or the pavement, the hole should be high enough to accommodate your watering can, unless you plan on watering with a hose in which case a low installation is still preferred. Next, pinch and fold the Rubber Hose Seal then insert and fit it around the hole. Lastly, lubricate the spigot with soapy water and screw it into the Hose Seal. The final install should look like Figure 1.

Figure 1

4. **Securing the Barrel.** Wrap the large loop-hole end of each Double Loop Cable **(A)** around the handles of your barrel and pass the other end of the cable (the one which has plastic attached) back through the loop-hole to secure (see Figure 2). If your barrel does not have handles, the same effect can be achieved by drilling a ¼" hole in the rim of the barrel and using the rim as a handle.

Figure 2.9 Rain Saucer text instructions.

2.4.3 JOJO Rainwater System [109]

In contrast to the previous two examples, builders is a more advanced company offering a wide range of products. One of their sections is dedicated to rainwater harvesting systems including many components to improve the harvesting experience. Their rainwater tank e.g. comes with two sets of instructions. One features text with photographs, the other is a video with an expert opinion (see figure 2.10). While their static instructions are very short, the video instructions are more elaborate and feature a lot of additional information that aids in installing the water tank. Despite being filmed outside, the video is still does not have distracting elements but has a clear focus on the overall assembly. It utilizes methods such as close-ups, voice-overs and time-lapses effectively.

The image instructions do feature images but they are not very meaningful as they only show a rough overview of a person working on the assembly rather than the process and single components. Still, it is more appealing than the instructions of Rain Saucer. And considering that they can be used as a guide after having watched the video instructions, they are sufficient to assemble the water tank.

Figure 2.10 JOJO Rainwater System Image/Text and Expert Opinion Instructions.

2.4.4 Conclusion

What can be concluded from these examples is that, similar to other companies working in different fields, providing static and dynamic instructions is most effective as it allows the user to approach the assembly process with his own preference. While the video is most useful for receiving a first impression on how the steps must be conducted, the instructions can act as a reminder when proceeding with the actual assembly process. One the one hand, videos however are more effective in explaining steps. On the other hand, the user does not have to pause the static instructions or watch it multiple times, but he can do it in his own speed using. Therefore, when combining both approaches, the best assembly experience can be achieved.

2.5 Methods for production of DIY-assembly-instructions

Different methods of DIY-assembly instructions were discussed and presented in section 2.2, each having its own method of realization. Therefore, a list of potential programs and equipment to produce instructions was compiled in this section. The list serves as a reference of possibilities with regards to the experience of the author. It gives an indication on programs that can aid in the production rather than the process of production self.

2.5.1 Text-based instructions

As text-based instructions do not include images and therefore can be written down in a text-editor, Microsoft Word [55] and Google Docs [56] are a suitable and widespread option. In this case, the only graphical element to be considered is the font. From a functional aspect, Colin Wheildone [57] has found that *serif* font supports the comprehension of text and is therefore more suitable in the context of assembly instructions. The difference between serif and sans serif is described in figure 2.11.

Figure 2.11 Serif vs Sans Serif font comparison.

2.5.2 Image-based instructions

Image-based instructions may either work by themselves or be put in association to text. They may consist of illustrations or photographs. These factors depend on the product and industry they are used in. Overall, the production of images is tied to a longer process than the production of text and therefore requires a larger variety of programs. Still, the use of images is common practice and preferred over text due to multiple aspects, such as increased comprehensibility [58] and increased interest of the consumer [59]. The production in relation to the use of programs can be divided into three steps: Sketch, Refine, Present.

Sketch

As it is possible to make traditional pen and paper sketches that are scanned and processed, the use of a combination of hardware and software offers more convenient options in the creation of instructions. It allows a simpler correction of mistakes and simple editing by scaling and flipping, it is cleaner and saves space by compressing all tools and colours in one program, you can use images as a reference to draw on to achieve the correct proportions and it is immediately ready to be further processed as it can be exported as different files [60]. Latter applies especially on the program Adobe Photoshop Sketch [61], that is a mobile application allowing professionals to sketch using e.g. their iPad Pro in combination with an Apple Pencil [62] and export it immediately via the Creative Cloud to other Adobe programs to receive final touches. The iPad Pro and the Apple Pencil allow to draw very precisely as they function as digital pen and paper, even simulating pen pressure via thicker lines at increased pressure. Another application supported by the iPad is ProCreate [63], offering a wider range of tools than Adobe Sketch but is not immediately connected to programs allowing further processing. However, it does offer the export as a variety of files, making it simple to implement. A less expensive option is the use of a drawing tablet connected to a computer, such as a Wacom Intuos [64] that is commonly used in the graphic design industry for the creation of sketches in programs such as Clip Studio Ex [65] and offers the same advantages as the iPad Pro. The only difference is that the user is drawing on a different device than he is looking at. After all, sketches are used for indication and do not have to be perfect. Therefore, the choice of method is not as relevant as in the next step. However, it does decrease the difficulty of the creation of the final image when having a high-quality sketch.

Refine

Differing between two different kind of image-based instructions: illustrations and photographs, different methods and programs need to be used for refining.

1. Line Art: Having finished the necessary sketches, these must be transformed into clean and precise line-art drawings, which is to be done digitally as it is not about drawing but rather about precise tracing of shapes. In this case, it has to be decided whether the images should be vector or raster images [66]. Vectors allow an infinite scaling without losing quality and can be printed very sharply, whereas raster images are easier to produce but do not offer these characteristics and are more prone to quality loss. Depending on the final product, either a program like Adobe Illustrator [67] can be used, creating a vector images based on previously made sketches or Adobe

Photoshop [67] that uses raster images. An open-source alternative allowing precise tracing is the program Paint.Net [68], which is however limited in its functions compared to Illustrator and Photoshop that offer a large variety of tools. Nonetheless, it satisfies the basic needs for a successful creation of line-art images.

2. Photography: Whereas photography does not need explicit sketches in order to transform them into more refined illustrations, it rather needs raw images that can be made using a camera. These are then refined via cropping, colour-editing, etc. This can only be done in raster image programs, since photographs do not consist of vectors but pixels. As mentioned before, a suitable program may be Adobe Photoshop that is commonly used for photography editing. Alternatively, the open-source program Photoscape [69] can be used, being more intuitive than Photoshop but also having less functions.

Present

Not only is the look of each graphical element important but the correct presentation enhances the viewing experience and aids in understanding the displayed process. To achieve this effect, lay-out programs such as Adobe inDesign [70] can be used. The programs focus is on the placement of elements and is designed to be simple and intuitive. An open source alternative offers Scribus [71], offering similar functions as inDesign. These programs are to finalize the image-based instructions by presenting them in a way that makes sense and allows to put the images in association with text.

2.5.3 Video-based instructions

Video-instructions may have many different formats, as they can be with- and without expert opinions, on a white and sterile background or in a regular setting or they can be completely animated. However, to create material for the instructions, equipment such as cameras, lightboxes, microphones and a background may be necessary. Differing from real-life recordings, animations have to be produced using an animation program. However, both recordings and animations need to be edited using video-editing-software order to be presentable. Only then can the produced material be finalized in useful instructions, meeting the user's needs and expectations.

Animation

Animations can have many different styles. It depends on the preference of the creator. The production, however, can be made in one program. An example is the use of the program Autodesk Maya [72], allowing very realistic renders or the program Blender [73]. The programs are used to sculpt the necessary

objects or import them from different sources and then have a function to animate them. The output are images, that have to be further processed in order to result in a video.

Editing

When having created the animation or finished filming the assembly process, the material can be transferred into a video-editing program that finalizes the instructions. There are common practices such as time-lapses, clean cuts, voice or music in the background and text that are used to aid the understanding of the video. Programs that offer these functions are e.g. Adobe Premiere Pro [74] as well as Techsmith Camtasia [75]. Each is suitable for editing video-instructions.

2.5.4 Conclusion

To conclude from this section, the graphic design industry standard is the use of Adobe products. The Adobe Creative Cloud offers enough resources to create instructions successfully. It only lacks the possibility to create 3D-animations, but this gap is filled by other programs such as Autodesk Maya. Also, for each listed program there are free alternatives when these are not available. Another aspect that needs to be considered when creating instructions is the equipment. While this section is dedicated to the programs and only briefly mentions the use of e.g. cameras, this area needs further research in order to produce suitable images and video-material.

2.6 State of the Art Conclusion

Concluding from the background research, it has been established that the Smart Rainwater Buffer is an affordable approach on dealing with rainwater problems in Enschede. However, it is not technically mature enough to be distributed over the city. It has to be transformed into a modularized system that can be assembled using a DIY-approach. Therefore, a modularized system and matching DIY-assembly-instructions have to be created. As different examples have shown, the complexity of the modular system should not be too high as the technical standard of users is relatively low. Also, the choice of presentation of DIY-instructions should be chosen to lower the cognitive load of the users, allowing them a simple assembly and a positive experience. This factor is relevant to overcome distribution barriers, the ability of assembling for instance, and allow a large-scale deployment of the SRB.

The research on other DIY-kits in different fields (furniture, consumer electronics) and of other DIY-rainwater harvesting systems gave insight on how instructions can be designed, and which aspects have to be customized based on product and distributor. These are aspects to be specified in accordance to the stakeholders as their needs need to be considered when designing the instructions. Pros and Cons, and other recommendations such as the availability of tools to design instructions have been summarized. Therefore, due to the availability of a diversity of methods to create instructions, a general solution cannot be found and has to be determined by using scientific research as it will be used in this thesis.

In other words, there is no existing solution to the opposed problem and the research question "*How to develop a DIY solution for all SRB-users to enable large scale deployment of SRBs?*".

3 Creative Technology Design Process: Methods and Techniques

As the focus of Creative Technology is designing products enhancing people's lives, the process of creation is built on user-centred design. Therefore, this section covers the procedure of how the research questions will be answered according to the Creative Technology Design Process as introduced by Mader and Eggink [9]. The process can be divided into four phases: *ideation, specification, realization* and *evaluation* visualized in figure 7. From the graphical representation it becomes apparent that the design process is iterative as well as utilizing a combination of divergence-convergence, emphasizing human-centred design by repeatedly incorporating user opinion to improve the envisioned product. In the course of this bachelor thesis, DIY-instructions will be created based on this concept. As working DIY-instruction concepts already exist, these are to be further explored and developed in order to adapt them to the SRB allowing large-scale deployment. The phases and the methods that will be applied to specify the design will be described in the following sub-sections.

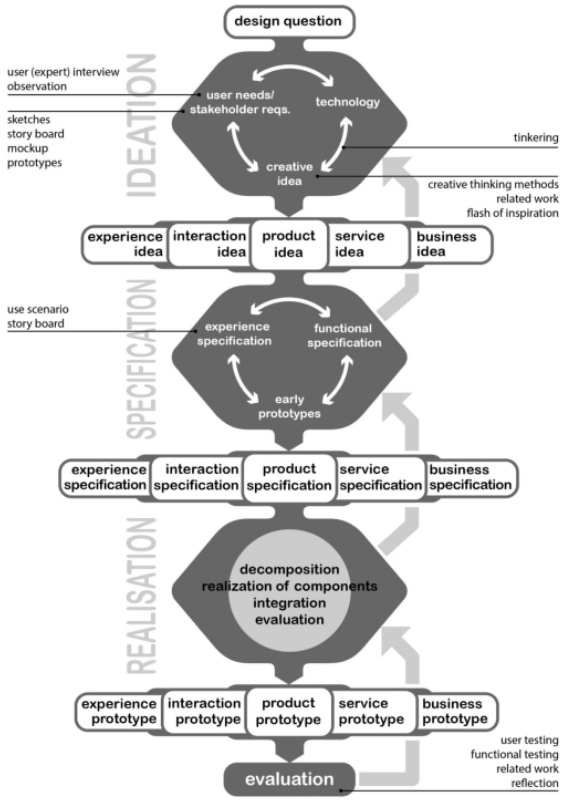


Figure 3.1 Creative Technology Design Process by Mader and Eggink [9]

3.1 Ideation

The initial focus for the ideation phase is learning about and understanding the user to set up requirements. These result from initial ideas about concepts for a product, an instruction from a client, or a creative inspiration. Early ideas can then be prototyped and evaluated by referring to the opinion of clients, users or experts. This is done using multiple low-fidelity prototypes that are evaluated with users' assistance. The aim of the ideation phase is to get a more elaborated impression about the envisioned product with possible ideas and associated requirements. Methods used in the ideation phase are: scientific research, research on similar systems as in the state of the art research, and ethnographic methods used in stakeholder analysis.

3.1.1 Research

In order to develop a guiding design concept, research on similar products has to be conducted. This gives an insight on the possibilities and limitations on the feasibility of ideas and can also serve as a source of inspiration in terms of development and improvement of already existing products. Scientific sources are to be collected and to be able to set requirements based on validated insights. The State of the Art (Chapter 2) already contains part of this research and may be extended in the ideation in terms of requirements.

3.1.2 Stakeholder Analysis

Stakeholders can be defined as subjects who influence or are influenced by a certain outcome, decision or project. Having different intentions, each stakeholder can represent a certain role and affect the project differently, as they can be a user, developer, decision-maker or legislator [87]. Therefore, a stakeholder analysis includes the identification of stakeholders, the role-division and the validation of their relevance by categorizing them based on influence and power [88]. This can be done byusing an influence/power matrix as can be seen in figure 3.2. Utilizing these methods, one can obtain a clear insight on the diversity of stakeholders, as each also requires an own method of analysis. These methods are derived from Lazar et al. [76] describing research methods and evaluating their effectivity in terms of goals and contexts. The collection of stakeholders' expectations and concerns allows the set-up and categorization of requirements using the MoSCoW-method [79] leading to the development of a suitable product for the stakeholders.

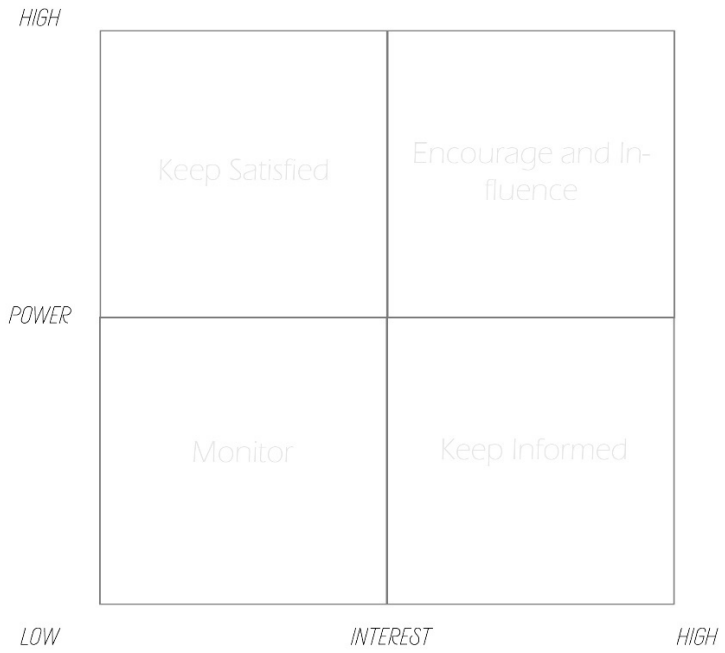


Figure 3.2 Stakeholder Matrix by Bryson [88]

In other words, stakeholders act as a data source to determine requirements for the development of the envisioned product. The method of data collection must be chosen based on the type of information to be collected, i.e. qualitative or quantitative data [76]. Qualitative research collects data that cannot be summarized in numbers and is used to understand the subject's situation and thoughts, whereas quantitative research can be evaluated using statistical analysis and is used to measure variables. Three research methods will be utilized and further specified: interviews, focus groups and surveys.

Qualitative Data: Interview [76]

In case a stakeholder is represented by one person, an interview poses to be the most suitable approach of analysing their needs. Interviews are time-intensive in execution and evaluation, allowing an intensive conversation, thus resulting in detailed information, which is important to be able to meet the stakeholder's expectations. The options of a *structured* and *semi-structured* interview should be considered, either collecting only answers to pre-set questions or allowing the interviewee to divagate and give new insights by asking questions that were not planned. Considering that the interviewee may share special knowledge in the field to be explored, this method is useful for this research. However, when only limited time is available, and the interview serves the purpose of confirming certain aspects rather than gaining completely new insights, a structured interview should be considered.

Qualitative Data: Focus Group [76]

Characteristic for some stakeholders is that they may differ between each other, having different concerns and expectations towards a product despite forming one entity. Therefore, a larger population needs to be asked for their opinion to be able to cover multiple design aspects. As interviews are time-intensive, other methods have been introduced, such as focus groups. Focus groups gather several people matching the target user-group and allow them to discuss about questions asked by a supervisor. As the focus is on obtaining relevant requirements, this method accelerates this process by combining multiple interviews into one being able to consider opinions of a diversity of people.

Quantitative Data: Survey [76]

In contrast to focus groups, surveys do not require the attendance of a supervisor/interviewer and due to the simplicity of spreading it, a large amount of answers can be gathered. Therefore, surveys are suitable when many answers are required. However, surveys can only specify certain questions, such as “Yes” and “No” or a Likert Scale [76]. Individually typed information does not aid in evaluation of results, leading to only a limited diversity of insights. The collected data can be used to confirm assumptions or show tendencies that should be further explored.

3.1.3 Idea Generation: Brainstorming

As the ideation phase aims to generate multiple concepts to find a suitable solution for the opposed problem, an idea generation technique must be applied. One of these techniques is brainstorming, introduced by Osborne in 1939 [85]. Brainstorming describes the process of idea generation individually or in a group. This process adheres to a set of rules:

1. The problem needs to be clearly stated.
2. All ideas need to be documented, also when not feasible. This can be done using e.g. a mind-map.
3. One cannot interrupt other participants.
4. The brainstorming phase finalizes with an evaluation, i.e. discussion of every idea, potentially leading to new ideas.

3.1.4 Prototypes

As the ideation phase does not intend to create a finalized prototype, it does require the generation of multiple concepts for a first exploration of possibilities and user-reactions. This can be done utilizing low-

fidelity prototypes [82], allowing the iteration of multiple design-approaches relatively quickly in order to find the most suitable solution. Methods for low-fi prototyping are pen and paper or video prototypes.

1. Pen and Paper Prototypes are the fastest and simplest method. One can create prototypes using drawings resembling multiple pages of an interface where one “click” leads to the next. It offers a first impression of functionalities and a possible look and feel. Whereas the pen and paper prototype may be made from sketches or well-designed in a more advanced version, depends on what purpose it serves, i.e. what should be tested. For example, instructions for the SRB may be presented as a pen and paper prototype in a sense of showing where elements could be placed and how the user feels about it.
2. Video prototyping is based on storyboards in order to examine what may be positive and what may be negative. As video-instructions such as animations may be considered for the final prototype, a simplified video-prototype could be created for testing.

After having created the concepts, they serve to gain insights from stakeholders. Therefore, meetings need to be arranged. This includes inviting stakeholders and preparing questionnaires.

3.2 Specification

As the ideation serves as the concept iteration for finding the final solution, the specification explores functionalities and user specification to conclude with further specifications. Overall, this section covers the specification of user experiences, functions and the requirements for a final prototype to be implemented in the realization phase. Each step requires different methods for successful specification. In the end, the requirements are re-evaluated, forming the final version of requirements.

3.2.1 Functional Architecture

The functional architecture visualizes the functionalities of the envisioned product in a flow-chart, showing the relations of each component to each other. Utilizing a level-approach, the functionalities are specified with increased detail after each level until they are too abstract to be further specified.

3.2.2 Experience Specification

Human-centred design requires an experience specification of the user-group. While the required information can be retrieved from the earlier conducted stakeholder-analysis, the specification can be done using a PACT-analysis [80] standing for *people, activities, contexts* and *technologies*.

1. People can be specified using personas representing the average user of the product.
2. Activities can be specified using storyboards representing the usage process of an average user.
3. Contexts can be specified using scenarios in different physical or social contexts, such as inside/outside a building.
4. Technologies can be specified by explaining how the envisioned product uses technology to achieve the user's desired effect.

3.2.3 Requirement Analysis

After having collected information using background- and state of the art research, as well as a stakeholder analysis, the insights are evaluated and transformed into functional and non-functional requirements. These allow to fulfil the needs and expectations of the stakeholders as emphasized in human-centred-design. When the requirements are set, they are categorized based on importance using the MoSCoW-technique, i.e. stating which requirement *must, should* or *could* be implemented in the final product [79].

3.3 Realization

The realization finalizes the product by developing the concept into the envisioned product. It is based on previously set specifications and requirements resulting from stakeholder-opinions. It is the result of user-centred design and multiple iterations.

As the final concept of the DIY-instructions is not clear, the method for realization cannot be specified. Independently of the chosen concept, the model of design process by Felker [86] describes the realization process of instructions and will be applied to realize the envisioned product (see figure 3.3). While the pre-design steps of "determine function", "define audience" as well as "determine contextual constraints" are already covered by the specification phase, the other steps will be applied in the realization phase. Only the post-design step "evaluate" will be covered by the evaluation phase.

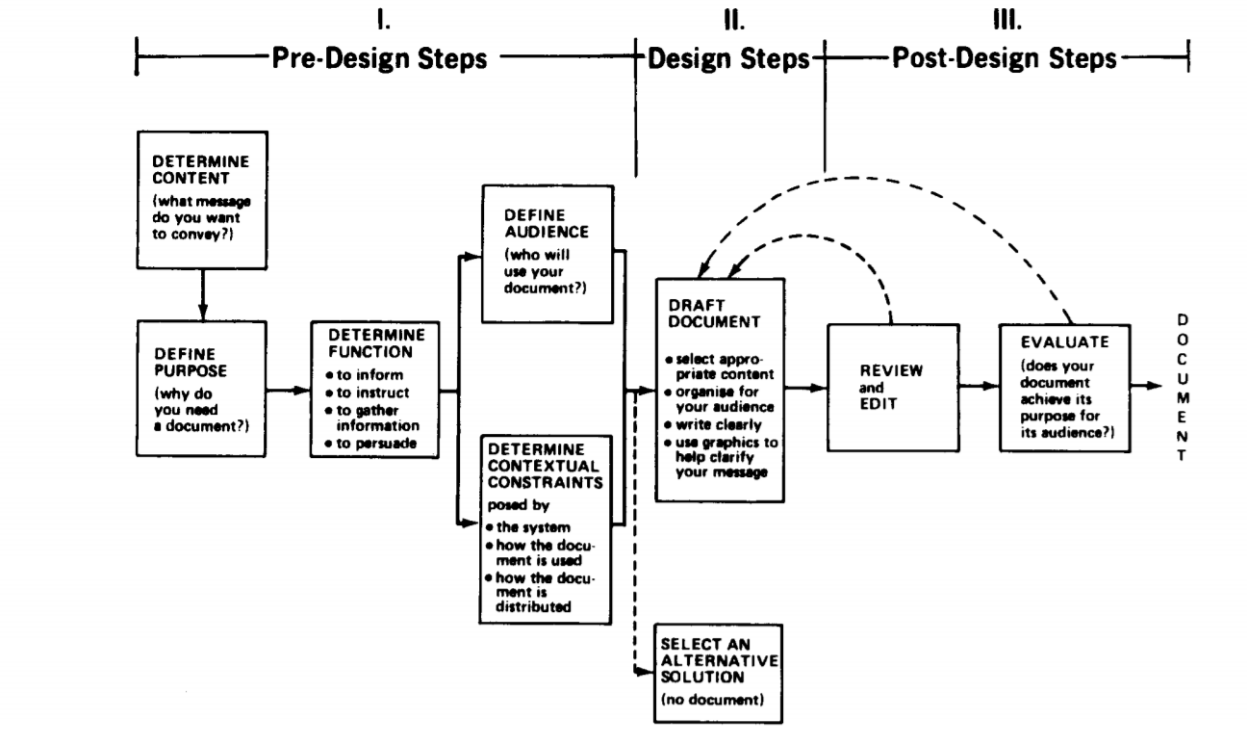


Figure 3.3 A model of the design process (Felker, 1980) [86].

"Review and Edit" however, will use the evaluation method of asking a professional to review the first version to identify the biggest problems in terms of design [86]. This evaluation does not determine the usability of the envisioned product but allows to quickly improve the overall appearance in order to avoid mistakes for a more detail-oriented user-testing process.

3.4 Evaluation

The evaluation phase concludes the process and is used to verify whether the requirements from the ideation phase and throughout the process are met. Overall, it serves as a verification of success or failure in realizing the product. Therefore, different aspects are taken into consideration and different approaches can be utilized in order to come to a conclusion. On the hand, functional testing has to be conducted verifying the incorporation of (must have) functional requirements and guaranteeing a functional prototype, on the other hand, user testing has to be conducted verifying the inclusion of user needs.

3.4.1 Functional Testing

Conducting a functional test, it can be determined whether all functionalities were incorporated. With reference to the functional requirements, this test can determine if at least all the must-requirements were met, and the envisioned product can be used for user testing or needs revision.

3.4.2 User Testing

During a user test a representative of the target group interacts with the designed prototype. The purposes of user testing in this graduation project are to test the usability of the prototype and to find out whether the prototype fulfils the user's needs [76]. Thus, problems with the prototype can be identified, if present. Before conducting a user test, a user testing protocol is created in advance to ensure that testing is smooth as well as consistent and yields interpretable results.

User Test Protocol

The user test protocol defines the purpose of the test, the test setup, the participants, the interaction device, the interaction method and the data collection method.

1. **Test Setup:** The test setup describes the schedule, location and equipment.
2. **Participants**: The participants section describes the participant recruitment criteria.
3. **Interaction method**: Interaction method illustrates how the participants will interact with the envisioned product which is usually the prototype of the envisioned product.

Two different interaction methods can be defined for usability testing: free interaction and task-based interaction. Free interaction means that the participant can interact with the prototype without any predefined tasks. In contrast to that, task-based interaction provides the participant with tasks which the participant needs to execute. When referring to the task-based interaction, it might be necessary to interrupt the testing and give the participant a hint, in case he or she does not understand how to perform a certain task. During the user test the observer is supposed to collect data on how the test participants interact with the envisioned product.

4. **Data collection method**: The data collection method defines how this is accomplished and specifies which qualitative and quantitative metrics are going to be used.

The methods that will be considered are the thinking-aloud and observation methods. These methods allow to gather the thoughts and experiences of the participants. Qualitative metrics concern the results of the thinking-aloud and observation methods — as well as for instance a questionnaire. Quantitative metrics are e.g. successful completion rates, error rates and time spent on a certain task. For the thinking-aloud method the concurrent method will be considered. The concurrent method is meant to make the participants talk about their experiences out loud during the test session. It is possible that participants forget the thoughts they had during the test session shortly afterwards. Therefore, the concurrent method is preferred over the retro perspective method. When observing the participants, additional information can be gathered by taking notes of important observations. These observations include the emotions that participants show when interacting with the envisioned product and if the interactions are enthusiastically. Combining these two methods, the experiences and thoughts of both the developer and the participants can be gathered. After the user test has been completed, the results are analysed, and a conclusion is drawn.

4 Ideation

The ideation phase is dedicated to the development of an idea and requirements based on information provided by stakeholders. Therefore, firstly a stakeholder analysis will be conducted in which they will be identified, described and categorized based on power and interest. After that, a collection of concepts that potentially fulfil their expectations and needs are brainstormed and illustrated. Choosing the most influential stakeholders, an interview will be conducted in which these concepts are presented for a first screening. Evaluating the latter, preliminary functional and non-functional requirements for further development of the final concept can be extracted, building the conclusion of the chapter.

4.1 Stakeholder Analysis

Based on previous research on the SRB [21] and discussion with the supervisor Richard Bults, multiple stakeholders could be identified. These are:

1. the Municipality of Enschede,
2. Waterboard Vechtstromen,
3. the University of Twente,
4. the co-developers Jeroen Waterink and
5. Thijs Dortmann and
6. the inhabitants of Enschede.

As some of the stakeholders represent a larger entity, the contact persons are summarized in table 4.1 including the role they have during this project. This is relevant due to the different power and interest of each stakeholder, determining whether they only will be informed or will participate actively in the development of the final product. These factors are visualized in an interest/power matrix in figure 4.1.

4.1.1 Decision-Maker: Municipality of Enschede – Hendrik-Jan Teekens

As the client of this project the municipality of Enschede can be considered the main stakeholder, in other words, the decision-maker for the development of the SRB. Their motivation in pursuing this project results from the rainwater problems in Enschede that leads to cost-intensive damage and dangerous situations for the inhabitants. Since the sewerage systems plays a large role in this scenario, it is the responsibility of the municipality to deal with this problem. Hence, a potential solution could be the

implementation of the SRB, buffering the rainwater and reducing the load on the sewerage system, which is overstrained during heavy rainfall leading to flooding of parts of the city. The municipality is represented by the water landscape designer Hendrik-Jan Teekens who is working on multiple water management projects in Enschede. His interest in the SRB is based on finding an affordable solution that also raises awareness of the inhabitants by including them in the execution of the project.

Stakeholder	Contact Person	Role	Participation
Municipality of Enschede	Hendrik-Jan Teekens	Decision-Maker	Encourage and Influence
Waterboard Vechtstromen	Jeroen Buitenweg	Decision-Maker	Encourage and Influence
University of Twente	Richard Bults	Decision-Maker	Keep Satisfied
Co-Developer	Jeroen Waterink	Co-Developer	Encourage and Influence
Co-Developer	Thijs Dortman	Co-Developer	Keep informed
Inhabitants of Enschede	-	Users	Keep informed

Table 4.1 Listing of Stakeholders with contact person, role and participation grade.

4.1.2 Decision-Maker: Waterboard Vechtstromen – Jeroen Buitenweg

The Waterboard Vechtstromen is a client and thus also a decision-maker. In contrast to the municipality, their responsibility is not the safety of the inhabitants but the functional reliability of the sewerage system. Therefore, both entities cooperate in finding a solution – which is the SRB in this case. As the sewerage system is the main concern in this challenge, the contact person is Jeroen Buitenweg, Senior Policy Maker and responsible for the sewerage system and climate in the city.

4.1.3 Decision-Maker: University of Twente – Richard Bults

In contrast to the municipality, the University of Twente is not a client, nor a user but it is a decision-maker as it is the communication unit between the developer and the client. The university is represented by the supervisor of this graduation work, Richard Bults who can provide a lot of expertise in this area. Therefore, his opinion is of great interest and is supportive in the development of the final product and keeps the projects within set resources.

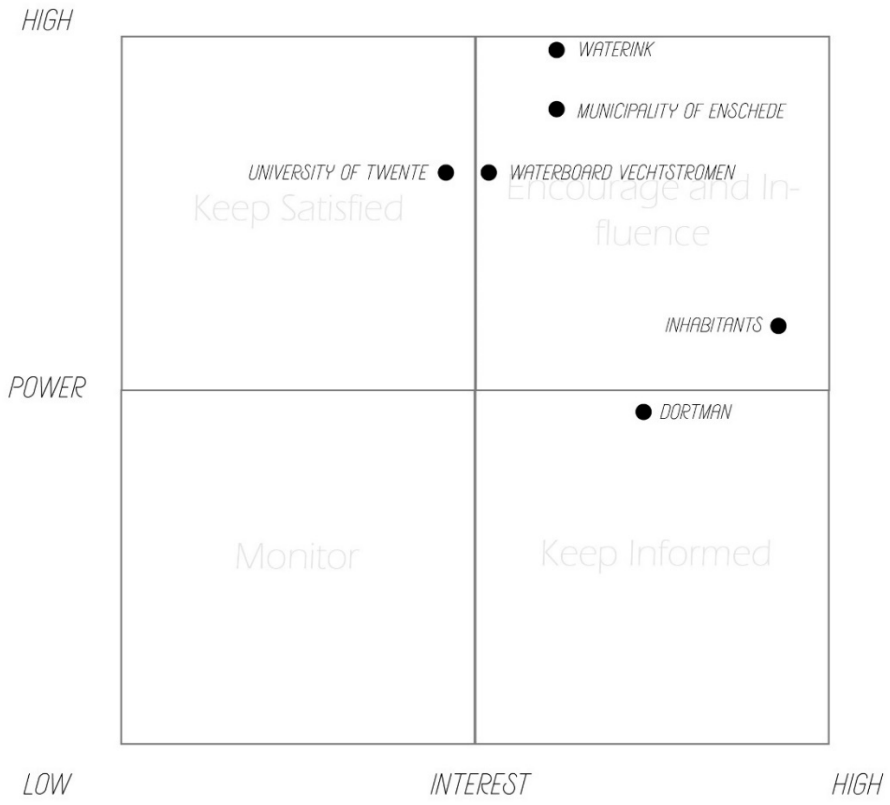


Figure 4.1 Stakeholder analysis in an interest/power matrix by Bryson [88]

4.1.4 Co-Developer: Jeroen Waterink

While this Bachelor Thesis documents the development of DIY instructions for the modularized SRB, the co-developer Jeroen Waterink will realize the actual product the instructions are designed for. His focus is on the functionality and creation of modules that allow an easy assembly. A close collaboration is necessary in order to create the instructions as the project pursued by this bachelor thesis is heavily dependent on his progress and decisions. Therefore, both parties need to communicate their needs and concerns and keep each other up to date to achieve a good result that can be used for a pilot-run.

4.1.5 Co-Developer: Thijs Dortmann

Having the responsibility of developing and designing a website for future SRB-users, the collaboration with Thijs Dortmann is less crucial than with Jeroen Waterink. Different than Waterink, Dortmann does not influence the creation of instructions but rather must incorporate the given input created throughout this thesis. Thus, the collaboration will only take place while finalizing the project and does not require much communication, as it is the case with Waterink.

4.1.6 User: Inhabitants of Enschede

The inhabitants of Enschede will be the future users of the SRB as they will place it in their gardens to harvest and buffer rainwater to improve the living quality of the city in preventing flooding and acting environmentally friendly using the harvested water. Therefore, their opinion is important in the implementation of the project. As the inhabitants consist of a large group, their characteristics such as age, education and interests can widely differ, meaning that there is a need of a solution that can be applied to a generalized audience. Overall, the inhabitants can be divided in sub-sets using the graph of innovation [84] (see figure 4.2). This must be considered as each sub-set has a different relation to innovative products, their assembly and usage.

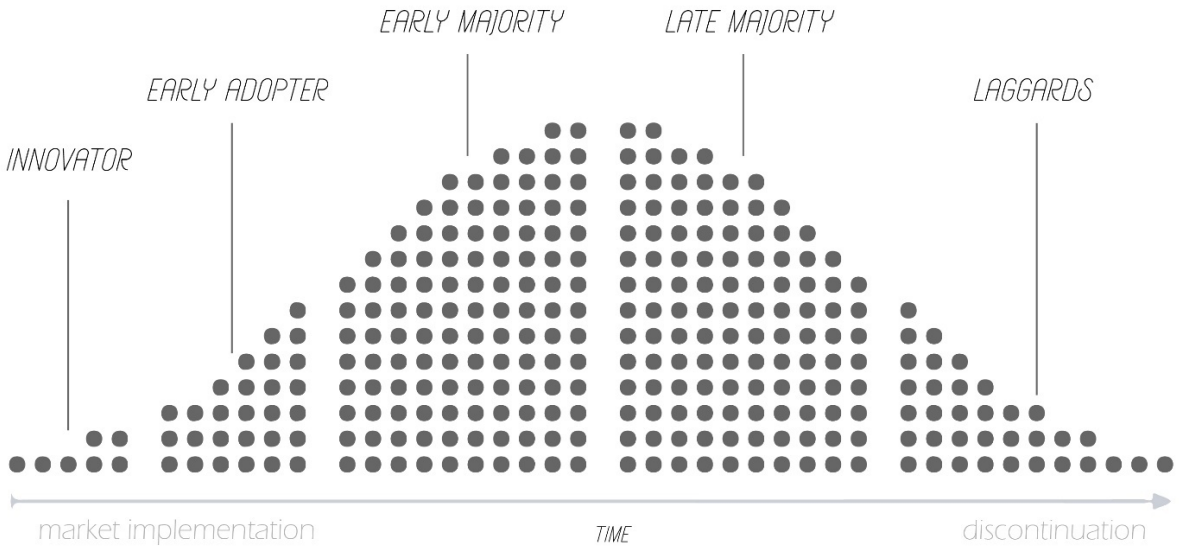


Figure 4.2 Graph of Innovation [84] showing the possible division of the inhabitants of Enschede using the diffusion theory by Everett.

Meeting certain characteristics, inhabitants can be assigned to an adopter category as described by Everett [84].

1. **Innovators** do not hesitate to take risks in adopting new products. This results from their financial resources that are not highly affected by failures. Other characteristics are a high social status, a relation to science and connections to other innovators.
2. **Early Adopters** have similar traits as innovators, such as a high social status, financial liquidity and an advanced education. However, they are not as risk-taking as innovators and rather adopt technologies with the aim of maintaining a central communication position in their circle.

3. The **Early Majority** adopts innovations (significantly) later than early adopters. Although they have a high social status, they do not inherit opinion leadership in their circle but connect with early adopters who do so.
4. The **Late Majority** is more sceptical towards innovation than previous adopters and only adopt innovation when most people already have. They have a lower social status and only little financial liquidity.
5. **Laggards** finalize the adoption process. They do not like changes and rather retain tradition. They tend to have the lowest social status, to have little financial resources and to be the oldest among all adopters.

These findings can be used to determine users for the evaluation of the envisioned product in order to test whether each adopter group can follow the instructions as intended or if the instructions have to be improved for a certain adopter group.

4.2 Concept Brainstorming Session

Resulting from the stakeholder analysis, it becomes apparent that collaborating and communicating with the SRB's co-creator is an essential aspect for being successful. Therefore, a joint brainstorming session with Jeroen Waterink has been arranged to devise multiple concepts of a potential modular SRB system that matched the needs of modular systems and DIY instructions. The brainstormed ideas have been summarized in a mind-map (see figure 4.3).

Based on these brainstormed ideas, concepts of modular systems have been elaborated, i.e. each idea was illustrated and briefly described. Furthermore, Waterink provided a preliminary component list (Appendix A) for an independent creation of a low-fi modularized SRB prototype. The prototype served as a representation of the SRB, consisting of several modules, allowing a first depiction of instruction methods. Overall, this section summarizes the different concepts to be presented to the decision-makers.

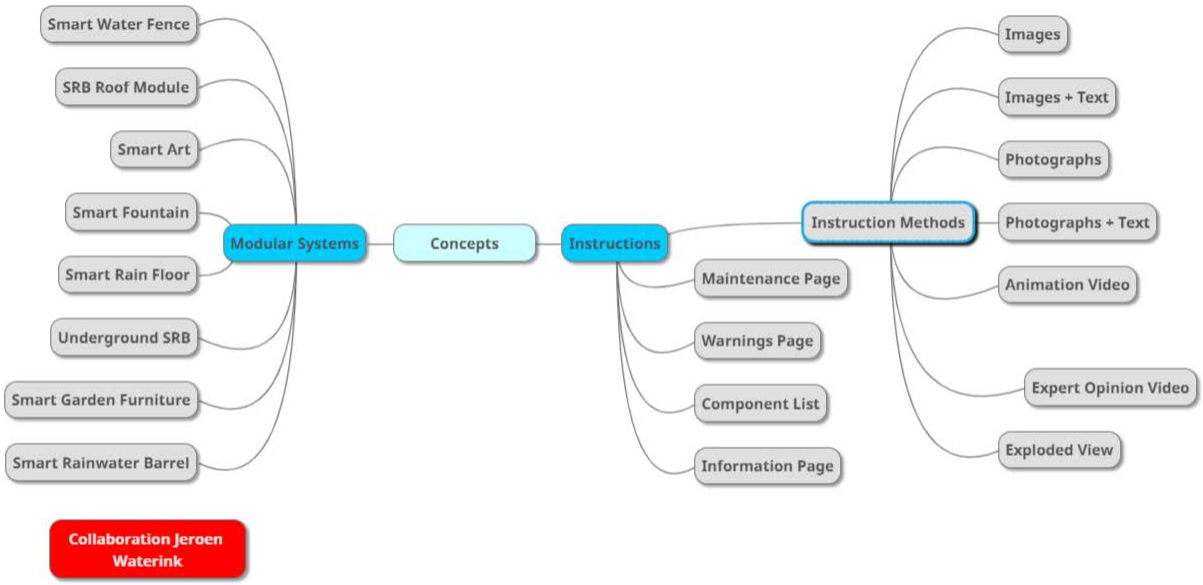


Figure 4.3 Mind-map summarizing brainstormed concepts in- and without collaboration of Jeroen Waterink.

4.3 Modular Systems

As Jeroen Waterink has the responsibility to build a modularized SRB, whereas the purpose of this Bachelor Thesis is the development of suitable DIY instructions for this future system, a joint brainstorming session has been arranged to devise different potential concepts to be realized. Having conducted research on modular systems and how their assembly is perceived by the user, certain characteristics to be considered have been established. These characteristics are summarized in table 4.2 determining the suitability of each brainstormed concept for the purpose of a DIY-assembly. The suitability is independent of the needs of Jeroen Waterink, as he has a different focus, i.e. the components and technology. However, the final concept is to be determined by the decision-makers who are to consider both point of views.

The evaluation matrix will be filled in with (--, -, -/+, +, ++), ++ being is the best score. All the scores are based on assumptions as the concepts are not developed far enough in this stage for more precise estimations. The evaluation matrix considers aspects that aim to reduce the difficulty of the assembly. For example, to reduce the difficulty of each assembly step, Mattson et al. [48] argues that the number of elements should not exceed 7 +/- 2, as the probability of confusing the user rises due to the short-term memory being unable to memorize a multitude of instructions at once. In contrast to that, Torres-Sanchez et al. [52] claims that the number of elements within a task should not exceed 5 +/- 2. Overall, the less

components are used, the less elements one has to consider [83]. For this reason, the regulation of both components and number of elements to be considered during a task is essential for creating a relatively easy and satisfying DIY assembly experience. Another evaluation of modular systems can be executed by implementing certain aspects such as cues on where to place the components and the repetition of tasks determine the difficulty of a task in the assembly process [83]. Furthermore, the need for additional tools that an ordinary household may or may not possess and the possibility of executing the installation independently are points to be considered.

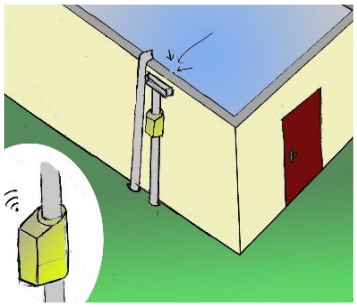
4.3.1 Concepts: of Modular Systems

In this section, eight devised concepts are briefly described and shown in a picture. Each concept was created, discussed, elaborated and illustrated in collaboration with Jeroen Waterink.

1. Smart Water Fence

This idea has been introduced by Vetter [23] in 2017. It is a fence, that acts as a narrow water container creating an extension of a regular fence. Positive is that the user has control, it is space-saving and does fit in the context of most gardens in the city. However, old fences might need to be replaced and the ownership of the fence might also not be clear.

2. Smart Roof Module



The SRB Roof Module utilizes the surface of flat roofs as a buffer. It stores the water on the roof and drains it slowly using the input of the sensors. The only negative aspect can be considered the limitation to flat roofs.

3. Smart Art

The Smart Art acts as a rain delay. It looks unique and is a creative method to buffer rain. But it cannot store water efficiently and is not suitable if placed in an area with high groundwater levels as it may increase it additionally.

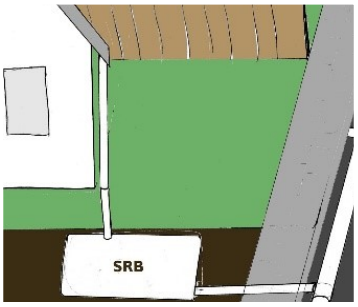
4. Smart Fountain

The smart fountain is similarly to the smart art more aesthetically pleasing. It allows the storage of water and uses the stored water for the fluidity of the fountain. Unfortunately, it has no protection from mosquitos since it lacks a cover and due to the complexity, it may be a costly solution.

5. Smart Rain Floor

The Smart Rain Floor is a rainwater buffer that is located beneath the user's feet and is therefore very space efficient. It has also a large buffer capacity and fits in the context of a garden. Other than that, challenges may be the installation and price.

6. Underground SRB

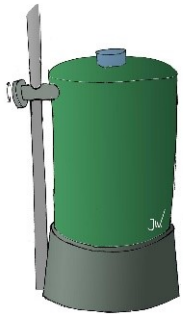


The underground Smart Rainwater Buffer is difficult to implement as it has to be placed deep in the ground. Furthermore, it does not allow the utilization of water unless installing a pump. However, it is very efficient as the buffer can be very large since it does not take up any living-space.

7. Smart Garden Furniture

The advantages of smart garden furniture are the customizability and the fact that it fits in the context of every garden as it is highly functional. Not only does it harvest water but it can act as a bench or similar objects.

8. Smart Rainwater Barrel



The regular Smart Rainwater Barrel is easy to maintain, functional and simple to install. It does not look special or have a twist but it works as the basic model. This model was introduced by Boaz Vetter [23].

4.3.2 Evaluation: Modular Systems

The evaluation matrix (see table 4.2) incorporates the most relevant aspects identified from previous research on modular systems in relation to DIY-assembly instructions. It is based on estimations discussed with the co-developer Jeroen Waterink and therefore may not be fully accurate. Nonetheless, it does give a first impression on the most suitable modular systems. Noticeable is, that the most suitable modular systems based on these characteristics are the ones introduced prior to this Bachelor Thesis by Boaz Vetter [23], i.e. the Smart Water Fence and the Smart Rainwater Barrel. Considering research from Defize [8] on the acceptance of each option, the fence was not very well received. In contrast to that, the Smart Rainwater Barrel was best-received. To conclude, the smart rainwater barrel is considered most suitable and will be recommended to the stakeholders with respect to these findings. Resulting from the stakeholder interview (Appendix B), the smart rainwater barrel was chosen for the final design.

Name of System	Predicted number of components	Predicted possibility of repetitive tasks	Complexity (7+-2 tasks)	Predicted possibility to add cues for placement of components	Need for additional tools	Installation can be executed by oneself	Total
Smart Water Fence	++	++	++	++	+	+	++
SRB Roof Module	++	-/+	+	-/+	+	-	+
Smart Art	+	-/+	+	+	+	+	+
Smart Fountain	--	--	--	-/+	+	-	-
Smart Rain Floor	--	++	-	-/+	-	--	-
Underground SRB	--	--	--	-/+	--	--	--
Smart Garden Furniture	+	++	++	++	+	+	+
Smart Rainwater Barrel	++	-/+	++	++	+	++	++

Table 4.2 Evaluation matrix of suitability of modular system concepts.

4.4 First Iteration DIY Instructions

During the state of the art research (Chapter 2), a variety of instruction methods have been identified and evaluated using renowned examples. Therefore, the goal is not the identification of benefits and

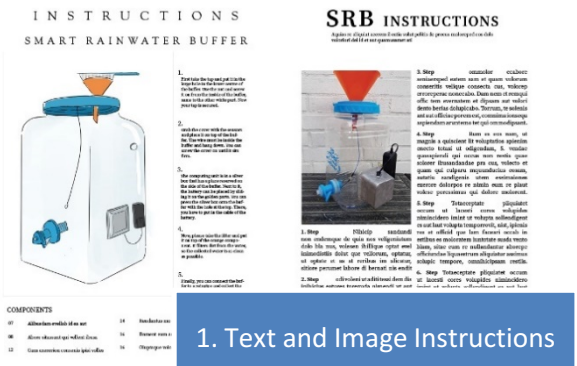
disadvantages or the generation of new ideas but to learn the stakeholder's preference by developing low fidelity prototypes of these instruction methods. However, as the modular system is not developed yet, a low fidelity prototype of the modular system was created for this purpose. It contains all components Waterink proposed in a preliminary component list (Appendix A). It is used to mimic the potential complexity of the final SRB in order to find which method of representation is most suitable for the final DIY instructions. The low fidelity prototype consists of a buffer, a filter, a lid with implemented sensors, a battery, a computing unit, a tap and a connection the rainwater pipe. It is small scaled and uses simple objects to represent real components (see figure 4.4).

For a first screening of concepts regarding their suitability, the decision-makers Hendrik-Jan Teekens and Richard Bults were interviewed. Using the approach of an unstructured interview, information was gathered on what was expected and which concept was most preferred. This approach narrows down the options and allows to widen the scope again on a more specific level. This section then concludes with a first list of preliminary requirements.

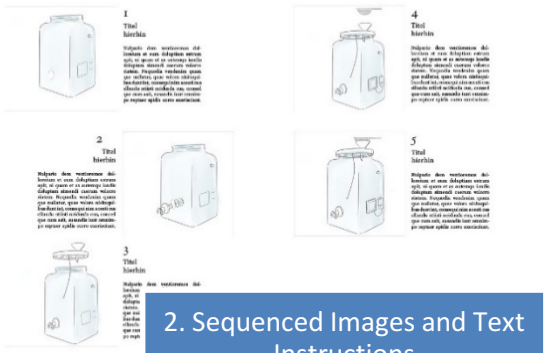
Figure 4.4 Components/modules of low fidelity prototype of a potential modular system.

4.4.1 First Iteration Instructions Concepts

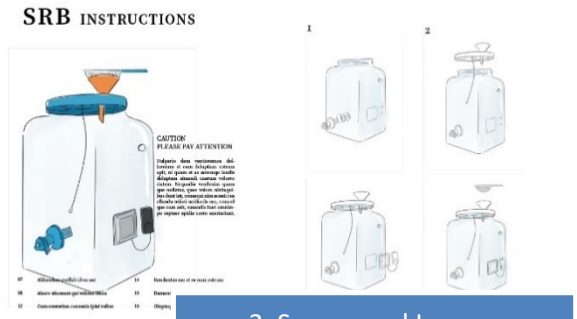
This section gives an overview on the first iteration of concepts, i.e. seven different instruction methods. The low-fidelity prototypes of the different instruction methods are supposed to represent the look and feel of the final version. In other words, the text is not accurate and filled with place-holder words. The purpose it to communicate whether images are sufficient, what type of images are most suitable and how/if text should be used.



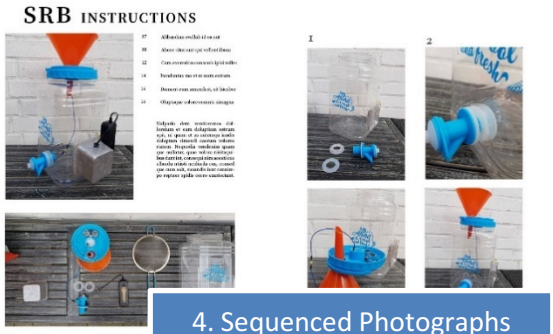
1. Text and Image Instructions



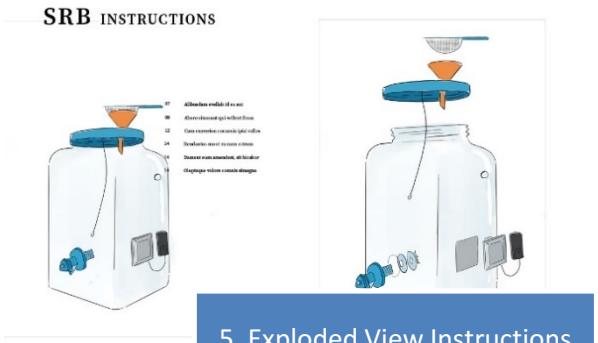
2. Sequenced Images and Text Instructions



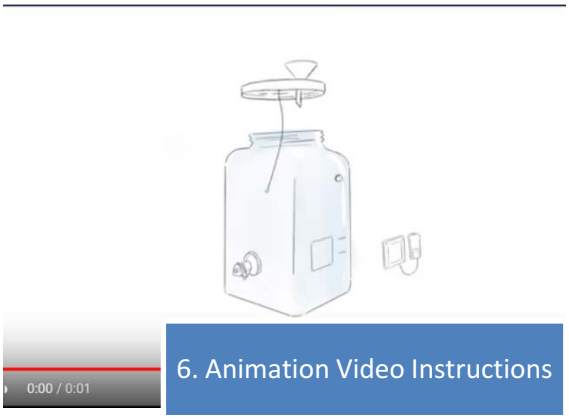
3. Sequenced Images Instructions



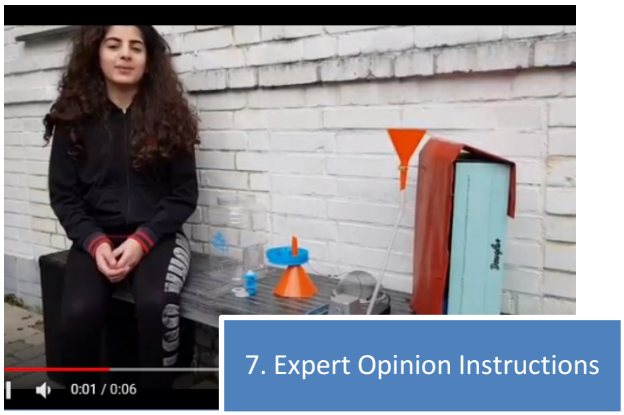
4. Sequenced Photographs Instructions



5. Exploded View Instructions



6. Animation Video Instructions



4.4.2 Evaluation of Concepts: Interview with Decision-Makers

To evaluate the concepts, a semi-structured interview has been prepared. This approach was chosen as it is more flexible, and questions can deviate allowing more in-depth insights. In addition, the goal is to reveal needs and interests of which Hendrik-Jan Teekens might or might not be aware by presenting the previously described concepts, as well as asking questions on how he imagined certain aspects of the product to be. It is not necessary to follow a structured interview as there will be no comparison to other respondents. A transcript can be found in Appendix B. To summarize, the following can be concluded from the conducted interview:

1. The modular system will be based on the concept of a smart rainwater barrel.
2. The instructions will consist of images and text and video instructions with an expert opinion.
3. The images must consist of illustrations as they are clearer in communication.
4. The images must be sequenced and showing a process of assembling the SRB.
5. The images must be black and white and follow the example of IKEA.
6. The images must be printed on maximum one double-sided A4 page.
7. The image instructions must be downloadable from a website in case of losing them.
8. The instructions must include a reference to the website.
9. The SRB will come with pre-defined holes that may be used but are not mandatory.
10. The claim “Made by Holland” must be included to indicate that the SRB is a high-quality product.
11. Next to the instructions, the manual must include a maintenance and information page.
12. As the SRB is a product promoted by the municipality, their corporate design must be included.
13. The manual must be in Dutch and English.

4.4.3 Preliminary Requirements I

Based on this information, preliminary requirements can be extracted. These requirements need to be further investigated and discussed with the client, leading to a final requirement list that the project should incorporate in order to be considered successful.

Functional:

1. Explain the steps a user must take for completing the SRB.
2. List all the necessary materials for completing the SRB
3. Give information on water stress in Enschede.
4. Give information on the online dashboard.
5. Give information on how to reach the dashboard.
6. Give information on the maintenance of SRB.
7. Offer two instruction methods for explaining how to successfully assemble the SRB.
8. Use Dutch and English language for communication.
9. Give contact Information for support.
10. Indicate and give the opportunity to view instruction manual online.
11. Mention „Made by Holland“

Non-Functional:

1. Present Instructions with text and images.
2. Images should be illustrated.
3. Images should be B/W.
4. Instructions must be printed on A4.
5. The manual design must match Corporate Design of the municipality Enschede.
6. Present instructions in a Video.
7. Video should include an expert.
8. Video must offer an expert opinion.
9. Video must be filmed in a sterile area.
10. Video may not be longer than 5 Minutes.
11. Video must be accessible via a QR-Code.
12. Instructions must be understandable for the user.
13. User should feel motivated and engaged to conduct DIY assembly of the SRB.

4.5 Second Iteration DIY Instructions

As the aim of the first iteration of instruction concepts was to find the most suitable instruction technique and preliminary requirements, the second iteration serves as a specification of characteristics for the implementation of the chosen concepts. Therefore, concepts for the implementation of the video instructions were prepared and three versions of the printed manual were created considering the set preliminary requirements or purposely ignoring them to gain new insights. These have been presented to all decision-makers, including the Municipality of Enschede, the Waterboard Vechtstromen and the University of Twente for a finalization of requirements of the chosen concepts. Hence, this section serves as a presentation of the second iteration of low fidelity prototypes and their evaluation by stakeholders.

4.5.1 Second Iteration Instruction Concepts

Resulting from the interview with the municipality and university, it was chosen to design a printed instruction manual adhering both to the functional and non-functional preliminary requirements (section 4.4.3). However, the requirements to print it in black and white (non-functional requirement 3) and on A4 (non-functional requirement 4) were agreed upon but did not lead to a satisfying product. The limitation of colour did not allow the successful implementation of the municipality's corporate design, restricted the effective presentation of information in terms of the infographic on page 1 and the online dashboard on page 2. Therefore, three different versions were printed and presented to the stakeholders that did not fulfil these two requirements as displayed in figure 4.5 the three versions are a) colour in A4, b) colour in A5 and c) in black and white in A5.

Aim of this prototype was to find more specific requirements. This has been done by asking questions related to certain aspects of the presented prototype or by receiving unrequested comments during the semi-structured interview with the stakeholders. Relevant topics were:

1. the size of the manual,
2. the colour,
3. the successfulness of implementation of corporate design,
4. the order of sections,
5. the content of sections and
6. the size of the typeface.

Therefore, different manual sizes printed in colour and black and white were presented, different typeface sizes were implemented in the concept manual and direct questions on the other aspects were asked

throughout the interview to gain insight and further elaborate on the requirements of the final instruction manual.

In contrast to the printed instruction manual, requirements for the expert opinion video have not been collected using concepts but rather with direct questions as further specification of a concept heavily depends on the complexity of the final product, determining e.g. the length of the video and type of shots. The questions are based on implementation of expert opinion videos by renowned companies in the state of the art research, such as IKEA. Aim was to find out in what setting the video should be filmed, what the length of the video should be and how the accessibility of the video should be provided to the user.

Figure 4.5 Three versions of printed instruction manual.

Figure 4.6 Basic Model Prototype of printed instruction manual. Full sized images in Appendix C.

4.5.2 Evaluation of Concepts: Interview with Decision-Makers

A second unstructured interview was conducted to finalize concepts and requirements. Furthermore, the preliminary set requirements were evaluated by each decision-maker based on their priority. The results and transcript can be found in Appendix D. Conclusions that could be drawn from the interview are:

1. People must be aware that water may flood the house when the SRB overflow is placed in their garden. It should be mentioned in the warnings.
2. It must be indicated that there are different choices of where to put the SRB overflow.
3. The manual must be in color and no longer in black and white.
4. The manual must have the size of A5 and no longer A4.
5. The order of the manual components must be: rainwater problem information, website-information, warnings and components, instructions, maintenance.
6. The font size must be 10px.
7. The corporate design of the Municipality of Enschede must be used but the Corporation with the waterboard Vechtstromen must be clearly indicated.
8. The University of Twente must be indicated on the back of the manual in order to demonstrate the scientific relation to the SRB project.
9. The instruction videos must not be longer than two minutes.
10. In case the video must be longer, it should be divided into multiple videos with different themes.
11. The video must be filmed in a garden setting and not in a sterile setting.
12. The video should be accessible via a link, not a QR-code.

4.6 Conclusion

The conclusion finalizes the ideation chapter with a brief description of the final concepts by using the second preliminary requirement list, categorized based by priority. It results from the stakeholders needs and wishes that have been documented and evaluated during semi-structured interviews.

Functional	Non-Functional
Must	
1. The instructions need to explain the steps a user should take for completing the SRB.	14. The order of the instruction manual components must be: information, website,

	warnings and components, instructions, maintenance.
2. The instructions need to list all the required materials for completing the SRB.	15. The instructions in the manual should be presented using images and text.
3. The instruction manual must give information on water stress in Enschede.	16. The images should be illustrated.
2. The instruction manual must indicate how to access the SRB website.	17. The corporate design of the Municipality of Enschede must be used.
3. The instruction manual must give information on the maintenance of the SRB.	18. The corporation of the Municipality and Waterboard must be clearly indicated on the front of the instruction manual.
4. The instruction manual must include warnings to prevent potential danger the SRB could cause.	19. The font-size of the manual must be at least 10px.
5. The instruction manual must mention “Made by Holland”.	20. The instruction manual must be printed in colour on A5-sized paper.
6. The instruction manual must contain contact information for additional support.	21. The instruction video must not be longer than two minutes.
7. The language of communication must be English and Dutch.	22. The instruction video must include an expert.
8. Alongside the instruction manual, video instructions must be offered.	23. The instruction video must include an expert opinion.
9. The instruction manual must indicate how to view the video instructions.	24. The instruction video must be filmed in a garden setting.
10. The instruction manual must indicate how to view the instruction manual online.	25. The instructions must be comprehensible for the user.
	26. The user must feel motivated and engaged to conduct the DIY-instructions.
Should	
11. The instruction manual should give information on the dashboard.	

Table 4.3 Preliminary requirement list.

5 Specification

To further specify the envisioned product, this chapter elaborates on the functional and the experience specification resulting from previous research and a user focus group. It serves as a summary of what will be implemented and how it may be perceived by the user. It confirms and adds more detail to the previously set functional and non-functional requirements as a conclusion of the chapter.

5.1 Functional Specification

The functional specification describes how the instructions shipped within the SRB package are related. As can be seen in figure 5.1, the package includes all the components and the DIY instruction manual, that will help the user to correctly assemble the SRB. The SRB instruction manual is the focus of this specification and will be described more closely.

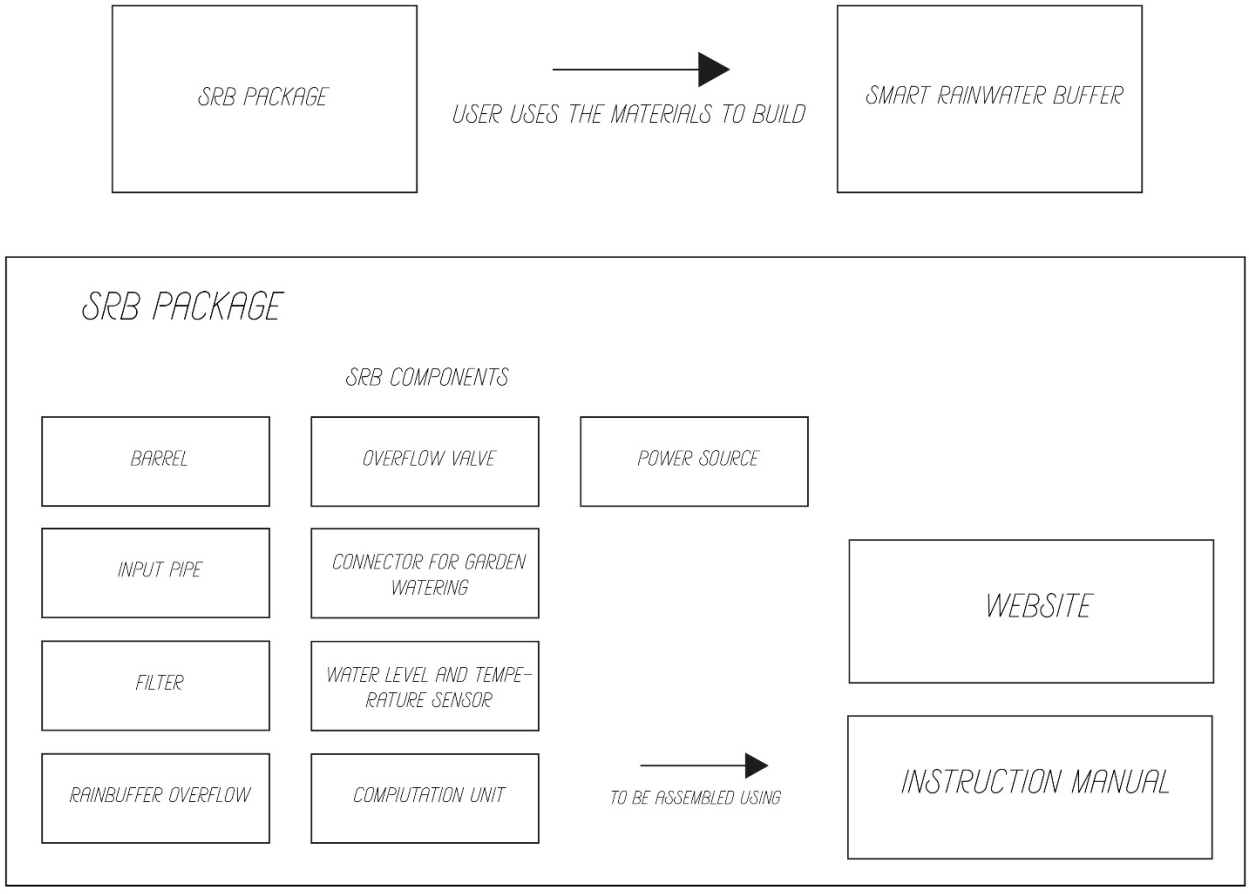


Figure 5.1 Placement of instructions alongside modular system components.

5.1.1 Instruction Manual

The instruction manual contains several components (see figure 5.2); an information page, assembly instructions and a maintenance page. These provide users a simple and enjoyable SRB experience. Furthermore, additional support is included and the claim “made by Holland” can be found on the front of the manual. The manual is not only delivered with the other SRB components but also available online as a PDF document to be downloaded on the SRB-website. Other than that, the instruction manual is available in two versions: Dutch and English language.

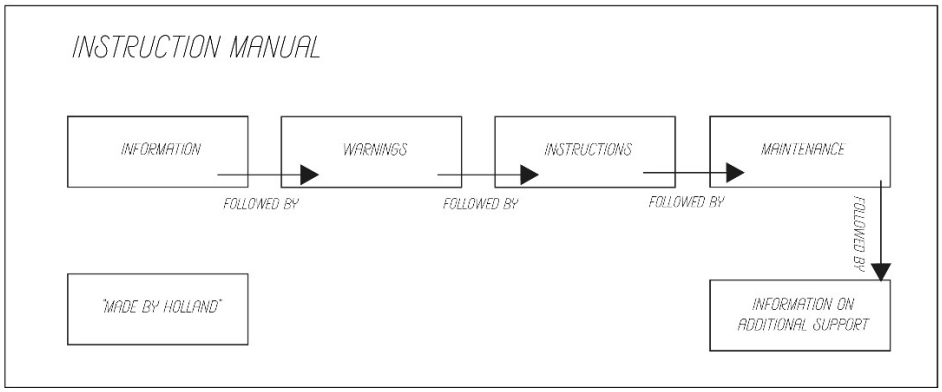


Figure 5.2 Functional Architecture of instruction manual.

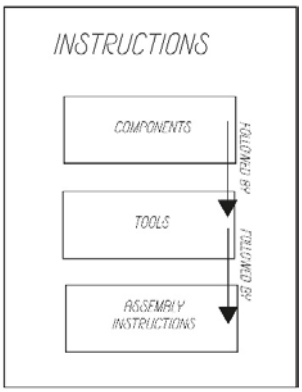


Figure 5.3 Functional Architecture of Instructions.

Information

The information page does not only inform about water stress and how the SRB aids in improving the situation, but it also contains links to the SRB website and indicate how to access the instruction video and digital instruction manual (section 5.1.2). It is used as a promotional tool in order to support a large-scale deployment as the research question implies.

Warnings

To avoid dangerous situations, the user is exposed to warnings before the instructions. He must be made aware that it is not advised to assemble the SRB by one self as well as assembling it while it is wet outside.

Instructions

The instructions begin with a list of the components that are included in the package as well as tools that will be necessary for the assembly. It concludes with the assembly instructions that consist of several steps in form of text and illustrations (see figure 5.3).

Assembly Instructions

The assembly instructions consist of several steps that lead to the completion of the SRB. The steps are summarized in a flow chart in figure 5.4.

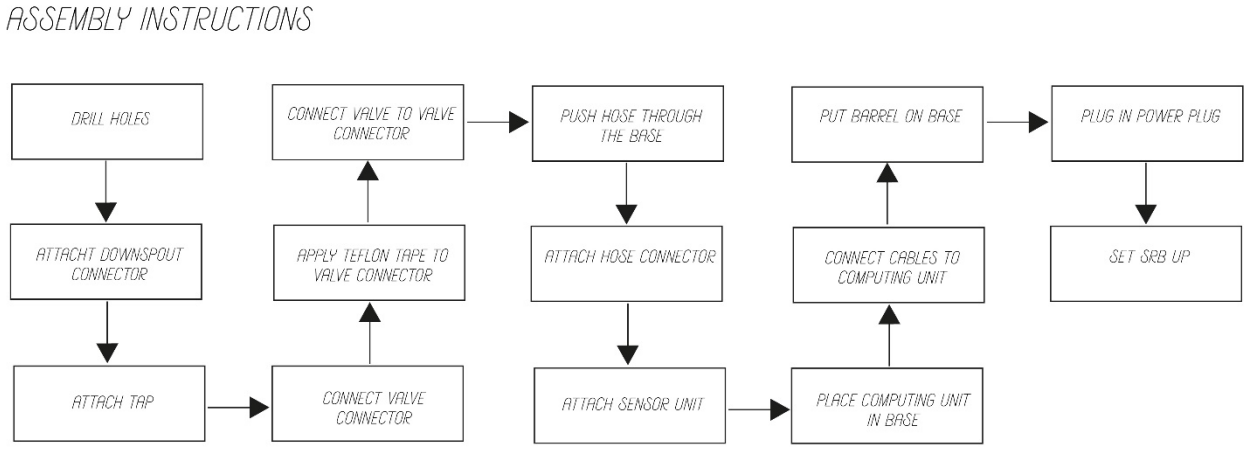


Figure 5.4 Assembly instructions flow-chart with each step of the assembly.

Maintenance

The final section of the manual is the maintenance. It must instruct the user when and how to maintain the SRB. The two components to be maintained are the outlet position and the filter.

Information on Additional Support

On the back of the instruction manual contact information for additional support must be given in case the instruction manual and the website do not answer the user's questions. This contact information for additional support consists of a name, a phone number and an e-mail address.

5.1.2 Website

The website is created by co-developer Thijs Dortmann. It contains a dashboard with information on the user's SRB, such as the fill-level, reminders for the maintenance or indications that the SRB may be defect and online instructions. These online instructions consist of the expert opinion video and the digital instruction manual. While the expert opinion video follows the same steps as depicted in figure 5.5 but is presented by an expert, the digital instructions are essentially the same as the printed instructions.

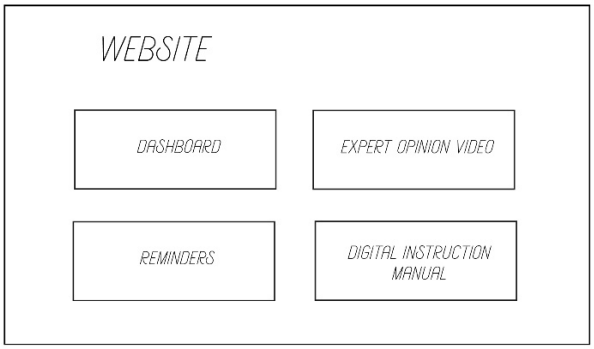


Figure 5.5 Functional Architecture of the website created by co-developer Thijs Dortmann.

5.2 Experience Specification

Having conducted research on the expectations of the decision-makers during the ideation phase to create a product they desire, the experience-specification aims on further tailoring the concept according to the user's needs. As the instructions are to be developed with a user-centred design approach, their input is relevant to fulfil non-functional requirements, such as requirement 25: "the instructions must be comprehensible for the user". Therefore, personas representing the user-group are specified, as well as possible use-case scenarios, contexts and technologies of the product. These are representable for examining the functionalities of the product from the user's perspective and give an indication who and what aspects must be involved in evaluating the final product.

5.2.1 Personas

What can be concluded from the stakeholder analysis, is that the inhabitants of Enschede will be the users of the SRB instruction manual to be developed throughout this Bachelor thesis. However, as the inhabitants may widely differ from each other based on a variety of characteristics, a solution that is generally applicable must be found. Considering the development stage of the SRB the instructions are made for and applying the theory of diffusion of innovation [84], the adopter groups "early adopters" and "early majority" will be the main users of the system. Therefore, to specify on people or rather potential users, two personas have been set up that represent the "early adopter" (see figure 5.6) user and the "early majority" (see figure 5.7) user that lives in Enschede. Their characteristics are based on research conducted on characteristics of early adopters and early majority, but also on the results from a focus group of inhabitants of Enschede. The transcript can be found in Appendix D.

PROFILE

Age	53
Gender	male
Job	university professor

A self motivated and confident professor who has extensive knowledge of the effects of climate change and successfully reduces his ecological footprint using smart devices to act environmentally friendly in an comfortable and effective manner.

EDUCATION

Highly educated. Has graduated in philoshical studies.

HOBBIES & INTERESTS

His hobbies are being active and enjoying nature. He likes to go hiking or riding his bike with his wife and children. Other than that, working in his garden and taking care of the plants is a method of relaxing for him.

EARLY ADOPTER

Figure 5.6 Marcus Scherpen, Persona for an early adopter.

PROFILE

Age	34
Gender	female
Job	highschool teacher

A friendly and positive highschool teacher emphasizing the exposure to different cultural and environmental conflicts with an aim to teach young adults critical thinking and motivating them to behaviour that stimulates a positive atmosphere in society.

EDUCATION

Well educated. Has a Bachelor in a technical study but continued the education to become teacher.

HOBBIES & INTERESTS

In her free time she likes to work with disadvantaged children and plans activities to rise their life-quality. Furthermore, she enjoys spending time in her garden and taking care of her self-grown vegetables.

EARLY MAJORITY

Figure 5.7 Melissa de Boer, Persona for the early majority.

The personas briefly describe the character, the education and hobbies and interests. These are the main aspects to be considered when designing for the user group who may be interested in the SRB. To conclude from the focus group, the early majority would only consider purchasing the SRB when it would be recommended by a respectable acquaintance and when there is an existing interest in gardening or fighting the effects of climate change. These findings match the assumptions of the theory of diffusion of innovation, as the early majority is influenced by the early adopters.

5.2.2 Scenarios

Different users may use the product differently. Therefore, scenarios must be specified as they can reveal potential problems and aspects of the product that need revision. Additionally, they give an overview of the functionalities from the user's perspective, showing e.g. whether a function is redundant, or a function is missing. Two scenarios have been visualized (see figure 5.8, figure 5.9) and have further described in a text.

Scenario: Early Adopter SRB use-case

Marcus Scherpen works as a philosophy professor at the University of Twente. As he had a meeting with a friend in the Zilverling building, he walked past the door of Richard Bults who had a scientific poster of the SRB attached to his door. Impressed by the capabilities of the system and based on his interest on improving the environment, he decided to contact Bults and schedule a meeting to receive more information on the system and how to purchase it. Having had an intensive and inspiring conversation about the background of the SRB and on how to support the development and purchase it, Marcus placed an order despite the relatively high price as he had investigated the scientific research done on the system and saw a lot of potential in the product.

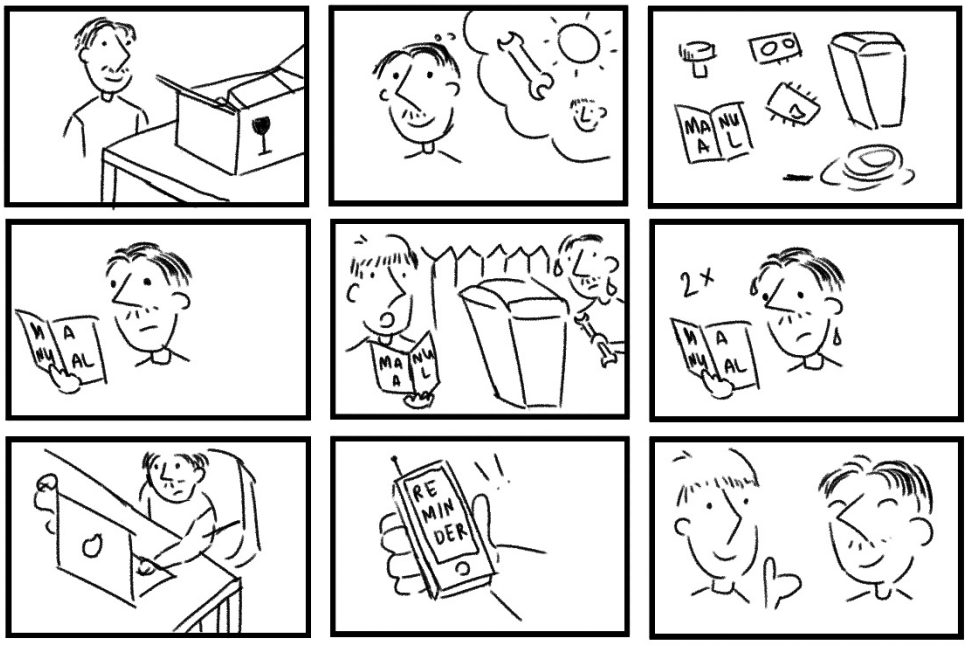


Figure 5.8 Persona Marcus assembling his SRB.

The next weekend he received his smart rainwater buffer (SRB) and decided on setting it up on his free day alongside his son as the weather was sunny and ideal for garden work. Opening the package, he found

the components and user manual containing information on the SRB, the website, assembly instructions and maintenance. Having had a quick look through the manual, he understood the concept and prepared all the necessary components and got his own tools from his shed for the assembly. With his son instructing him on the steps to be taken for the successful assembly, Marcus set up the SRB without further complications. Also, after the assembly, he once more looked through the manual and bookmarked the SRB website and registered his SRB in order to be able to retrieve statistical data on his SRB performance, followed by setting up a reminder on his phone for the maintenance of the SRB.

Scenario: Early Majority use-case

Melissa de Boer is a high school teacher who organizes parents' meetings in every semester for her students to discuss relevant topics such as extra-curricular activities. One of the present parents was Marcus Scherpen whose son is attending Melissa's class. Discussing potential class trips and themes for elective projects, the water flooding problems in Enschede was mentioned by Marcus. He brought the instruction manual of the SRB that explained the problem at hand. He wanted awareness to be raised and proposed to educate the children about this theme. Therefore, he sent an e-mail for further information on the SRB to all parents after the meeting.

Considering the water flooding problems in Enschede as a good theme for a project, Melissa decided on examining the SRB as a solution more closely, as the system is only effective when it is widely distributed. This means, that the inhabitants of Enschede can take responsibility for their city's wellbeing which is an important aspect to be passed to the children who must learn to feel responsible and act. She accessed the SRB website and found the online instructions. The information she received from digital manual and watching the assembly video convinced her, to feel confident in being able to assemble the SRB.

As soon as she received the SRB package, she opened it and was thrilled to finally set it up and tell the other teachers about her experience. However, when it came down to the actual assembly process, she felt slightly overwhelmed by using her boyfriend's tools and was not sure whether she could assemble it by herself based on the illustrated instructions. So, she decided to call her boyfriend and to assemble it together using the expert opinion video as it gave them a clearer insight on how everything had to look like. Having finished the assembly, the couple was happy about the result and took a picture to post it on social media.

Figure 5.9 Persona Melissa assembling her SRB.

5.2.3 Context of SRB use

A diversity of contexts with different focus can be specified. Relevant for the manual is the physical context as the product the instructions are designed for will be placed outside. At the same time, the manual is not only used for the assembly but also as a mean to inform users about the purpose of the SRB. Therefore, the social context must also be specified.

Physical context

The system is designed for placement in the garden of the user, so the physical context of the assembly instructions may be the user's garden. He will follow these instructions there in order to assemble the SRB, either using the printed or/and video instructions. As the assembly is not intended to take place during bad weather, the physical context should be dry and well illuminated (by daylight). Another potential physical context is inside the house when the user reads additional advice on maintenance or on the website.

Social context

One component of the instruction manual is the additional information on water flooding problems in Enschede and the efficiency of the SRB to ease this problem. Since the instruction manual can be downloaded from the SRB website and therefore, it is not necessary to keep it. The printed manual can be given to friends and family as promotional material. It serves as a channel of communication for the

distribution of the system. This means, the social context could be in many situations. However, due to the branding of the SRB, people visiting owners of the SRB may ask them about it, being the most common social context. The manual acts as the “business card” of the SRB.

5.2.4 Technologies

The instruction manual delivered with the SRB system is printed and does not contain technology itself. The information is summarized on paper. However, as there are video instructions, as well as a digital version of the delivered instruction manual, the technologies used are a video-player and a PDF reader. These can be accessed via an internet browser by visiting the SRB website. The video-player only requires clicking on the start-button, whereas the browser itself can act as a PDF reader, directly displaying the PDF in a new tab. This means, that the online instructions are accessible for users with little technology experience.

5.3 Final Requirements

Having specified the functional and experience specification, new conclusions could be drawn and additional requirements specified that aimed on improving the user experience. Therefore, the preliminary requirements have been revised and a final requirements list has been set up that includes not only the decision-makers preferences but also considers the users needs and expectations. The newly introduced requirements are marked blue in table 5.1.

Functional	Non-Functional
Must	
1. The instructions need to explain the steps a user should take for completing the SRB.	18. The order of the instruction manual components must be: information, website, warnings and components, instructions, maintenance.
2. The instructions need to list all the required components for completing the SRB.	19. The instructions in the manual should be presented using images and text.
3. The instructions need to indicate all necessary tools for completing the SRB.	20. The images should be illustrated.
4. The instruction manual must give information on water stress in Enschede.	21. The corporate design of the Municipality of Enschede must be used.
5. The instruction manual must indicate how to access the SRB website.	22. The corporation of the Municipality and Waterboard must be clearly indicated on the front of the instruction manual.

6. The instruction manual must give information on the maintenance of the SRB.	23. The font-size of the manual must be at least 10px.
7. The instruction manual must include warnings to prevent potential danger the SRB could cause.	24. The instruction manual must be printed in colour on A5-sized paper.
8. The instruction manual must mention “Made by Holland”.	25. The instruction video must not be longer than two minutes.
9. The instruction manual must contain contact information for additional support.	26. The instruction video must include an expert.
10. The language of communication must be English and Dutch.	27. The instruction video must include an expert opinion.
11. Alongside the instruction manual, video instructions must be offered.	28. The instruction video must be filmed in a garden setting.
12. The instruction manual must indicate how to view the video instructions.	29. The instructions must be comprehensible for the user.
13. The instruction manual must indicate how to view the instruction manual online.	30. The user must feel motivated and engaged to conduct the DIY-instructions.
14. The instruction manual must indicate that it is recommended to assemble the SRB with two people.	31. The assembly instructions must be suitable for early adopters and the early majority.
Should	
15. The instruction manual should give information on the dashboard.	32. The assembly instructions should be suitable for every adopter group of the inhabitants of Enschede.
16. The instruction video should indicate that there is additional information in the instruction manual.	33. The instruction manual should be able to act as a means of promotion for the SRB.
17. The instruction video should show a link to the digital instruction manual.	34. The user should understand that he and society benefits from the installation of the SRB.

Table 5.1 Final requirements list.

6 Realisation: Instruction Manual

Incorporating the information and requirements gathered in previous chapters, the realization summarizes the design-decisions of the envisioned product and presents the final result, whichwill be used for an evaluation of the successfulness of the product. First, the best methods and tools of realization will be determined. Then, the design will be decomposed in different sections for a smooth realization process. And lastly, these components will be integrated in the final design. This chapter only covers the realisation of the instruction manual, whereas chapter 7 deals with the realization of the expert opinion video.

6.1 Methods and Tools

Considering the model of design process by Felker [86] that was introduced in section 3.3, all steps until "draft document" have been taken. However, before creating the first draft, research on the realization approach must be conducted. Tools have already been compiled in the state of the art but more elaborate research on the chosen approaches must be conducted to determine what is important for the manual and what additional aspects must be considered. Challenges that need to be considered are inaccurate information, incomprehensible information and unstructured information [86]. This means that the content and presentation must be adequate in order to overcome these obstacles. Determining guidelines on the presentation of text and the right software for the creation of graphics will lead to a satisfying product that fulfils the previously set requirements.

6.1.1 Text in Instruction Manuals

As the instruction manual will contain additional information of rainwater problems in Enschede and text-instructions, the correct writing style must be applied to convey the right message. Guidelines on the writing style have been found for the information text and assembly text also known as technical writing and technical copywriting. Furthermore, the effective presentation of warnings has also yielded results that need to be taken into account during the realization.

Information Text: Technical Copywriting [91]

Technical copywriting is used to promote rather than explain a technical product. In order to write persuasively, the target audience has to be identified and their technical knowledge must be assessed to match the writing style to it. Then descriptive technical writing must be used, conveying the message using technical language that is comprehensible to the audience.

Before the Assembly Text: Warnings [106]

Warnings must be designed in such a way that they are easily noticeable. Therefore, four components must be included to convey the message successfully: (1) signal word, such as “danger”, “warning” “caution” and “notice”, (2) identification of the hazard, (3) explanation of consequences and (4) how to avoid the hazard. The last three points can be done using a representative image, which can be seen in figure 6.1.

Figure 6.1 Examples of warning-designs used in the U.S. [106].

Assembly Text: Technical Writing [86]

Technical writing has more guidelines than technical copywriting. It aims on making the assembly experience as simple and pleasant as possible. The guidelines that were found are:

1. *Write the text in such a way, that the user can easily remember it.* Allowing him to do multiple steps at once rather than having interruptions aids in a positive assembly experience.
2. *Use precise wording.* Leaving room for interpretation may lead to confusion and therefore words, such as “often” should be avoided and replaced by an exact number, e.g. “five times”.
3. *Indicate consequences.* Giving the user a reason to take the instructions seriously will lead to a higher success rate as users will follow the instructions more closely.
4. *Write what you do, before when to do it.* Conditional sentences should be structured in such a way, that user first understands what he must do before when he must do it. It is easier to process.
5. *Write sentences in an affirmative way.* “Extinguish cigarettes” is more effective than negative instructions, such as “Do not leave cigarettes lighted”.
6. *Structure the text.* Structuring the text makes it easier to read and indicates what the user can expect.

To increase the readability when having written the text, one should check for unnecessary content and words and leave them out. Also, replacing difficult words with common words and splitting sentences increases readability.

6.1.2 Software for Instruction Graphics

With reference to state of the art (section 2.2), further research has been conducted on industry standards and possibilities for tools of realization of illustrated DIY instructions. Multiple approaches and software have been found that will be evaluated based on availability, experience of the author, sufficiency of functionalities for the purpose and sustainability, meaning whether the alteration of instructions will be simple or whether it requires a long process.

Based on Wright, instructions are continuous and need to be updated when the product is being altered [86]. Therefore, a sustainable method must be determined that allows easy access to alteration. Two approaches have been found influencing the sustainability of the instructions. One possibility is using photographs as a reference and drawing over them to create line-art images of the set up [92]. The second possibility is to 3D model the components and use their renders [93]. In contrast to drawing, 3D models are continuous and can be easily changed in the future. Additionally, not all images have to be photographed and re-drawn, but only have to be rendered according to the new set up, being less time-consuming. Therefore, the latter is considered more suitable, as the instructions are made for a first generation SRB and will be subject of alteration in the future. This means, that for this purpose 3D-models will be used. These models can either be modelled using a 3D-modelling software or 3D-scanned using the real object.

In contrast to 3D modelling, 3D scanning is more convenient as it saves time and does not require a lot of expertise in 3D-modelling programs for complex shapes. This approach has been tested with accessible technologies such as the phone application Qlone [94] and an Xbox 360 Kinect [95]. However, while Qlone did not deliver satisfying results due to wavy surfaces of the scanned objects, the Xbox 360 Kinect proved to be precise a. Nonetheless, it did not recognize elements that were smaller than 50x50cm. Since the objects to be scanned are relatively small, 3D scanning using the Xbox 360 Kinect is not possible. Therefore, a 3d-modelling software must be determined that is suitable for modelling the components.

Research on different 3D modelling software has been conducted. Industry standards such as Autodesk Autocad, Autodesk Fusion 360 [96] and Solidworks Composer [97] have been found. A simplified version of Autocad called Autodesk Tinkercad [96] has also been examined, as the author has no experience with

previously mentioned programs. Other than that, Autodesk Maya [96] has also been included due to the author's experience. Each software has been examined based on availability, author's experience and the sufficiency of functionalities for the planned purpose (see table 6.1). The result shows that Autodesk Maya is most suitable, as it fulfils all requirements and therefore will be used for modelling the components.

Program	Availability	Author's Experience	Usability	Result
Autodesk Autocad	Yes	None	Sufficient	++
Autodesk Tinkercad	Yes	Little Experience	Insufficient	+
Solidworks Composer	No	None	Sufficient	+
Autodesk Maya	Yes	Experienced	Sufficient	+++
Autodesk Fusion 360	Yes	None	Sufficient	++

Table 6.1: 3D-modelling software comparison.

6.2 Decomposition of Final Concept

As it has been described in the functional architecture, the instruction manual consists of several components that need to be realized. These are general information on the SRB, the assembly instructions and the maintenance. As the manual is based on the product Jeroen Waterink is developing, the content has been planned in collaboration. Furthermore, the information in the information section has been provided by Hendrik-Jan Teekens, the representant of the municipality of Enschede. The decomposition of the final concept elaborates on what and how the instruction manual components will be realized.

6.2.1 Information

The introductory information text has been provided by the municipality of Enschede and was written by Hendrik-Jan Teekens. This text will be accompanied by an infographic explaining the concept of the SRB, as can be seen in figure 6.2.

"Enschede redesigned the urban water management in order to become a climate resilient city that is sustainable, liveable and profitable on the long term. The city's climate strategists work on projects to make the city climate proof. One of these projects is the smart rainwater buffer (SRB). A system the University of Twente worked on to answer the questions: "Can we buffer water before it comes into contact with waste water in the sewerage system?" and "Can we buffer the rain in the location it falls to prevent it from streaming into the sewerage system?". As one of the first owners of the SRB, you are amongst the

first inhabitants that help fighting the climate challenge allowing the UT to answer this question with a "Yes!". Have much joy collecting and using clean water for any purpose you like utilizing the SRB."

Furthermore, information on the SRB dashboard and the availability of online instructions will be provided to engage the user visiting the SRB website. The information on the dashboard contains screenshots of the dashboard and promotional text to engage the reader visiting the SRB website.

It will say "*Maintain your own SRB dashboard and track your performance*", as well as "*Track your performance*!", "*Compare yourself to others*" and "*Reminders to maintain your SRB*". Next to the functionalities of the dashboard, it will also be indicated, that there is an availability of online instructions: "*Find the instruction manual and an instruction video online*!"

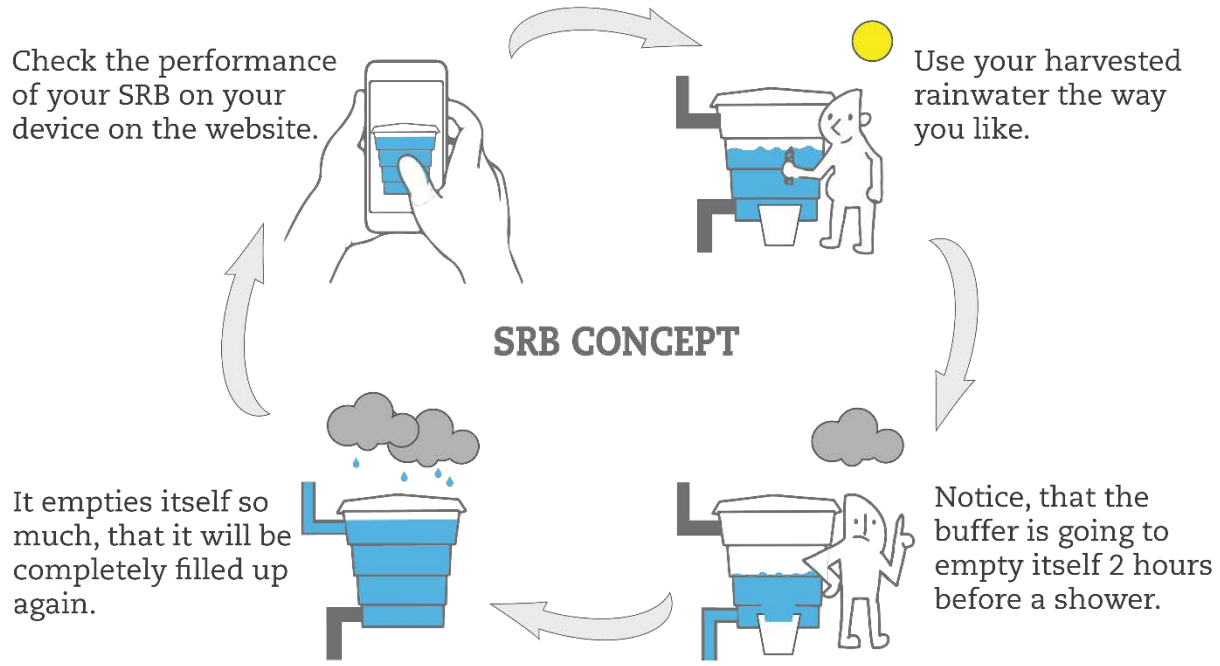


Figure 6.2 Explanation of SRB concept in an infographic.

6.2.2 Assembly Instructions

In collaboration with co-developer Jeroen Waterink, the instructions have been specified in terms of warnings, components, tools and the assembly process. Waterink provided a final component list that can be found in Appendix E. Furthermore, he indicated the tools to be used and explained the assembly. Latter was summarized in text and divided into single steps. The order was discussed and set based on convenience for the user. Each step will receive an own explanatory illustration.

Safety:

As the assembly of the SRB by oneself may lead to injuries, the user must be made aware of the fact that it is advised to assemble it with a friend. Furthermore, as the SRB includes electronics, the user must make sure that everything is dry before assembling it to prevent danger. Instead of utilizing text to convey this information, illustrations will be used as safety measures must be understood despite language barriers.

Tools:

For the assembly of the SRB, three tools are necessary that are not provided in the DIY-kit but need to be arranged by the user himself. It has been agreed upon during the first decision-maker interview (Appendix B) that the user can be expected to possess or have easy access to these tools. These are a *hole saw (size 90mm, 40mm, 25mm)* and *a knife*, to prepare the barrel for the assembly.

Instructions:

The assembly process can be divided into multiple steps. Each step will be described in text and accompanied by one image that visualizes the procedure. The images consist of illustrations that emphasize the relevant aspects in a simplified manner. While each step will be illustrated in a close-up, an overview image will also be used to support the assembly process. The steps that have been listed together will be on one page and have one overview image.

1. Find a suitable spot to place your SRB. Make sure that it is close to a downspout and that the area is level. In case it is not, use an underlay for the base to make it level. Now prepare your hole saw. In total, you must make six holes.
    b. Drill two holes next to each other for the in- and outlet in the upper area of the side facing in the direction of the downspout (90mm).
    c. Drill a hole in the lid for the sensors (90mm).
    d. Drill a hole in the bottom of the barrel (40mm diameter).
    e. Drill a hole for your tap on the lower centre on the front of your barrel (25mm).
    f. Drill a hole for your outlet on one side of the base you prefer it to be (25mm).
    g. Extend one of the existing holes in the base using a knife.
2. Extend the hole using a knife.

3. Place the two large rain pipe connectors inside the holes drilled in the upper side of the barrel. Make sure that the rubber is placed inside the barrel.
4. Screw on the tap in the drilled hole.

5. Place the valve connector in the hole in the bottom of the barrel. Make sure, the rubber is on the inside and screw it on.

6. Wrap the Teflon tape tightly around the valve connector. Make sure to wrap it clockwise.
7. Screw the valve onto the valve connector.

8. Put the hose through the holes you made in the base.
9. Add a hose clamp to the hose without tightening it yet.
10. Connect the hose connector to the hose and tighten the hose clamp.
11. Screw the hose onto the valve.

12. Screw the sensor unit on the lid.
13. Route the cable via the backside of the barrel. Connect it to the control unit. Connect the valve-cable to the control unit.
14. Place the barrel on the base and put the lid on. Plug in your SRB to the grounded power socket and set it up.

Set-Up:

The set-up can be started when the SRB is connected to a power-source. A device that can connect to the internet must be used, a smartphone or a laptop for instance. A connection to the network “SRB” is made which redirects the user to a screen that allows him to set-up an internet connection between the SRB and his private Wi-Fi. Both screens will be included in the instruction manual.

6.2.3 Maintenance

The components were chosen to minimize the required maintenance for the user. Therefore, only two aspects must be specified in the manual. They will be accompanied by a representative image.

Downspout Filter:

The nylon filter must be cleaned every quartile of the year. It can be done by removing the filter and cleaning it to be able to re-use it or one can dispose it and use a new filter. Four filters are included in the DIY-kit. Others can be bought at the local hardware store.

Outlet:

The user is not obliged to maintain the outlet. However, as the groundwater levels change depending on the time of the year, the user may be interested in placing the outlet in his garden when the ground is dry

(April – October) and placing the outlet in the sewerage system when the ground is wet (October – April). This prevents flooding during wet conditions and supports keeping the ground moist during hot weather conditions.

6.3 Final Design

Having researched best practices and incorporated the requirements set by stakeholders, the design of the instruction manual has been developed in two iterations and will be presented in this section. According to the model of design process by Felker [86], a first evaluation by a professional must be conducted on the first draft of the instruction manual. This process is used to identify large problems from a design-perspective, which must be resolved before developing and evaluating the final envisioned product with users from a usability-perspective. A professional was approached and asked for feedback to avoid technical mistakes and problems as well as improve the current design. Using the provided feedback, the design was finalized in a second iteration.

6.3.1 First Iteration

The feedback session on the first draft of the instruction manual was conducted on 15th of June with Chris Vermaas. He was chosen due to his expertise in visual communication and experience in graphic design. The session was structured in such a way that a print of the draft manual was presented, and the expert has given suggestions on potential improvements for each page. These will be summarized with reference to the presented material. The draft design can be seen in the figures 6.2 – 6.5 including the notes of the expert on how to improve certain aspects, that will be incorporated in the final design.

Information (see figure 6.3)

- The size of the section title should be increased and be very large. Decency is not necessary, it must be visible.
- The red box should not include the title but a quote from the information-text.
- The title should be moved above the text.
- The upper border of the red box can be aligned to the red element on the right side, so a “graphical moment” is created that looks visually appealing and connects the pages.
- The infographic should be redrawn in such a way, that it fits the rest of the manual and does not look crowded anymore.

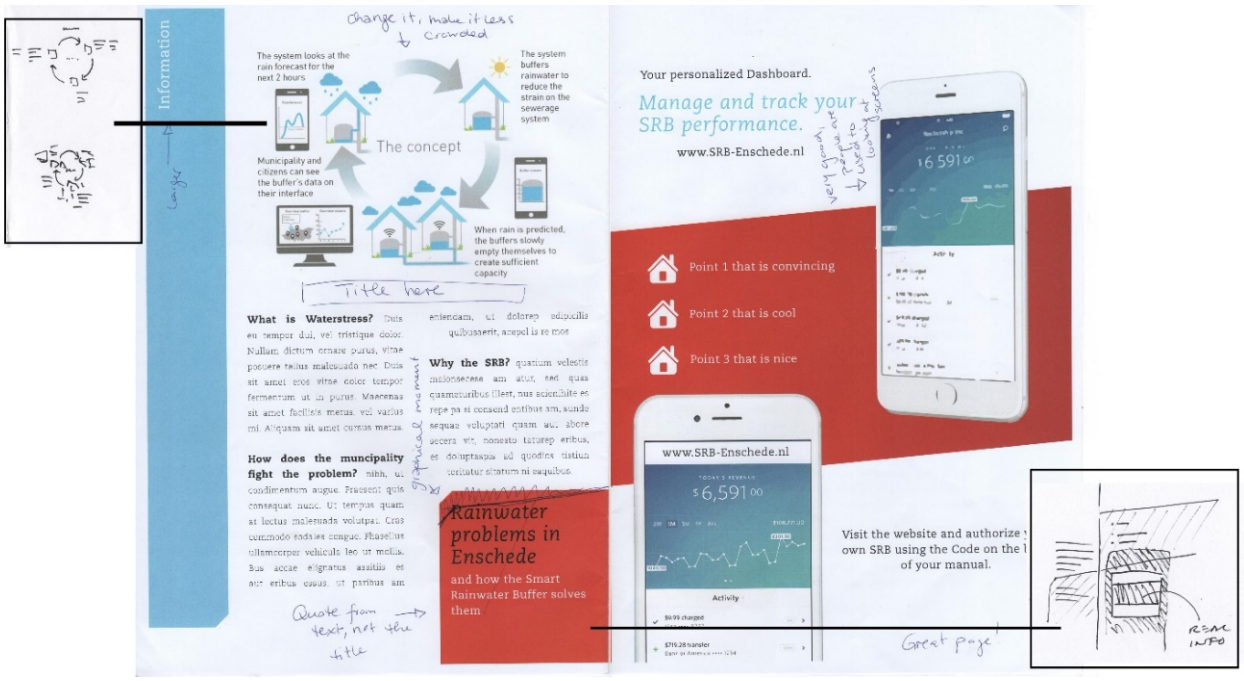


Figure 6.3 Information section in first iteration design.

Warnings (see figure 6.4)

- The red boxes make sense in terms of the corporate design but do not look visually pleasing as they fill up the page very much and overwhelm the user.
- Must be more decent, perhaps use IKEA [31] as a reference for safety and component-list.
- Text should be aligned to the left to be easier to read.

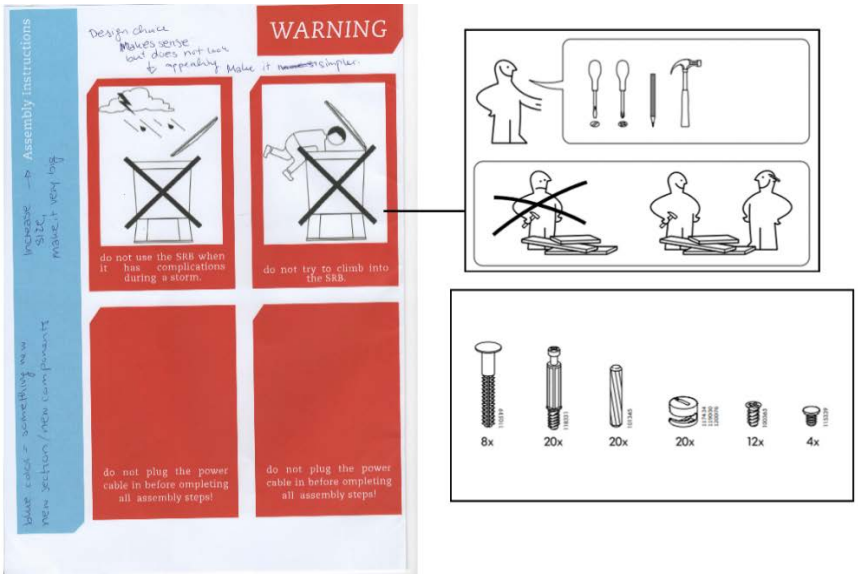


Figure 6.4 Safety and Components section in first iteration manual.

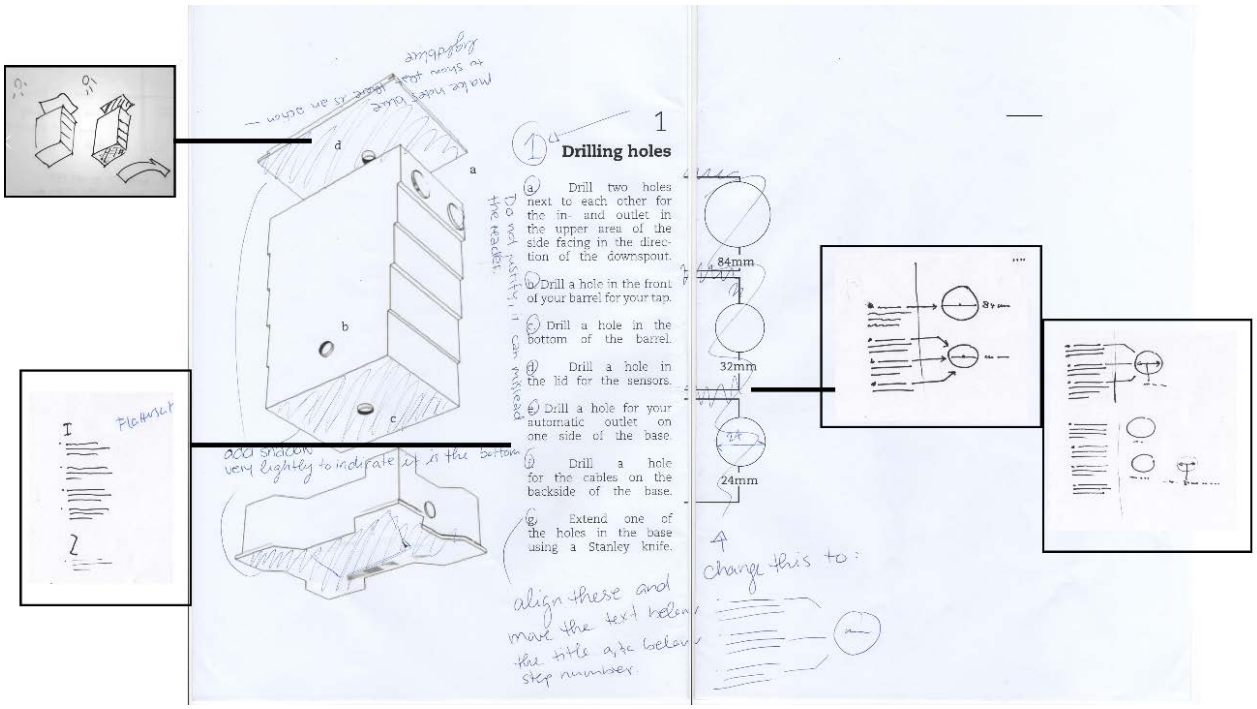


Figure 6.5 Drilling holes assembly description first iteration.

Drill Holes (see figure 6.5)

- Use shadow to show that the overview image is a bottom view. Use a shallow grey that does not interfere with the rest of the picture.
- Colour the holes in blue to be consistent with the other steps.
- Format the text, so it is left-bounded. This guides the eye of the user as it keeps the same space between words and lines. It is a functional text and does not have to be aesthetic.
- Put the step numbers on the left side of the title.
- Put the alphabetical order below the step number and the text below the title to be easier to read.
- Change the indication of the hole saw size by using lines that point to the circle from each paragraph.

Step 2 – 4 (see figure 6.6)

- Use flat arrows. They are appealing and do convey spatial information more effectively.
- Elements should also align to the overview image on the left, so the tap and the valve connector image must be swapped.

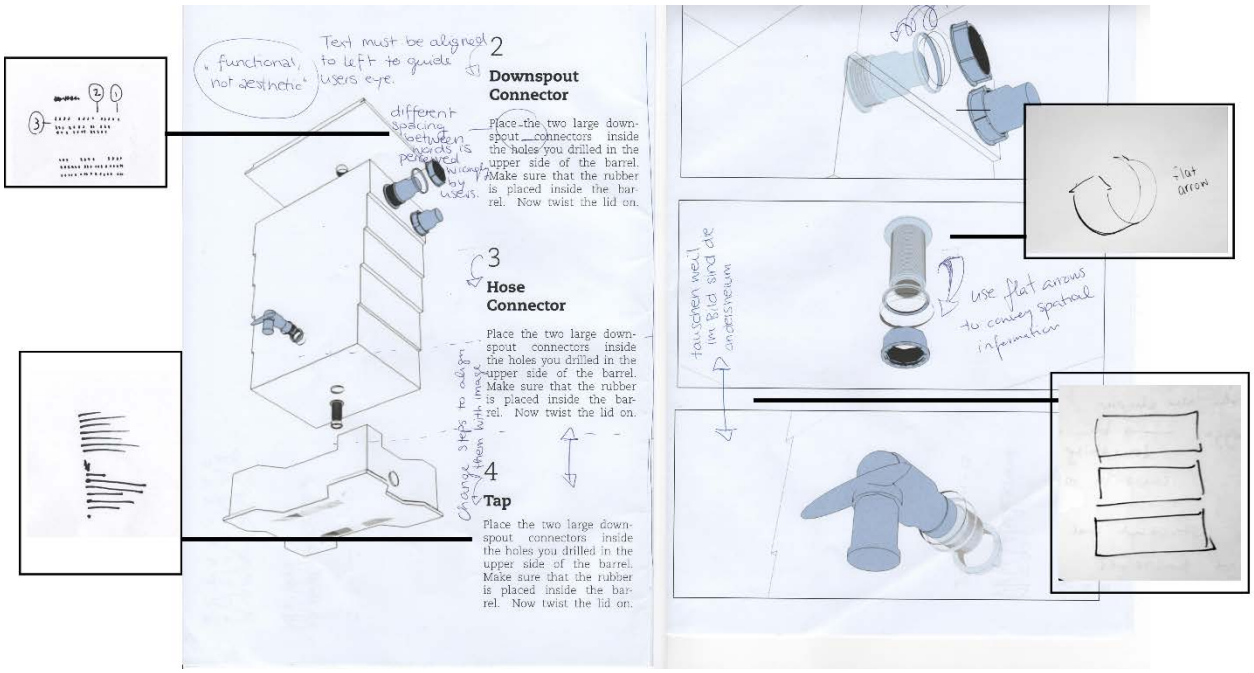


Figure 6.6 Step 2-4 assembly instructions first iteration.

6.3.2 Second Iteration

The second iteration of the assembly manual has incorporated the professional's feedback and changed the lay-out accordingly. The instruction manual is presented and related to the requirements to justify the design decisions made on appearance and content. All requirements related to the instruction manual have been processed in the design. The manual is divided into four sections: information, assembly instructions, set-up and maintenance (*requirement 18*). Additionally, there is the front- and backside of the manual. It has been printed in colour on A5-sized paper (*requirement 24*).

Information Section

The information section (see figure 6.7) contains information on rainwater problems in Enschede and an infographic on how the SRB works (*requirement 4, 32, 34*) making assembly more engaging due to the motivational words of being part of improving life quality in Enschede (*requirement 30*). The right side covers information on the dashboard, on how to access it and what the benefits are (*requirement 5, 15*), also indicating that there are online instructions (*requirement 12, 13*). The colour scheme and font choice are based on the corporate design of the municipality (*requirement 21*).

Figure 6.7 Second iteration on information section.

Assembly Instructions Section

The assembly instructions section begins with a visualization of the necessary tools and safety measures (*requirement 7*) that need to be taken into account before the assembly, which can be seen in figure 6.8. It is advised to assemble the SRB with a friend (*requirement 14*) and to make sure that it is dry outside. Other than that, images of the components included in the DIY-kit are provided alongside their quantity (*requirement 2, 3*). The lay-out is similar to the IKEA-presentation [31] of safety measures and component-lists, as it was advised by the expert. The titles are placed in a red box in the bottom right corner of each page (*requirement 21*).

This is followed by the assembly steps (see figure 6.9-6.14), consisting of illustrations made in the 3D-modelling software Maya (*requirement 20*) that have the same lay-out on each page to lower the cognitive load of the user. The overview image on the left is used to indicate where the new components (highlighted in blue) are supposed to be placed, whereas the right side shows how the component must be assembled (*requirement 1*). To make the actions clear, flat arrows are used to convey movement and spatial information. Additionally, the steps are explained using text (*requirement 19*). The text is written in a simple style and aligned to the left to be more readable for the user. The serif font also aids in the comprehensibility and the size of the font is 10px to guarantee readability (*requirement 23*).

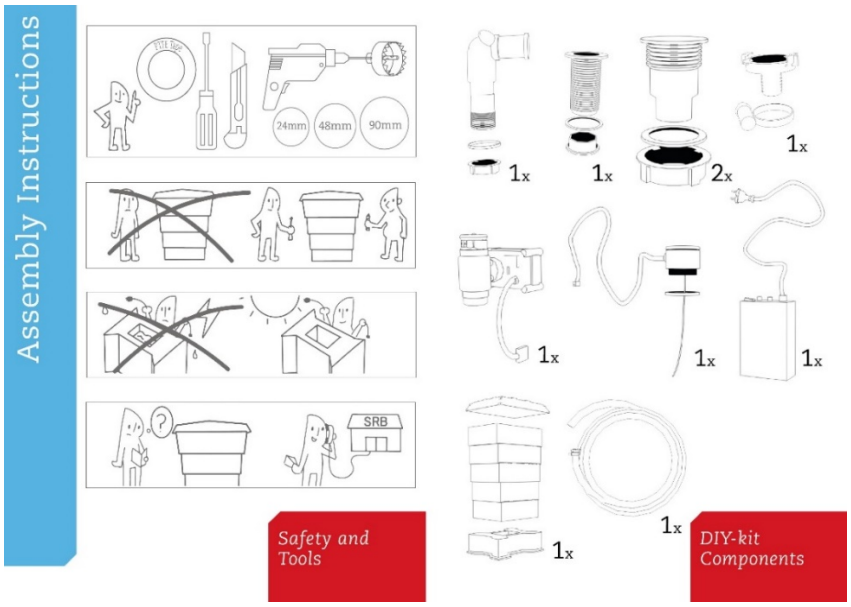


Figure 6.8 Second iteration on safety, tools and component list.

Set-Up Section

The set-up section (see figure 6.14) has the same style as the other assembly images. However, the overview image shows a finished SRB and the close-ups were replaced by phone mock-ups that show the screen the user will encounter when connecting his SRB to the internet.

Maintenance Page

The maintenance page (see figure 6.15) utilizes images that have the same fashion as the infographic in the information section and the safety measures in the assembly section to show consistency. They are accompanied by text describing how to maintain the filter and the outlet (*requirement 6*).

Front and Back

The front shows an illustration of the completed SRB, the title, the corporation of the municipality and waterboard (*requirement 22*) and the quote “Made by Holland” (*requirement 8*). The back contains contact information for further support if the instructions are not sufficient (*requirement 9*). Both can be seen in figure 6.16.

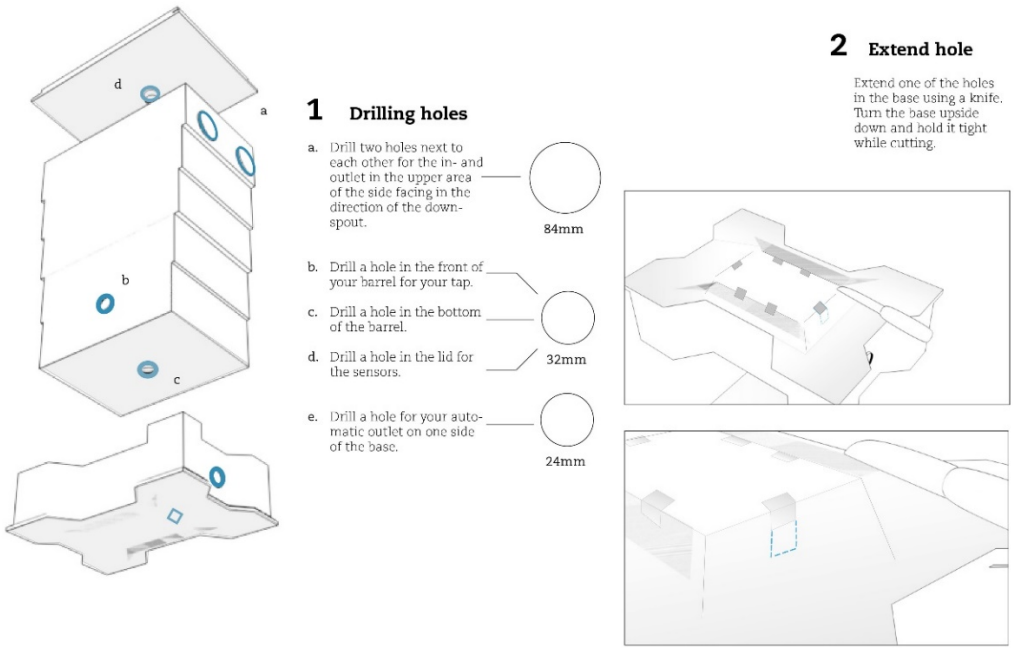


Figure 6.9 Final Design of first Assembly Page.

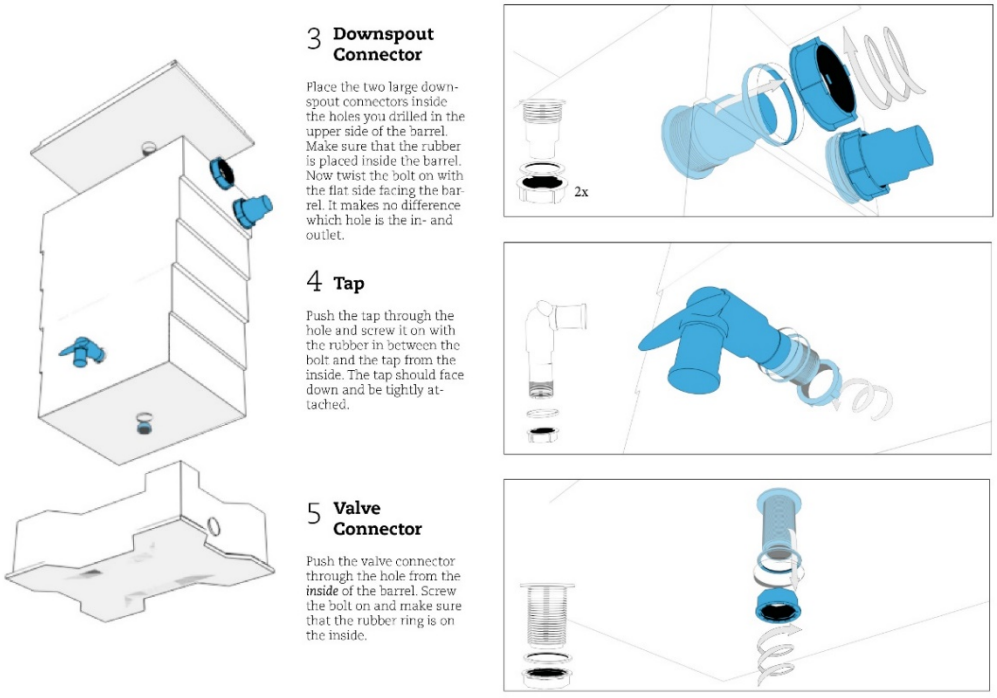


Figure 6.10 Final Design of second Assembly Page.

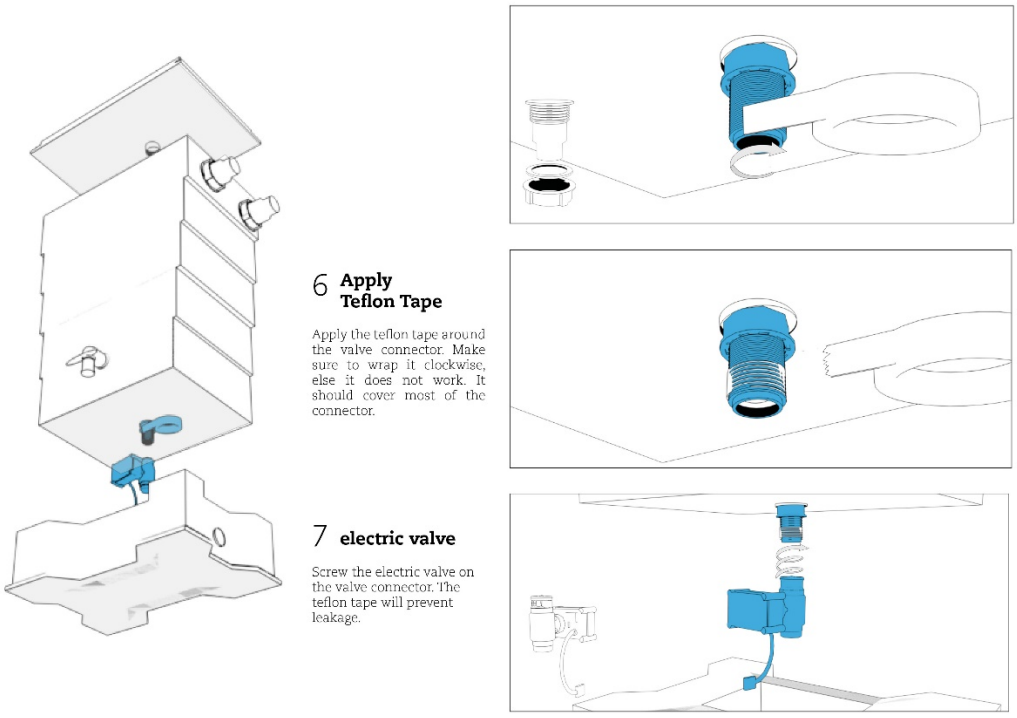


Figure 6.11 Final Design of third Assembly Page.

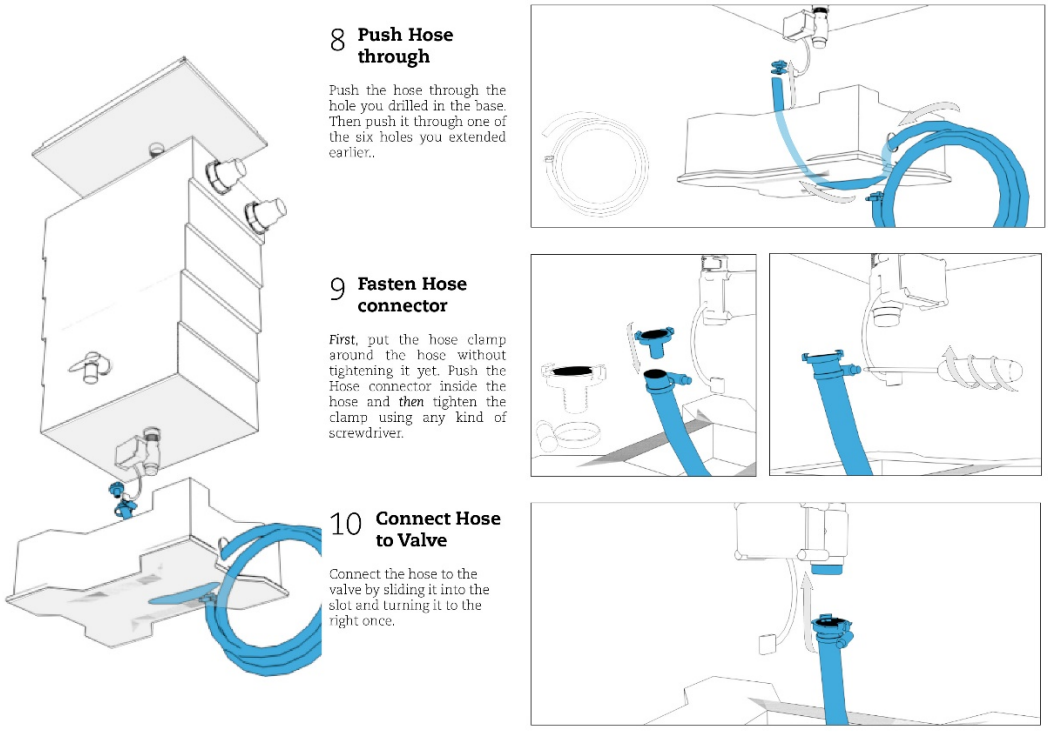


Figure 6.12 Final Design of fourth Assembly Page.

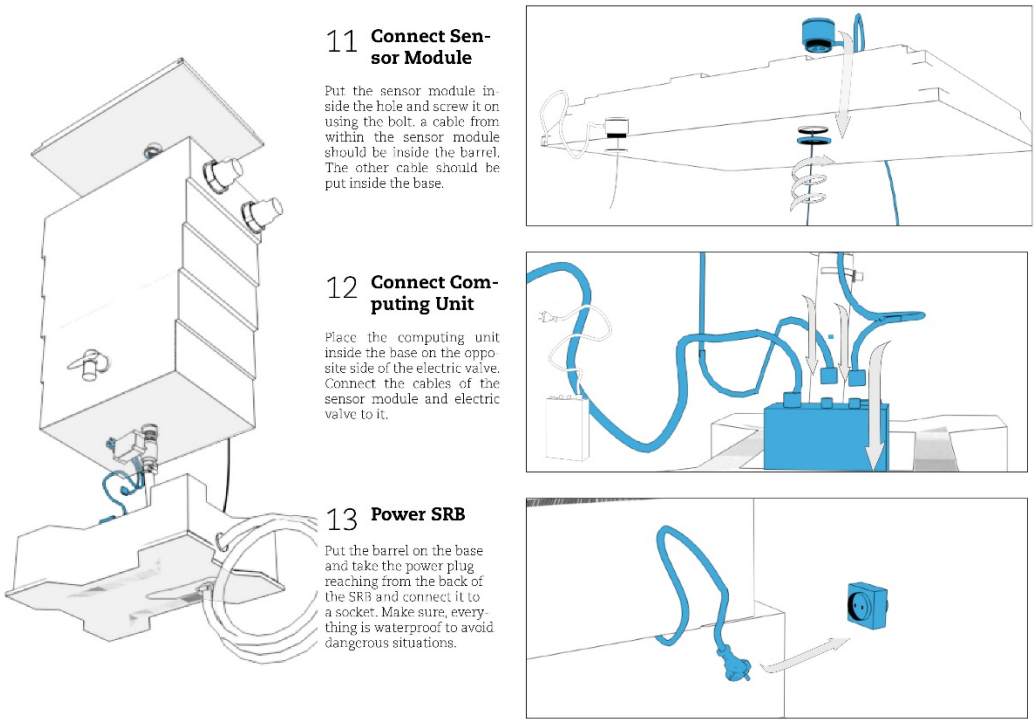


Figure 6.13 Final Design of fifth Assembly Page.

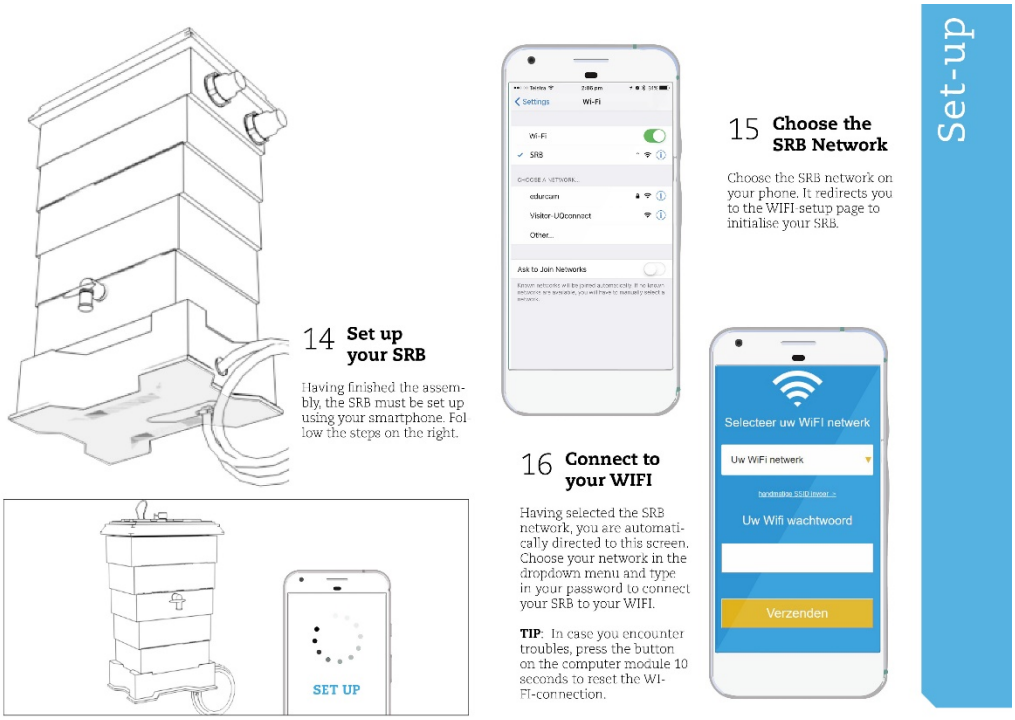


Figure 6.14 Final Design of Set-Up Screen.

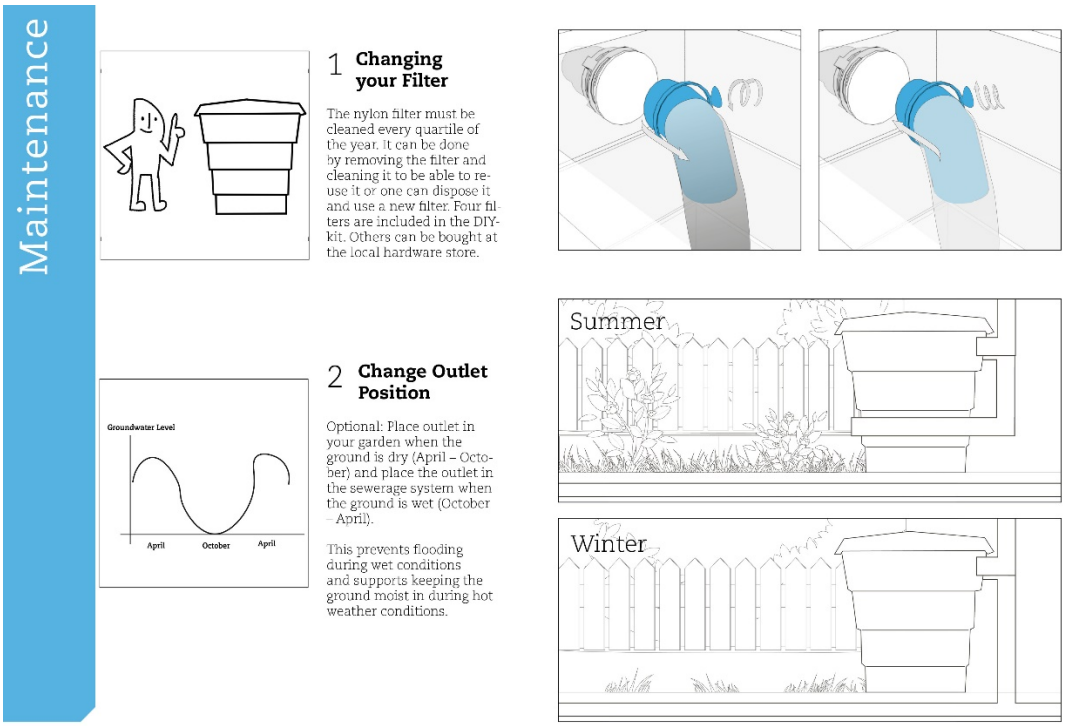


Figure 6.15 Final Design of Maintenance Page.

Figure 6.16 Final Design of front and back page.

7 Realisation: Expert Opinion Video

Similarly to the realization of the instruction manual, this chapter presents the developed expert opinion video and elaborates on design decisions that have led to the final envisioned product. This means the preparation, execution and final design of the realisation of the expert opinion video.

7.1 Tools and Methods

To film a convincing and appealing video, different aspects must be considered. Three stages of filming can be distinguished: pre-production, production and post-production [98] each having their own guidelines that have been compiled in this section.

7.1.1 Pre-Production

The pre-production covers the preparations of a well-organized shoot in terms of the right equipment and creating a script as well as a storyboard.

Equipment:

The choice of equipment determines video- and sound-quality. Therefore, the most suitable must be chosen. For low-budget filmmaking, as it is the case, the most relevant tools are a camera, microphone, tripod and light [99].

1. **Camera**: A DSLR camera is suitable for filming DIY-instructions.
2. **Microphone**: A wireless Lavaliere microphone can be clipped on the clothes and subtly record the experts voice in a better quality than the DSLR camera.
3. **Tripod**: A tripod allows steady shots.
4. **Light**: Lightboxes are an affordable option to produce sufficient light for shooting.

Script:

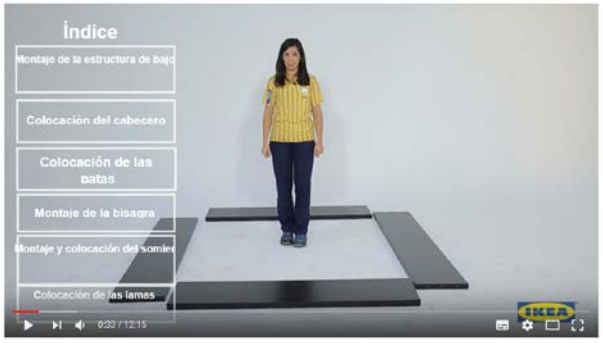
The script specifies what the expert does and says. It must be specified to keep track of what must be filmed to lead to a satisfying result including all necessary components [98]. The script should be designed in such a way, that the user appears to be authentic, have humour and wit [100]. Especially in instructional videos certain guidelines should be considered that aid in the user experience. The expert should preview the task and promote the goal before executing it for instance. When promoting tasks, the expert must show them in their context and provide procedural information, i.e. explaining the steps and showing them. The steps should be clear and simple to be easily comprehensible to the user [101].

7.1.2 Production

Examining examples of instructional assembly videos with an expert opinion, one can refer to the YouTube-Channel of IKEA ESPANA [35]. Looking at their videos, they use certain techniques to convey how to assemble their products. Their video about assembling the MALM bed has been examined and the techniques have been summarized below using a reference image. These techniques can be applied during the (post-)production phase to provide the necessary shots in order to convey information effectively.

Techniques for improved user experience in assembly videos [102]:

1. Presenting an Image of the final product.



2. Clickable table of contents to skip to required section.

3. Introduction of Expert with text written on screen.

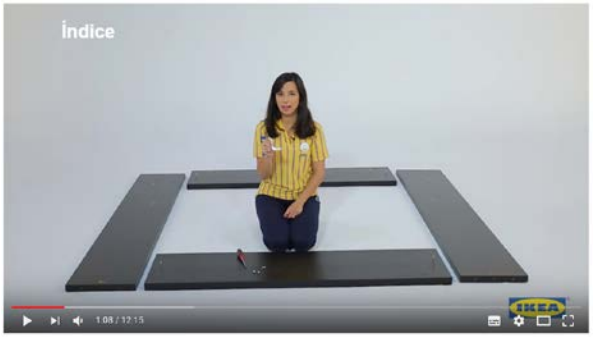
4. Compilation of tools and components.

5. Title image of chosen section.

6. Expert presents components of step.

7. Close-up of components that are referred to.

8. Close-up of tools that are referred to.



9. Expert interacts with components and shows how to assemble it.

10. Close-up of expert assembling the components.

7.1.3 Post-Production

The post-production edits raw shots produced in the production phase to create a video that is appealing to the audience [98]. This is done using the software Adobe Premiere Pro [74] as it is the industry standard for designers and provides all necessary functionalities to create an instructional video. However, other than the software, the length of the video and the background music must be discussed.

Length:

Based on research conducted by Wistia [103], the optimal video length is not longer than two minutes. With increased video-length, less people are watching the video until the end. But as it is no promotional video but an instructional video, other research proposes four minutes length [100].

Music:

Except the expert's voice, video also contains music. An example is the video by IKEA Espana [102]. Therefore, the right music must be chosen to achieve a friendly and inviting atmosphere. One moment where music should be chosen is the in- and outro [104]. These indicate the beginning and the end and give a first impression of the 'feeling' of the video [105]. Furthermore, music within the video should be

free from vocals [104] [105] and not compete with the person speaking on-screen but staying almost unnoticeable in the background [105]. In other words, no songs should be utilized but repeating rhythms are the correct choice [104].

7.2 Decomposition of Final Concept

In contrast to the user manual, the expert opinion video only includes the assembly process of the SRB and e.g. does not give information about the rainwater problems in Enschede. It consists of the same steps as specified for the manual (section 6.1.2). However, the presentation is different and will be elaborated on in a script and a storyboard. Also, the expert will be described more closely.

7.2.1 Expert

The expert assembling the DIY SRB will be represented by co-developer Jeroen Waterink. Considering that he has developed the SRB, he is qualified to represent the expert and has enough expertise to provide a useful expert opinion to the audience. Additionally, he can fulfil the requirement of providing this information in Dutch, as he is a native speaker. Since the video will be filmed in a garden, the expert's appearance must match the surroundings to radiate authenticity to be positively perceived by its audience [90]. Hence, Waterink will wear garden-work clothing in a similar fashion as can be seen in figure 7.2. His overall impression will be positive and enthusiastic to motivate and engage his audience to assemble the SRB with his assistance.

Figure 7.1 Work clothing by Engelbert Strauss. [89]

7.2.2 Storyboard

To elaborate on the script, the storyboard offers an overview of all sections that will be filmed and how they will be filmed. The storyboard can capture camera perspectives and the division of the screen, which the script cannot specify (see figure 7.1, 7.2).

Figure 7.2 Storyboard of Expert Opinion Video - Part I

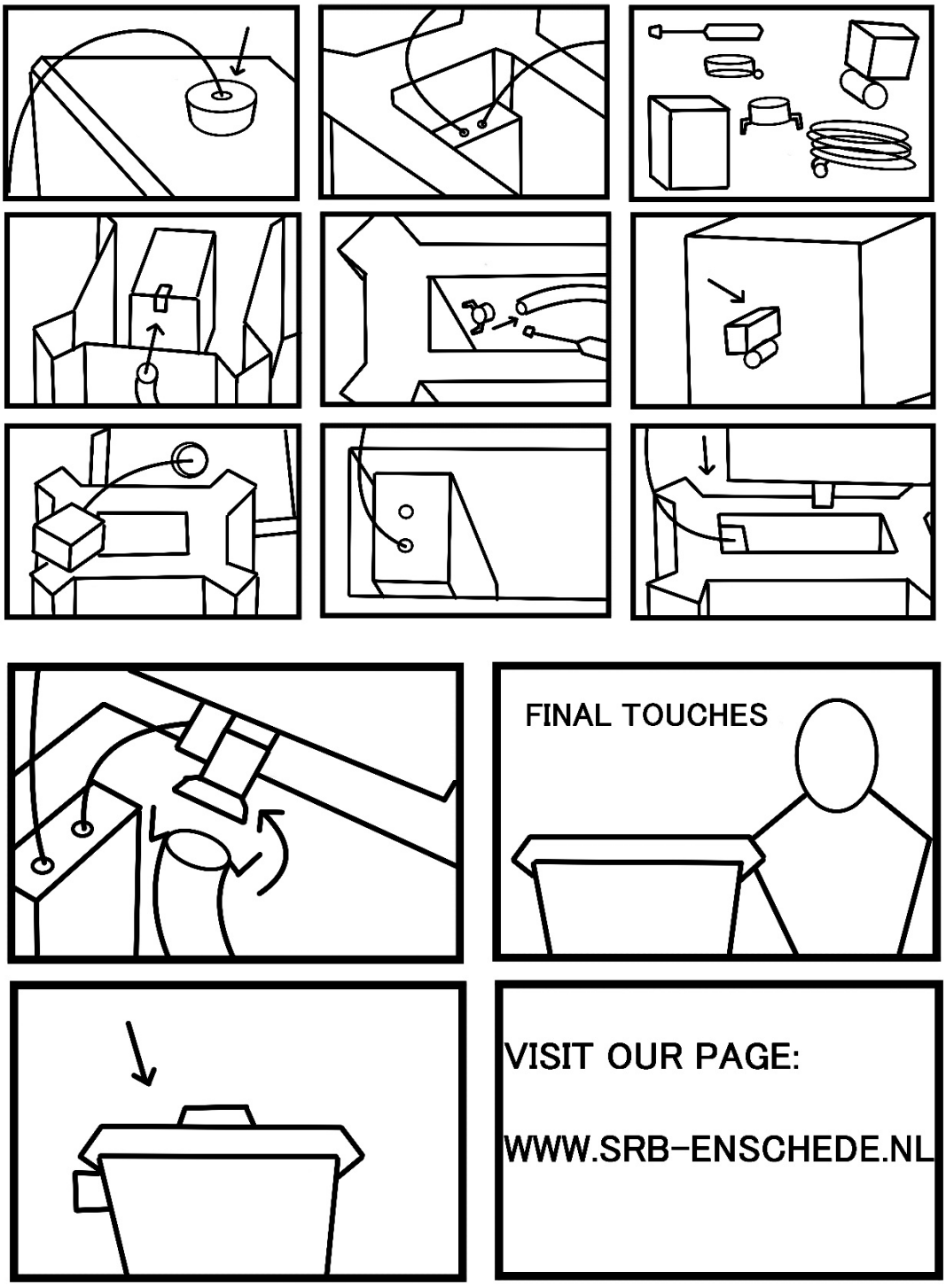


Figure 7.3 Storyboard of the expert opinion video – part II

7.2.1 Script

As the requirements have specified, the video will be filmed in a garden setting and each section will not last longer than four minutes. This means, the video will be divided into multiple sections with different focus to provide a clear overview to the user who then can decide to watch the sections that are relevant

to him or her. The script specifies what will be shown on the screen and what will be said. The full script can be found in Appendix F.

7.3 Final Design

This section describes the final video design justifying design decisions and relating them to the requirements. All requirements that have been specified were incorporated in the expert opinion video. The video can be watched on YouTube[1]. The expert opinion video has been filmed using a DSLR camera placed on a tripod for steady shots and a Lavaliere microphone to record the voice of the expert without noise. As it was set outside, it was chosen to film in the morning (9AM) until the early afternoon (3PM) to have sufficient light. The different scenes were filmed utilizing the previously prepared script and the way it was edited is based on the storyboard.

The instruction video is presented by an SRB-expert, co-developer Jeroen Waterink, who provides the audience with additional information the manual cannot provide (*requirement 26, 27*). The expert speaks Dutch and English subtitles are available for non-Dutch speakers (*requirement 10)*. He structures the explanations of a step in such a way, that he first shows what component to use, then indicates the purpose, and concludes by showing how it is assembled with an additional tip. The video includes each assembly step from the manual besides the set-up as it cannot be further elaborated on what is provided in the instruction manual.

In order to make the instructions more interactive and less time-consuming for the user, the assembly has been divided into four sections that each do not last longer than four minutes (*requirement 25).* Each section starts with a title screen showing a picture and the name of the section (see figure 7.4) and is followed by a list of components (see figure 7.5). With a voice-over, the components are enumerated, allowing the user to check whether he has all available. This is always followed by a shot of the expert who is about to explain, what the first step is.

The sections have not been divided based on the sequence of steps as in the manual but based on their themes, such as “Drilling holes”, “Preparing the holes”, “Make it smart” and “Final Touches”. Since drilling holes is a skill and not a sequence of tasks that must be explained, the manual does not include an

[1] https://youtu.be/6tTLIhLH8Xs and https://youtu.be/FCEhZ_4szC4

extensive explanation but only indicates where holes in what size must be drilled. Therefore, the expert opinion video provides the user with additional help in this section. The second section then covers the components that need to be placed inside the drilled holes before all components can be connected to each other, which is done in “Make it smart”. The assembly is finalized in “Final Touches” in which the audience is redirected to the instruction manual to set-up their SRB.

Figure 7.4 Video screenshot of expert Jeroen Waterink cutting the base of the barrel in a garden setting.

To convey authenticity, the expert communicates with the audience directly and only uses voice-overs when close-ups are utilized to demonstrate the assembly more visibly. His character is friendly and represents an authority due to his extensive knowledge and smooth assembly procedure. Additionally, he presents the instructions in a garden setting and wears a worker’s outfit to capture an authentic atmosphere (figure 7.2, *requirement 28*). This is supported by positive-tuned background music called “happy ukulele and fresh piano”.

Figure 7.5 Video screenshot of expert Jeroen Waterink cutting the base of the barrel in a garden setting.

Figure 7.6 Video screenshot of expert Jeroen Waterink cutting the base of the barrel in a garden setting.

8 Evaluation

Aim of the evaluation chapter is determining whether the functional requirements were incorporated and user-expectations are met. Functional requirements are evaluated using a functional test, determining whether the prototype is sufficiently developed for a user-test. Subsequently, the user test identifies issues in need of improvement to deliver a product wanted and appreciated by the user.

8.1 Functional Test

To determine whether all functionalities were incorporated, a functional test has been conducted. Utilizing the list of functional requirements, it has been determined which requirements were successfully implemented and which were left out. The functional requirements and their implementation can be found in table 8.1. Considering that each must-requirement has been met, the test was successful, and a user-test can be conducted.

Functional Requirement	Implementation
Must	
1. The instructions need to explain the steps a user should take for completing the SRB.	✔
2. The instructions need to list all the required components for completing the SRB.	✔
3. The instructions need to indicate all necessary tools for completing the SRB.	✔
4. The instruction manual must give information on water stress in Enschede.	✔
5. The instruction manual must indicate how to access the SRB website.	✔
6. The instruction manual must give information on the maintenance of the SRB.	✔
7. The instruction manual must include warnings to prevent potential danger the SRB could cause.	✔
8. The instruction manual must mention “Made by Holland”.	✔
9. The instruction manual must contain contact information for additional support.	✔
10. The language of communication must be English and Dutch.	✔

11. Alongside the instruction manual, video instructions must be offered.	✔
12. The instruction manual must indicate how to view the video instructions.	✔
13. The instruction manual must indicate how to view the instruction manual online.	✔
14. The instruction manual must indicate that it is recommended to assemble the SRB with two people.	✔
Should	
15. The instruction manual should give information on the dashboard.	✔
16. The instruction video should indicate that there is additional information in the instruction manual.	✔
17. The instruction video should show a link to the instruction manual PDF.	✔

Table 8.1 Functional requirements and their implementation.

8.2 User Test Protocol

The user test protocol is utilized to specify relevant aspects of a user test guaranteeing a smooth process and same conditions for each participant to avoid bias in the results. Purpose of this test is, to determine how the assembly experience is perceived by the user. The results will serve as a partly assessment on whether the envisioned product is a DIY-solution for every user that allows large-scale deployment, answering the research question of this thesis. A test of the user test protocol has been conducted prior to the final testing. It allows to iterate on the largest design-problems leading to a more detail-focused approach [76]. The documentation of the pre-test can be found in Appendix G.

The questions to be answered utilizing this user test are to confirm whether the envisioned product has met user-centred requirements compiled in the specification section, as well as whether the process of creating the envisioned product can be considered an answer to the research questions of this thesis.

1. Are the DIY instructions understandable? If not, what aspects need revision?
2. Are the DIY instructions suitable for all adopter groups?
3. Are the DIY instructions suitable for people without technical background?
4. Is the DIY approach engaging the users to purchase and assemble the SRB?
5. What is the average assembly time?

8.2.1 Test Setup

The user test will be conducted in the garden of the SmartXP, room A138 in Zilverling at the University of Twente. A disassembled SRB-DIY-kit, the instruction manual, a toolkit and a laptop with the instruction video on a table will be provided.

8.2.2 Participants

As the SRB aims on a large deployment in Enschede, each inhabitant of Enschede is considered a potential user. This means, that anyone who lives in Enschede and has a garden can participate in the user test. However, utilizing the theory of diffusion of innovation [84], certain criteria can be used to distinguish between the users. Therefore, participants will be categorized using a questionnaire (Appendix H). This will aid in investigating whether there is a pattern between or within adopter groups depending on whether enough potential users from each adopter group participate.

8.2.3 Interaction Method

The interaction method of the user test will be task-based interaction. However, only one task will be defined, which is “Please assemble the Smart Rainwater Buffer. You can find the manual on the table”, asking the user to use the prototype of the envisioned product in order to assemble the prototype of the SRB designed by co-developer Waterink. Although only one task is clearly defined by the observer, single tasks to complete the SRB are summarized in the prototype of the envisioned product. The user is free to use the printed instructions, watch the expert opinion video or do both. The observer will not interrupt the participant in case he or she is making mistakes. Only in case that the test cannot be continued without additional help, the observer will assist the participant with the next step, in the way a step is defined in the instruction manual.

8.2.4 Data Collection Method

Throughout the user test, quantitative and qualitative data will be collected. Qualitative data will be collected using the concurrent thinking-aloud method, observations and a questionnaire. The process of assembly and impressions by the user need to be captured to understand whether he or she has a positive experience in terms of feeling confident in conducting the assembly and understanding the assembly steps. Quantitative data will be collected by measuring the duration of the assembly using a stopwatch and checking whether steps were executed correctly, as well as which instruction method was used.

8.3 User Test Results

The test was conducted on 21st and 22nd June 2018 with each five participants. Results of the questionnaire on adopter groups showed, that four participants belonged to the group early majority, four to the group late majority, one to the early adopters and one to the laggards. The participants do all live in or around Enschede and have an interest in gardening, climate change and/or the rainwater problems in Enschede. They were asked to assemble the SRB DIY-kit and have been handed the interaction device, i.e. the user manual. The test was stopped after ten participants as no new insights were documented and most of the problems were identified [76].

8.3.1 Quantitative Data

Different aspects have been measured to draw conclusions on the interaction with the envisioned product. The results of table 8.2 were collected utilizing a survey. The time was stopped using a stopwatch. It started when the user opened the manual and was stopped when the barrel was put on the base.

Participant	Video (1) or Manual (2)	Most Difficult Step	Most well-explained Step	Number of Mistakes	Noticed Video Instructions?	Difficulty of Assembly (1-5 most diff.)	Remembered safety measures?	Would purchase SRB?	Time
# 1	1	13	6	0	Yes	1	No	Yes	16:56
# 2	1	9	3	1	Yes	2	No	Yes	20:52
# 3	2	13	3	0	Yes	2	Yes	Yes	15:32
# 4	2	9	3	3	No	1	No	Yes	30:19
# 5	2	13	3	2	Yes	2	No	Yes	35:39
# 6	1	13	3	0	No	2	No	Yes	25:22
# 7	1	13	3	0	Yes	1	No	Yes	23:03
# 8	2	12	8	2	Yes	3	Yes	Yes	19:57
# 9	2	5	6	2	No	2	No	Yes	14:17
# 10	2	Identifying Components	5	1	No	4	No	No	21:24

Table 8.2 Functional requirements and their implementation.

Data based on the number of mistakes was collected using observations. It has been observed which steps led to mistakes and whether the user recovered from those or did not know that he has made a mistake. This has been divided in instruction methods to receive a clearer insight on potential design problems of each (see table 8.3).

8.3.1 Qualitative Data

Qualitative data was collected using observations and the concurrent thinking aloud method. The data was colour-coded in order to identify what instruction-method the user utilized (light blue), what mistakes were made (red), whether the user recovered from these mistakes (orange), if aspects that could be

improved were noticed (dark blue) and when positive feedback was given (green). General thoughts were marked in grey. The participant was categorized in an adopter group based on his survey results that is indicated below the participant number, as well as gender and age.

Step # based on Manual	Number of Mistakes		Recovery	
	Manual	Video	Manual	Video
3	3	2	0	2
4	2	1	0	1
5	0	1	0	1
6	0	0	0	0
7	0	0	0	0
8	2	0	1	0
9	0	1	0	1
10	1	0	0	0
11	1	2	1	1
12	2	0	0	0
13	1	0	0	0

Table 8.3 Compilation of number of mistakes and recoveries during assembly collected using observations.

Participant 1 (16:56)

(Male, 36-45 years, Late Majority)

- The user takes a look at the manual.
- He decides to watch the video.
- While watching, he checks whether the mentioned parts are there.
- He pauses the video and takes the downspout connectors and puts one through the hole.
- He resumes the video and realizes that he put the first one wrongly, as he did not take the ring.
- "This should have been indicated earlier and not so late"
- Then he corrects his mistake and watches the video further.
- He looks for the tap and takes it. He pauses the video and connects it. Calls it the same as in the video as it helps him to distinguish between electric valve.
- Then he takes the electric valve connector but needs to re-watch the part of the video.
- He pauses it and connects it correctly.
- He does not like the fact that you must crawl into the barrel to attach components.
- Then he resumes the video. Jeroen did not get to the point of the next step fast enough and therefore the participant wants to check the printed instructions. However, before being able to open them, Jeroen explained the next step.
- He takes the sensor module but places it the wrong way. He realizes that he has made a mistake and recovers from it.
- He puts the cables through the backside of the base. "The cables are not nice. It feels like they do not have their own space designed for them but are just hanging."
- He watches the video and puts the hose inside the base as explained.

- He connects the cables correctly and asks the observer for support in putting the barrel on top of the base.
- "I liked the video a lot. You have a real-life reference making it easy to relate to and understanding what you have to do. It was well-explained."

Participant 2 (20:52)

(Female, 36-45 years, Laggard)

- The participant looked at the manual.
- She decided to watch the video as she thinks itis easier than looking at the images. It makes her feel more confident.
- Watches the video and starts with taking the downspout connectors.
- She stops the video and puts the connector and rubber inside but screws the bolt on wrongly.
- She continues watching the video, pauses it and corrects it.
- She takes the electric valve connector and looks which bolt is correct. First takes the wrong component but then takes the correct one and connects it.
- She does not appreciate the fact that she has to get inside the barrel.
- She forgets about the tap and wants to continue with next step. Then she sees it and remembers that she must connect it.
- She has difficulties connecting it. Asks for assistance as "it does not work. It needs two people."
- Receives assistance from observer. Holds the tap while she screws the bolt on.
- Then she continues watching the video. Pauses it to put the Teflon tape on the electric valve connector.
- She continues video and watches how the hose has to be put twice. Then puts the hose inside the base.
- She continues the video and looks for the sensor module. Does not understand that it has to be put through the hole and screwed on. Needs interference from observer.
- She puts hose connector but forgets to put the hose clamp first. She sees it and takes the hose connector off to put the hose clamp.
- Then she continues the video and connects the cables to each other.
- She asks for assistance and puts the barrel on the base.
- "This also needs two people. It is not too hard because the video is very good, but you can't do it by yourself."

Participant 3 (15:32)

(Female, 19-25 years, Early Majority)

- Starts with reading the manual.
- Skips the information part. Only looks very shortly at the safety measures and component list.
- She reads the text first and then she looks up where the components are. Does not know what is meant by "downspout connector" and tries to find it. As she realizes that it is not written anywhere, she looks at the images on the right and knows what the downspout connector is.

- Attaches the downspout connector correctly to the barrel.
- Then she reads and checks the images. She finds the tap but does not know where the bolt is. She does not realize that the bolt is already attached to the tap.
- When she found that no other component did fit, she examined the tap and found that the parts were already attached. "I should have realised this since it was the same for the downspout connectors"
- She thinks a while about where the rubber must be but then puts it the correct way as it was different than with the downspout connectors. Also, "the text was not well explained".
- Then she attaches the valve connector and tap correctly. She looked at the images and did it after each other. "It is all basically the same."
- She looks at the images and adds the Teflon Tape the required way.
- She then screws the electric valve on.
- In the next step she has troubles putting the hose through the base. She does not know where is the top and bottom but eventually she understands.
- She puts the hose clamp first and then the hose connector. Then she tightens it using the screwdriver.
- She encounters difficulties when attaching the hose to the valve. "I know how to do it but I am not getting it on." So she explained it and the observer assisted.
- Afterwards she looks at the text and image and connects the sensor module correctly.
- The same for the computing unit. She puts it in place and connects it.
- However, she needs assistance when putting the SRB on the base. "I cannot do this by myself"

Participant 4 (30:19)

(Male, 19-25 years, Early Majority)

- Uses manual.
- Reads information page first.
- Checks whether all the tools are there using the components list.
- Reads the first step and wants to know what the downspout connector is. Searches for it through the manual but only knows it when he looks to the right.
- Re-reads the text to make sure he understood everything. Then attaches the downspout connector correctly.
- Then attaches the electric valve connector without further complications.
- Reads the instructions on the tape and asks "Does it matter from which side you start attaching the tape?" This should be indicated.
- Afterwards he attaches the valve.
- Always reads the text first and then compares it with the images.
- Does not understand how to put the hose. Needs assistance of the observer.
- Then he continues following the steps. He asks himself why the image (10) looks different than the reality.
- Takes the wrong side of the hose to connect it to the valve.
- Does not know which hole is meant in step 11. It should be said that it is the lid.
- I was looking for a label with computing unit. Took the computer unit and had doubts.

- Does not know how to connect the cables to the computer unit. Mixes up the base with the barrel and thinks it needs to be put inside the barrel. Receives further explanation on terms "base" and "barrel" by observer.
- Then he does everything correctly.

Participant 5 (35:39)

(Male, 56 years or older, Late Majority)

- Reads the manual carefully. Wants to use the manual and not the video.
- Checks whether all components are there but has few minor difficulties in locating parts.
- He follows the step by reading the title first and looking at the images. Only sometimes he reads the whole text.
- "You should put numbers on the left and right image to indicate that they belong to this step. That makes it easier to understand where is what."
- "Image 5 has a mistake. The bolt is placed upside down."
- When wrapping the tape around the connector, he does not know how often he must wrap it around. Write down that I have to do it once or twice or more often.
- When attaching the electric valve, he wants to know if it must be positioned in such a way that it is level. "I want to know this. You should write it down."
- He puts the hose inside the base in a different way than intended but it works.
- All the steps until step 8 were doable for the participant. He did not make mistakes as he examined the images very carefully and gave comments on possible improvement.
- Step 8 and 10 are difficult for him as he stopped reading the text and only looked at the title and images.
- He needs some time to attach the hose to the electric valve but manages it.
- Step 12 is not entirely clear to him in terms of placing the computer unit. He places it the wrong way and therefore the barrel did not fit on the base.

Participant 6 (25:22)

(Female, 19-26 years, Late Majority)

- Reads the manual and sees that a video is offered. Wants to use the video and not the manual.
- Still, compares whether all components are there using the manual.
- “I am a video person, I like people showing me things”
- Follows every step correctly and has no difficulties. However, when she thinks she understood what the expert showed, she does it and skips further explanations.
- She missed one step because of the skipping but re-watched the section and found how to attach the component.
- She was confused about which cable belonged in which port, but eventually realized that it could only be done one way.
- “It should be at least two people doing this”

- Has difficulties putting the barrel on top of the base and receives assistance of observer.

Participant 7 (23:03)

(Female, 19-26 years, Early Majority)

- Reads the manual and cannot decide whether to use the video or printed instructions.
- Decides to use the video instructions. "Although I love IKEA-like instructions, I want to try the video."
- Follows the steps of the video. But also adds parts intuitively, such as the electric valve. She screws it on and looked up in the manual whether she did it correctly.
- "This is like IKEA furniture. It is in my Swedish blood!" as she perceives the assembly as easy and enjoys connecting the parts.
- However, she thinks some aspects are not very well constructed, e.g. screwing on valve unscrews the valve connector.
- She watches the section, takes the component and then continues watching.
- "It is not difficult but two people would be more convenient"
- "Making the cable of the valve longer could help connecting it more easily."
- Asks the observer for assistance when putting the barrel on the base. Everything was fit in.

Participant 8 (19:57)

(Male, 19-26 years, Late Majority)

- Takes manual and skips the introduction.
- Starts with the first step, reads text and does not know what a downspout connector is. Therefore, he wants to check it in the book but does not find it.
- Needs assistance and observer explains that images correspond to text.
- Attaches the downspout connector and puts *one* bolt on wrongly, i.e. he does not realize that this is relevant.
- He did not realize that the rubber of the tap was already on and just ignored it, when he could not find it.
- Wrapped Teflon Tape around the valve connector only once.
- "It is not clear where all the cables must go through before connecting them."
- Connected parts quickly overall and did make minor mistakes. Always referred to text and images.

Participant 9 (14:17)

(Female, 19-26 years, Early Majority)

- Reads the manual.
- Does not understand where the image on the right is meant to be. "I can image it is in the top right on the left image, but It needs a reference such as a line."
- Attached one downspout connector the wrong way.
- "It would be easier if you would use the same colors as in reality instead of blue."
- Puts the rubber ring on the wrong side of the tap.

- "I can see only two text paragraphs but three images, that is confusing."
- She was confused about which cable belonged in which port, but eventually realized that it could only be done one way.
- "The image of step 13 is confusing"

Participant 10 (21:24)

(Male, 19-26 years, Early Adopter)

- Reads the manual.
- Instructions are not clear as he does not understand that text and images relate to each other.
- Does not know what a "downspout connector" is and would prefer numbered components or a list with names.
- Puts the ring of the downspout connector on the outside.
- Follows the other steps correctly but takes long to check how it must be done.
- "It would be nice to know how often I have to wrap the tape around the connector"
- When he got used to the instruction style, he considered it as "quite fun".
- "I only used the images to connect it, but it was sometimes quite confusing. There is a gap."

8.4 User Test Conclusion

The collected data was analysed, and several conclusions were drawn answering the research questions that were set prior to conducting the user-test. An answer to each will be provided with respect to the results of the user tests.

8.4.1 Are the DIY instructions understandable? If not, what aspects need revision?

A diversity of data has been collected in order to identify whether the instructions were successful in explaining the assembly or in need of revision to be clearer. Quantitative data, such as number of errors and recovery, as well as the participant's perception of which step is most difficult and the fact of being able to recall certain aspects has been collected. Also, qualitative data, such as thoughts and suggestions have led to identification of design problems. In this section, all problems for both the instruction manual and the expert opinion video will be summarized.

Which steps led to most mistakes?

Putting the number of mistakes and the recovery of the mistake into association with each other, it becomes clear that most users recovered from mistakes when watching the video (see figure 8.1). Only one mistake has not been recovered from. Overall, the video counts less mistakes than the instruction

manual as well. In contrast to that, the manual needs rather extensive revision. Step 3, 4, 8 10, 12 and 13 caused mistakes that the participants did not recover from. These were mistakes such as putting the rubber ring on the wrong side or screwing the bolt on wrongly. The text and images must emphasize these aspects in order to prevent these mistakes for a positive DIY-experience and the desired result.

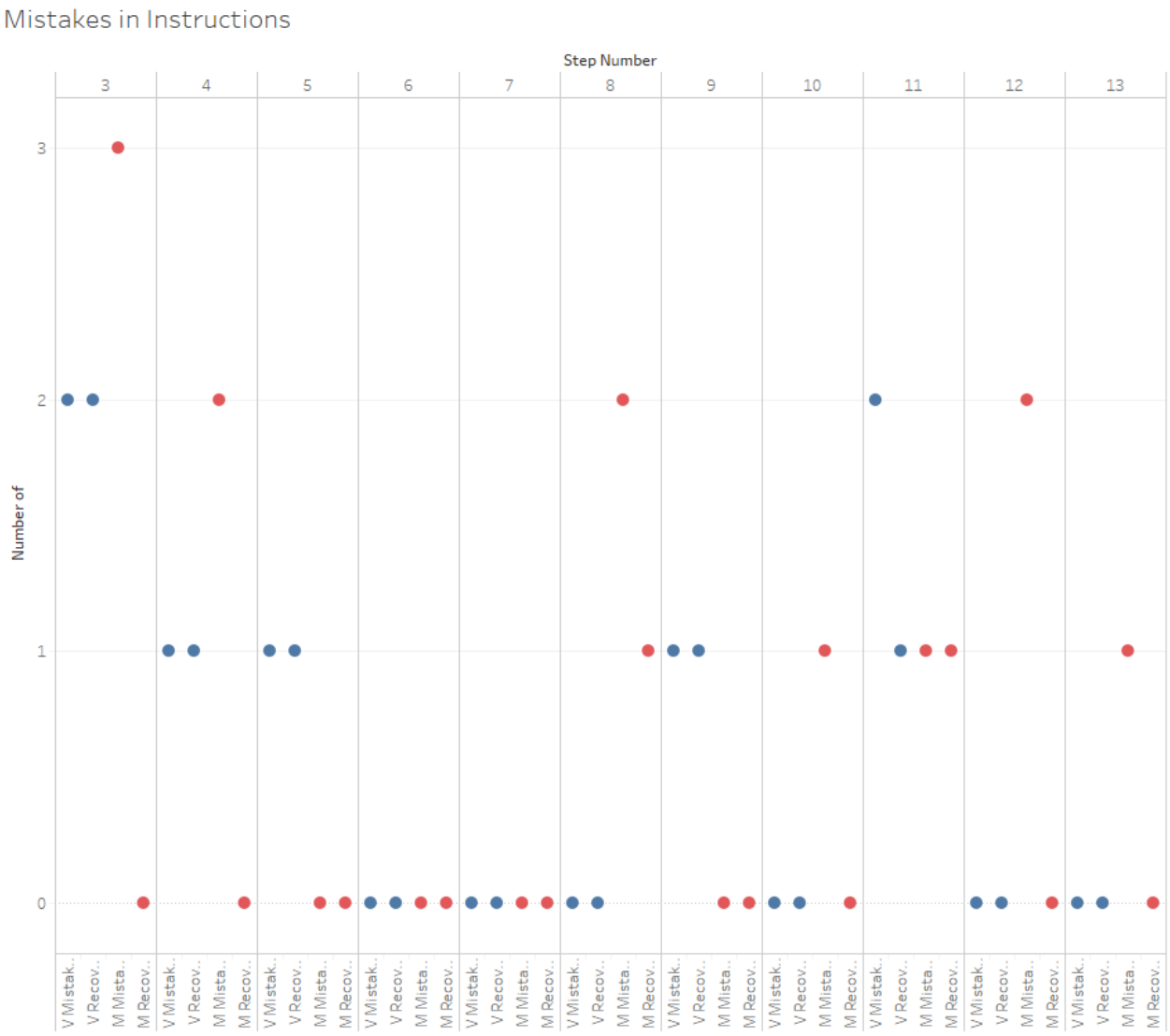


Figure 8.1 Compilation of number of mistakes and recoveries during assembly collected using observations.

How can the instruction steps be improved?

After identifying which steps have been misleading to the participants, these were put in association with their actions and comments in order to determine what exactly has to be changed about each step to become clearer. Also, steps that did not yield mistakes but were perceived as confusing have been listed with suggestions of improvement retrieved from the observations of participants. As the video was

perceived positively and did not lead to major mistakes, it is considered understandable and only the instructions manual will be further examined.

Step 3 – Downspout Connector: It must be emphasized that the bolt must be twisted on with the flat side facing the barrel. Also, it must be indicated more clearly that the ring belongs on the inside of the barrel.
Step 4 – Tap: The text must be clarified in terms of where the rubber belongs. Also, consequences of placing it wrongly must be mentioned in order to point out importance of the correct assembly.
Step 5 – Valve Connector: The image shows the bolt being upside down.
Step 6 – Apply Teflon Tape: It must be indicated from which side the Teflon tape should be applied and how often it should be wrapped around the valve connector.
Step 7 – Electric Valve: It must be indicated that the valve is supposed to be level in order to fit inside the base.
Step 8 – Push Hose through Base: It must be made more visible where the hose goes through in the base. It could be done using two images rather than one. Also, the side of the hose to be pushed through must be indicated more clearly.
Step 10 – Connect Hose to Valve: It must be made more visible how the hose is attached to the valve.
Step 11 – Connect Sensor Module: It must be indicated in the text that the sensor module is placed in the lid of the SRB.
Step 12 – Connect Computer Unit: It must be pointed out that the computer unit must be placed in such a way that all components fit inside the base. The relative position to the valve must be indicated.
Step 13 – Place Barrel on Base: The step of placing the barrel on the base needs an own image.

Which further improvements could be implemented in the manual to aid in the comprehensibility?

As the concurrent thinking-aloud method was applied, comments and thoughts have been documented that verbalize what aspects confused the participants and what they demanded from the manual in order to improve their DIY assembly experience.

1. A check-list with components that shows images and names.
2. Text must be formulated less complexly.
3. Put numbers on close-up images and overview image that corresponds to step number of text to clarify the relation.
4. Indicate problems that arise when not conducting steps correctly.

Additionally, it has been determined that 5 out of 10 users were not aware of the existence of video instructions. Despite being made more prominent in the presentation, it has not been enough to be noticed by the participants and therefore needs further revision. Also, only 2 out of 10 noticed and could recall the safety measures before installing the SRB, which is fatal in case of dangerous situations. This means, that the lay-out must be changed to achieve the desired effect of raising awareness.

5. Make safety measures clearer.
6. Make the existence of video instructions more prominent.

8.4.2 Are the DIY instructions suitable for all adopter groups?

The answer to this question has been investigated by putting the perception of the difficulty and number of mistakes in relation to the adopter group (see figure 8.2). The number of mistakes were counted by taking the mistakes and subtracting the number of recovery from them. Also, it has been taken into consideration whether the participants utilized the instruction manual (square) or video (circle). The answer to this question however is limited by the participants as the sample group was not large and diverse enough to represent each adopter group accordingly.

Nonetheless, what can be conducted from the results is that eight out of ten participants graded the difficulty of the assembly a two or lower out of five. Only the early adopter graded it a four and one participant belonging to the late majority graded it a three. Both have used the instruction manual and not the instruction video, which may be the reason as several design problems have been identified in the manual prototype. When resolving the identified problems, the perceived difficulty could be decreased. Overall, not more than two mistakes were made, most resulting from unclear text/images that could be avoided with an improved manual. This means, based on this data, that at least one of both instruction methods is suitable for each adopter group.

8.4.1 Are the DIY instructions suitable for people without technical background?

The DIY instructions have only been tested by two participants without technical background, which are participant #1 and #2. As both have decided to watch the video rather than using the instruction manual, no answer can be given to the suitability of the manual. Nonetheless, based on their performance and comments, the video is a suitable instruction method for people without technical background.

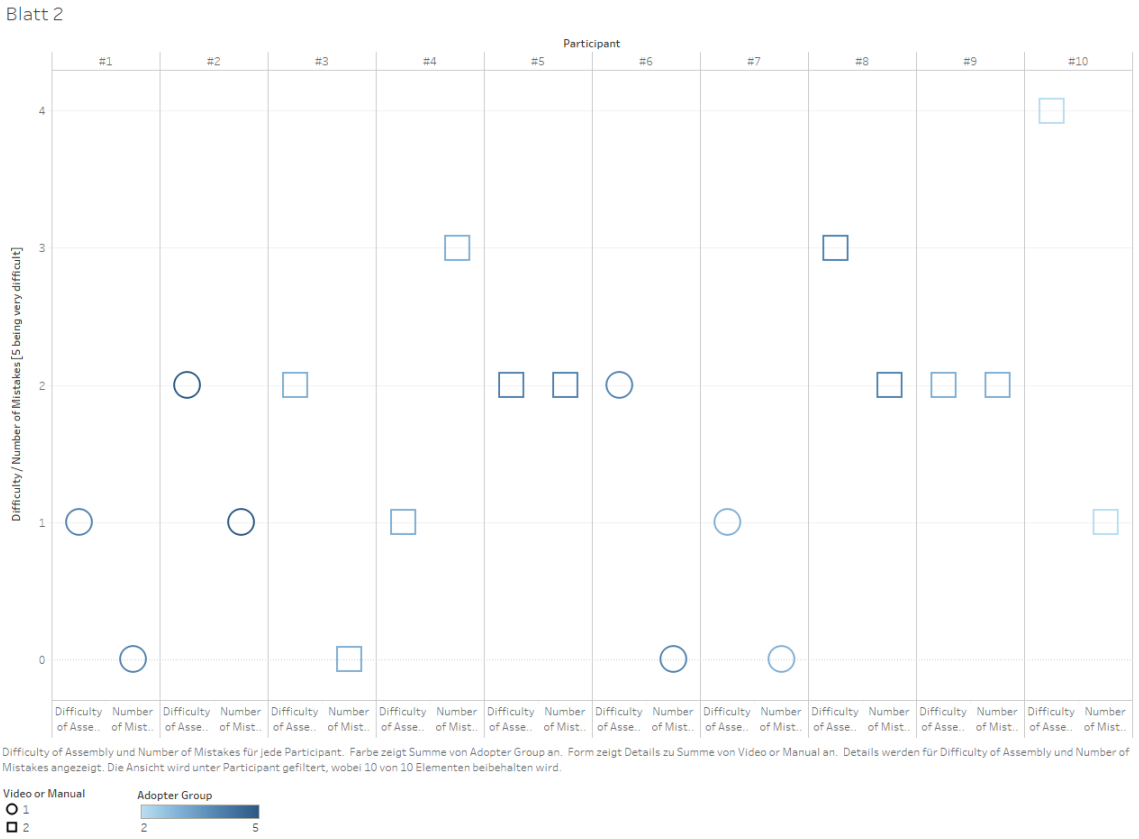


Figure 8.2 Comparison of perception of difficulty, number of mistakes for each participant. The adopter group is indicated using colour (dark blue: laggard, light blue: early adopter). Also, circle means using video instructions and square means instruction manua

Whereas participant #1 has made no mistakes, participant #2 only has made one. Also, their assembly times 16:56 and 20:52 were faster than participants with technical background. Furthermore, they did not perceive the assembly as difficult and said that they have enjoyed watching the video, as it explained the steps very well. This is a clear indication for the video's suitability based on these two participants. For a more certain answer, the instructions should be tested with more non-technical participants. Also, the instruction manual should be taken into consideration.

8.4.2 Is the DIY approach engaging the users to purchase and assemble the SRB?

In the survey it has been asked whether the participant would purchase/place the SRB in his garden. Nine out of ten answered positively and would like to place the SRB in their garden. Also, positive comments that approve of the DIY-approach have been documented. Even though some assembly-steps were not appreciated by participants, such as crawling into the barrel in order to reach for components in the bottom, it has been observed that most would still conduct the DIY to be able to place the SRB in their

garden. This also heavily depended on the physique of the participant. While participants who were tall and sporty did not have a problem, older and less fit participants did not like this aspect.

8.4.3 What is the average assembly time?

The average assembly time has been calculated using rounded values of the recorded time for each participant (17, 21, 16, 30, 36, 25, 23, 20, 24, 21). The average assembly time is 22.3 minutes with a standard deviation of about 6.7 minutes. With a confidence level of 95%, the necessary assembly time is between 19.5 and 27 minutes. This is only valid for the DIY-steps without drilling the holes.

Mean: 22.3 *Sample Variance*: 44.46 *Standard Deviation*: 6.67

8.5 Client Feedback

Based on the feedback collected through the user test, the user manual was changed, and a final version was created. Aspects that were subject to change have been compiled in section 7.4.1, describing what exactly must be improved to create a more user-friendly version of the DIY instructions manual. These changes have been applied and the result can be found in Appendix I. Some chapters of the manual have received a new lay-out and steps were made more explicit using simplified text and more images.

Additionally, it incorporates details that were missing due to new aspects introduced by co-developers, such as the implementation of a filter and screenshots of the user interface of the SRB website. The final design has been evaluated by the municipality in order to determine whether the result is in accordance with their expectations.

8.5.1 Feedback Municipality of Enschede

As the DIY instructions were commissioned by the municipality of Enschede, their opinion had to be obtained for a final evaluation of the instructions, determining whether the envisioned product fulfilled their expectations or further recommendations could be given. Therefore, the test on the 21st and 22nd June was repeated on the 29th June with two participants from the municipality of Enschede. The test was altered in such a way, that participants must use the instruction manual and both participants conducted the assembly together. This approach was chosen, as a first-hand experience gives the client a deeper insight that allows developing a more elaborate opinion on the envisioned product.

Results

Data was collected via observations and a questionnaire. The same questionnaire as in the previous user-test was utilized. The results are listed in this section. Quantitative data has been summarized in table 8.4, showing information of both participants of the municipality of Enschede. Qualitative data has been written in notes with a reference on the timing of when and by whom it was said or done (see table 8.5). Conclusions have been drawn in the next section, answering the question whether the envisioned product is what the municipality expected.

Category	**Participant 1** (20:29) (Male, 36-45 years, Late Majority)	**Participant 2** (20:29) (Male, 46-55 years, Early Adopter)
Most difficult step	14	8
Most well-explained step	3	All steps excluding 8
Number of Mistakes	0	0
Noticed Video instructions?	Yes	Yes
Difficulty of assembly (1-5 most diff.)	1	2
Remembered safety measures?	Yes	Yes
Would purchase SRB?	Yes	Yes
Time	20:29	20:29

Table 8.4 Results of the user test with the municipality of Enschede.

Time	**Both Participants**	**Participant 1**	**Participant 2**
0:22	• Look at the manual	• "It is even in the style of the municipality, very suitable"	
0:30	• Read the information on the dashboard	• Tries to find the website but observer interrupts and explains that it is only a mock-up	• Reads the name of the website, so participant 1 can find it. • Then realizes that it is still in development.
1:20	• Check for the components and tools • Make jokes about bringing tools and have fun	• Supports participant 2 while checking.	• Has the manual in his hands and goes component for component and checks whether everything is there.
3:16	• Turn the page and look at the safety measures.	• "Now we are going to colour in a colouring page" and laughs.	• Laughs about participant 1's joke.

			• Then checks whether all conditions are fulfilled (2 people, dry weather)
3:45	• Check whether all holes are drilled. Read the manual out loud.		• Has a feeling of satisfaction as they already reached the middle of the manual.
4:18	• Read step 3. • Compare the images with the real barrel.	• Takes the components of step 3.	• Has the manual in his hands and reads the next steps.
4:57	• Put in the downspout connectors and twist the bolt on.	• Is faster than participant 2. • Laughs at him and says that "I do it daily" to make fun and show his skills.	• Has problems with twisting on the bolt.
5:30	• Look at the next steps.	• Checks if everything was done correctly. • Then explains the next step and says "the tap must be on the outside" to make fun of participant 2. • Holds the barrel so participant 2 can twist it on.	• Participant 2 grabs the tap and laughs. • Twists the tap on from the inside.
6:40		• Realizes the ring of the tap must be on the inside, but they placed it on the outside.	• Removes the tap and connects it correctly.
7:50	• Execute the next step.	• Pays a lot of attention to the rubber rings. • Explains that it must be on the inside to prevent leakage.	• Agrees with him and laughs.
9:47	•	• Holds the manual and looks at participant 2. • "You need to apply the Teflon Tape." • Shows how it must be done to him. Emphasizes that it must be clockwise and done four times.	• Takes the Teflon Tape to apply it. "Yes, I am the Teflon Tape Expert." • Laughs and has fun.
10:20	• Read how to connect the valve. • Need some time and read it twice.	• Tries to imagine how the barrel will be placed on the base to put it correctly.	• Takes the valve and attaches it the way participant 1 instructed him to do it.
11:50	• Put the hose through the base.	• Takes the hose and pushes it through the holes. • Says no and shows it in the manual.	• Says that it is wrong. • Understands it and does it correctly.
14:20	• Make jokes and laugh while hose-steps are executed.	• Did not realize that participant 2 already executed all steps and takes time to check if everything was correctly.	• Attaches the hose clamp and hose connector intuitively to the hose. Then connects it to the valve. Does everything very quickly.
16:06	• Take the sensor module.	• Is very impressed by the sensor module. • It is his first time to handle 3D-printed components.	• Holds the lid. • Tries to screw it on tighter.

		• Screws it onto the lid.	
18:02	• Start putting everything inside the base.	• Reads the manual.	• Does what participant 1 instructs him to do.
18:56	• Attach electronics. • Have difficulties with the cables.	• Reads the manual and checks if participant 2 does it correctly. • "Very good, I see you are a technical person" • Does not understand step 14.	• Connects cables. • Waits for instructions from participant 1. • "I do not like that it does not go through a hole."
20:18	• Put the barrel on the base.	• Takes the barrel and puts it on the base.	• Checks if all components fit in the base. • Put the lid on.

Table 8.5 Observations of user test with the municipality of Enschede.

Conclusion

Looking at the results of the user-test, it becomes apparent that the municipality perceived the assembly as easy to do (1/5 and 2/5 with 5 being most difficult) which is confirmed by the fact that they have made no mistakes. Furthermore, in contrast to the last user test, the video instructions were noticed and the safety measures have been remembered by the participants. In addition, the assembly time of 20.5 minutes lays in the lower end of the average time needed for the assembly (19.5 until 27 minutes) being a good result. Based on the observations, one can conclude that the participants had a good time assembling the SRB together. They have verbalized positive comments, made jokes and have recovered from mistakes due to the newly incorporated "tips" and in italic highlighted words. This means, that conducting the user test with a friend is not only safer but also more engaging to complete the SRB.

After the user-test, the municipality confirmed that they were content with the envisioned product and that it has met their expectations. This means, that the user test was successful and the final design can be considered an answer to the proposed research questions.

9 Conclusion

Having developed a DIY-solution for the SRB, the conclusion serves as a reflection of the conducted work, assessing whether it can answer the research questions which have been set in the introduction of the thesis. In case the research questions can be answered, the project is considered successful. Therefore, the key findings of this research will be described as an answer to the research question: “How to develop a DIY solution for all SRB-users to enable large scale deployment of SRBs?” and both sub-questions that elaborate on non-technical users and motivational aspects of the DIY. These are followed by further recommendations on possibilities to proceed with the research.

9.1 Key Findings

This bachelor thesis has documented the process of developing a DIY-solution for all SRB users to enable large scale deployment of SRBs. Key findings are, that it consists of several steps that will be revised in this section as an answer to the research question. To clarify, the process will be divided in sections based on the Creative Technology Design Process.

9.1.1 Ideation

In the ideation phase, the concept of the DIY-solution is determined using research, creativity and communication with stakeholders. Therefore, the first step is to identify all stakeholders and categorize them based on power and interest. After that, research on existing work must be conducted to collect scientific sources or products, that could be taken as a reference. Best practices on characteristics of instructions and different instruction methods have been found which can aid in the development of a DIY-solution. This includes information on modularized systems which was the focus of co-developer Jeroen Waterink. Having finished the compilation of information, ideas can be brainstormed in collaboration with the co-developers that relate to what was found.

These ideas must be developed into concepts by e.g. illustrating and describing them more closely in order to be presented to the stakeholders with the most power, namely the municipality of Enschede, the waterboard Vechtstromen and the University of Twente. As an expert, one must consult the stakeholders when deciding on a concept by elaborating on the benefits and disadvantages of each. Using the input of the stakeholders with the most power, the stakeholders with the most interest, i.e. the users must be consulted as well. They can give information on certain criteria the other stakeholders cannot provide, such as which aspects make the instructions more user-friendly. A method to communicate with a diverse group such as the users is a focus group that contains a diversity of participants.

In multiple iterations the concept of the DIY-solution must be further specified and discussed with the stakeholders to agree on certain preliminary requirements to be incorporated. The DIY-solution of the SRB will consist of an instruction manual and an expert opinion video.

9.1.2 Specification

Having decided on a final concept for the DIY-solution, it must now be specified in terms of its functionalities and the user experience. On the one hand, a functional architecture must be created dividing the DIY-solution in realizable steps based on the functionalities. On the other hand, a PACT-analysis must be applied to focus on user-centred aspects that must be taken into consideration. Combining both, a final list of requirements can be created that is categorized based on priority using the MoSCoW-method.

To elaborate on how to design instructions for users with non-technical background, the experience specification was utilized to document what aspects must be considered. Information on their preferences has been collected utilizing the focus group. It was found that participants without technical background felt more comfortable using an expert opinion video as well as having company when assembling the SRB. Therefore, the DIY instructions must incorporate these aspects. This has been confirmed during the evaluation of the DIY-solution. Both participants without a technical background decided to watch the expert opinion video rather than using the instruction manual and have completed the assembly successfully below the average assembly time.

9.1.3 Realization

In the realization phase the DIY-solution is put into practice. Therefore, research on best practices to fulfil the previously set requirements has been conducted and a first draft was realized. After that, a professional was approached to solve the largest design conflicts. Having incorporated the professional's feedback and evaluated the DIY-solution, an optimized lay-out has been created and a list of guidelines has been compiled on how to design the DIY-solution for the SRB.

To make the DIY-solution accessible for every SRB user, it should consist of an instruction manual accompanied by an expert opinion video. The manual instructions should consist of illustrations and text. Further information on how to design the DIY-solution can be found in the following guidelines:

Instruction Manual – General:

1. Inform the user about the SRB.
2. List all components of the SRB DIY-kit. Use images and names.
2. List all necessary tools. Use images and names.
3. Provide a space to tick off the components and tools.
4. Inform the user about safety concerns.
5. Inform the user about the existence of an expert opinion video.
6. Explain the assembly.
7. Inform the user about the maintenance.

Instruction Manual – Assembly Instructions Lay-Out:

1. Use an overview image of the SRB to show where new components will be placed. This avoids changes of perspectives that confuse the user.
2. Use close-ups give to provide more detail on how these new components must be assembled.
3. Clarify how the components must be assembled using arrows. Use flat arrows to convey spatial information more effectively.
4. Use blue to highlight the new components. The sparingly use of colour focuses the user's attention on certain aspects. The colour blue is a neutral colour that does not disturb the rest of the images.
5. Clarify the relation of the overview image, text and the close-ups by using step numbers for each instruction component.
6. Use explanatory text to reach a wider audience that cannot execute the instructions based on images.
7. Structure the text in such a way, that it uses only simple words, short sentences and clarifies the consequences of a step when done wrongly. The inclusion of tips and subtly highlighting words with italic also reduces the number of mistakes.
8. Use serif font and format the paragraphs to be left-bounded to enhance the reading experience.
9. Use a sequence that is intuitive and easy to remember. This allows users to execute the instructions faster.
10. Include a footnote directing the user to the expert opinion video in particularly difficult sections.
11. Keep a consistent lay-out.
12. Use 3D-modelling software to create the illustrations.

Expert Opinion Video:

1. Use a script and storyboard to structure the filming and editing process.
2. Divide the video in sections to allow the user to only watch what is relevant for him.
3. Make the videos shorter than four minutes.
4. An expert must host the video.
5. The expert must provide additional information to the manual.
6. Show the components before the assembly instructions.
7. Film the scenes in such a way that the expert communicates with the audience.

8. Utilize close-ups with voice-overs to show the assembly process in greater detail.

9.1.4 Evaluation

After the realization, an evaluation was conducted that showed what aspects needed improvement in order to create an effective DIY-solution. The results on improving the lay-out have been summarized in section 9.1.3. In addition to the lay-out guidelines, the evaluation also yielded other results, such as whether a step must be made more specific and whether an illustration or text is misleading. This cannot be determined without a user-evaluation and is therefore a mandatory step in creating a DIY-solution despite obeying to all guidelines.

Furthermore, the evaluation has answered the question on how to make the DIY engaging. It has been found that conducting the assembly with a friend makes the DIY-assembly a fun activity for the users. Also, reading the information and understanding the purpose of the SRB engages them in placing an SRB in their garden, despite the fact of needing to assemble it themselves. This means incorporating additional information and advising to conduct the assembly with two people engages the users to conduct the DIY.

9.2 Further Recommendations

Following the previously described steps leads to a DIY-solution for every SRB user that allows large scale deployment of SRBs. Still, difficulties and relevant topics have been encountered throughout the development of a DIY-solution that are considered aspects for further recommendations on how to proceed with this research.

As the inhabitants of Enschede were divided in different adopter groups, based on the theory of diffusion of innovation by Everett [84], it was planned to determine how each adopter group perceives the instructions in order to examine whether they are suitable for every inhabitant of Enschede or only for certain adopter groups. Despite having collected much feedback on improvements of the instruction design, the number of participants was neither large nor diverse enough to draw conclusions on the adopter groups. Therefore, an evaluation with focus on this aspect could be conducted in the future with sufficient participants from each adopter group, providing better insights in this topic to confirm or disagree with the findings. Research on their ability to use electronic tools should be considered, too. This may be relevant as the first step of the instruction manual, i.e. drilling holes, was not subject to the evaluation due to lack of resources.

A second aspect to consider is the investigation of 3D-scanners. With more resources research on 3D-scanners could be conducted that can create clean scans of the SRB components, leading to more accurate depictions. The improvement of accuracy could influence the perception of the user either through more insights or by creating more details to process, which may be not necessary for the user to understand the instructions. A trade-off between these aspects could be investigated to determine the best solution.

For users that do not want to purchase the DIY-kit including the barrel but prefer using own components, additional instructions should be designed in such a way that they are applicable for every kind of barrel and give recommendations on where to buy certain components. This can be done by collaborating with certain stores that sponsor the SRB being a method to collect money for the municipality to make the SRB cheaper for those who prefer to buy the DIY-kit.

Making the instructions universal could be further supported by investigating the possibilities of DIY instructions with augmented reality. As drilling holes is heavily affected by the type of barrel, the use of augmented reality could visualize more clearly where the holes should be located on the barrel. It could also recognize certain components from the DIY-kit or sections in the manual and show the respective video-section on how to assemble that component when users encounter difficulties. This could improve the assembly experience as it is making it easier and giving it an innovative twist that reflects the SRB as a product engaging the users to execute the DIY-assembly.

Considering the analogue instructions, it may be interesting whether different printing approaches can aid in the comprehensibility of the steps. An example is to use transparent pages as overlays, keeping the same overview image on each page and only adding the components to it. This could make the blue colour redundant and offer a possibility to create a manual in grayscale, even potentially saving costs.

A last recommendation is the investigation of the lay-out and its potential. The instruction lay-out of the SRB could be applied to different products and conclusions could be drawn on whether it is a DIY-solution for the SRB or a general DIY-solution which is widely applicable.

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Appendix A: List of Components Version 1.0

List of components based on preliminary requirements

Draft version 1.0 - 26-04-2018

Source: Jeroen Waterink, j.waterink@student.utwente.com

Components

- Barrel
  - Closed barrel
  - NOT transparent
  - 200 / 250 liters
- Input pipe
  - Connected to rain pipe by "Regenton vulautomaat[1]" or directly connected to rain pipe (depends on what municipality wants → directly connected means 100% guarantee that water goes into the barrel.
- Filter (to filter water at the input)
  - Should be easily cleanable
- Rain buffer overflow
  - Pipe or hose near the top of the barrel to prevent the barrel from overflowing incase of unexpected weather of failure of the system.
- Output valve or valves (at the bottom of the barrel). See figure 2
  - Incase of more valves this could maby be combined into 1 module.
- Connector for garden watering supplies at the end of the output valve (Geka or Gardena connector) See figure 2
- Connector to connect valve to tank
  - 2 options
    - 1. Barrel with build in valve connector at bottom
    - 2. Drill a hole in barrel and place a water proof connector See figure 2, 3, 4
- Sensors
  - Water level sensor (probably a small ultra-sonic sensor at the top)
  - Temperature sensor (long wire hanging form the top op the barrel in to the water)
  - Both sensor could be in one module at the top
- Computer/communication unit
  - Can be placed everywhere → Bas Sala placed it close to the valve. See figure 1
- Power source
  - Can just be a simple power plug or a small solar panel (depends on Richard and municipality)

1 https://www.voertonnen.nl/regentonnen/regenton-accessoires/regenton-vulautomaat?gclid=Cj0KCQjw8YXXBRDXARIsAMzsQuVUxwaswCaizaeJ313-8KcyhV6WAR8o3c5kKmqiU0rY22ghe9ok1FIaAkZREALw_wcB

Figure 1: Slimme regenton Bas Sala, output and computing unit module, Source: Bas Sala

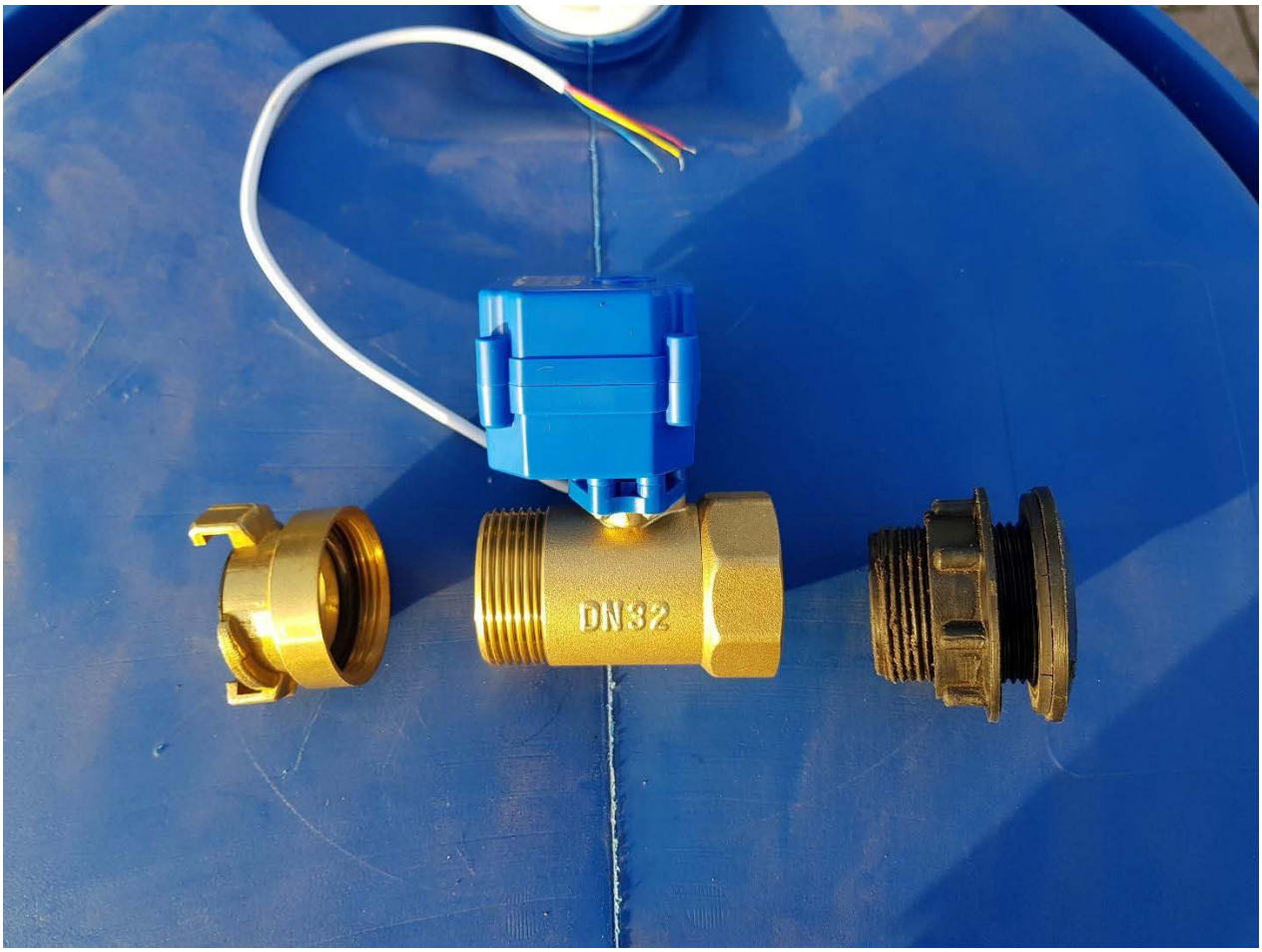


Figure 2: Geka connector, Valve, Valve-Barrel connector, Source: Jeroen Waterink

Figure 3: hole in prototype barrel Source: Jeroen Waterink

Figure 4: prototype barrel Source: Jeroen Waterink

Figure 5: painted prototype barrel with output hole Source: Jeroen Waterink

Appendix B: Decision Makers Interview I

Hendrik-Jan Teekens, Municipality of Enschede

Richard Bults, University of Twente

Date: 03.05.2018

Introduction:

Dear Hendrik-Jan, I am Sefora and my part of the project is constructing the DIY-instructions in order to allow large-scale deployment. Therefore, I need to engage users to follow the DIY by making them feel that they are capable and they achieve something by doing it. But to be successful, I need some input from you and Richard.

I have prepared several concepts for the implementation of DIY-instructions including their Pros and Cons. Please have a look at the possibilities and indicate which one you would consider most suitable and why. I have asked Jeroen for the component list and create a low-fi prototype that includes each of these components. I used it as a reference to create SRB instructions. I have seven different kind of instructions to offer. They resulted from extensive research on instructions from large and successful companies, such as IKEA and LEGO but also other DIY-Rainwater Harvesting systems.

Presentation of Concepts using a PowerPoint presentation with images/videos and a portfolio with printed versions of the static instruction methods:

1. **What type of instructions do you prefer most and Why?**

I prefer the image and text instructions as they offer the most insight for someone who conducts a DIY. Additionally, a video would be suitable. The expert opinion video is a better option than the animation for that and can complement the illustrations with real shots of the Smart Rainwater Buffer.

(*Teekens*)

Side comments:

1. *Text instructions* – Text as a medium is not sufficient and needs something visual.
2. *Image instructions* – Images alone may be misleading or not meaningful enough.
3. *Photograph instructions* – Photographs have too many details and deviate from what is fundamental.
4. *Images and text instructions* – This is the best version. I like this.

5. *Exploded View instructions* – They may be misleading, especially with more components.
6. *Animated Instructions* – Looks good but is not enough.
7. *Expert opinion instruction* – The video is a good addition to the image instructions. Big companies also offer multiple instruction methods, and most are with an expert opinion.

2. What language should the instructions be in?

It should be in Dutch. (*Teekens*).

English for the thesis and Dutch for the inhabitants. (*Bults*)

3. What components should the DIY-manual include? Information or maintenance pages?

An information page would be good for promotion and the maintenance page is a must. (*Bults*)

You are right. We will keep in touch for the content of the information page. (*Teekens*)

4. Coloured instructions or B/W?

In your portfolio the images of the text and illustration instructions are b/w, too. They should be black and white. (*Teekens*)

5. How many pages may the instructions have?

Challenge yourself and put them on two A4 pages. (*Teekens*)

6. So, the instructions should be printed!

Do not print them but indicate how to access them on the website. (*Bults*)

I think, they should be printed. Printed instructions belong to a DIY-kit. (*Teekens*)

Questions on the modular system rather than the instructions manual:

1. How well-prepared will the SRB be? Holes already drilled? Parts already assembled?

The holes should not be drilled. Everyone should be capable of drilling a hole. If the person does not have the tools, it also works with a knife. Also, the holes restrict the user in positioning the SRB. Indications for where a hole could be, should be there but no fully drilled holes. (*Bults*)

2. Are there materials we can(not) use? What is your preference? Materials from China?

As long as the quality is good, that is not a problem. (*Teekens*)

But then you cannot sell it as a product with Dutch materials.

You can write “Made by Holland” like they do in Sweden. That confirms the quality despite the use of Chinese materials. (*Bults*)

3. **How much should it cost? How much is the municipality going to cover?**

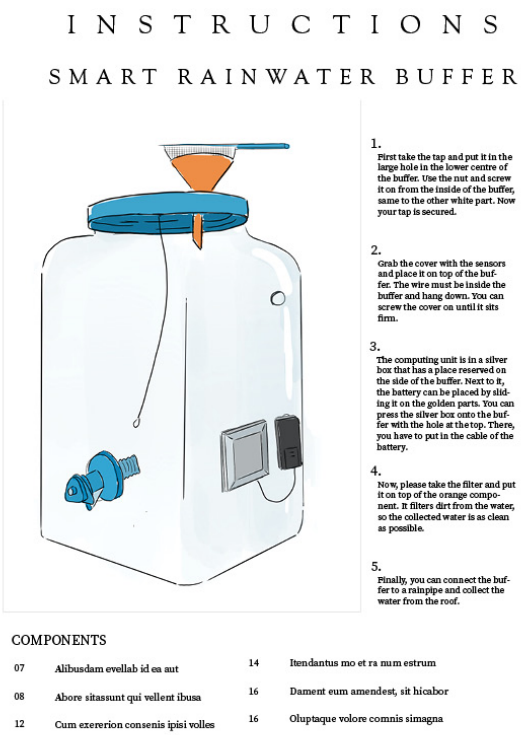
It will cost about 400 Euros and the municipality covers around half of it. (*Teekens*)

4. **Who will own the SRB?**

The SRB should be owned by the user but the user agrees on sharing his data collected by the SRB with the municipality. (*Bults*)
I agree with that. (*Teekens*)

Presented Concepts – Images and Pro & Cons

1. Text Instructions (Two Versions):



INSTRUCTIONS

SMART RAINWATER BUFFER

1. First take the tap and put it in the large hole in the lower centre of the buffer. Use the nut and screw it on from the inside of the buffer, same to the other white part. Now your tap is secured.

2. Grab the cover with the sensors and place it on top of the buffer. The wire must be inside the buffer and hang down. You can screw the cover on until it sits firm.

3. The computing unit is in a silver box that has a place reserved on the side of the buffer. Next to it, the battery can be placed by sliding it on the golden parts. You can press the silver box onto the buffer with the hole at the top. There, you have to put in the cable of the battery.

4. Now, please take the filter and put it on top of the orange component. It filters dirt from the water, so the collected water is as clean as possible.

5. Finally, you can connect the buffer to a rainpipe and collect the water from the roof.

COMPONENTS

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12	Cum exererion consenis ipisi volles	16	Oluptaque volore comnis simagna

SRB INSTRUCTIONS

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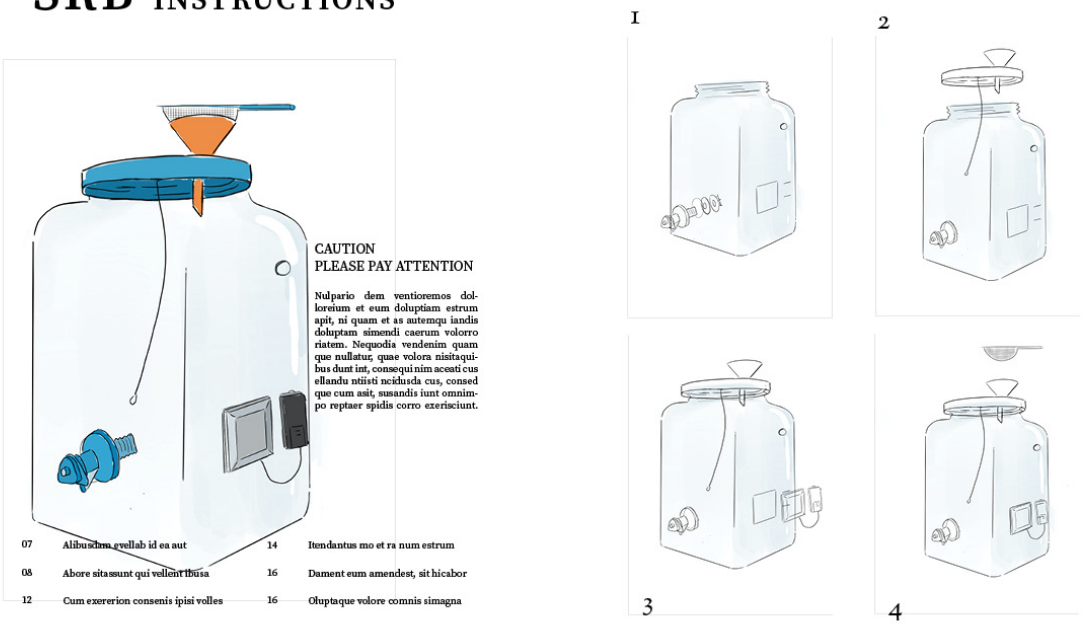
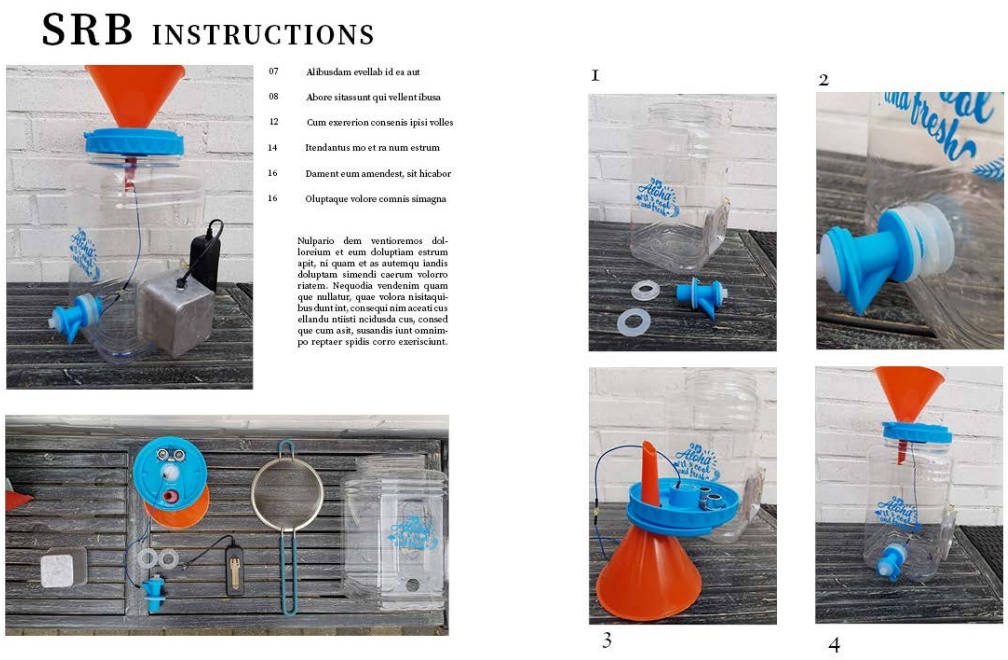
2. Sequenced Image Instructions:



3. Sequenced Photograph Instructions:



4. Sequenced Images and Text Instructions:

I

Titel
hierhin

Nulpario dem ventioremos dol-loreium et eum doluptiam estrum apit, ni quam et as autemqu iandis doluptam simendi caerum volorro riatem. Nequodia vendenim quam que nullatur, quae volora nisitaqui-bus dunt int, consequi nim aceati cus ellandu ntiisti ncidusda cus, consed que cum asit, susandis iunt omnim-po reptaer spidis corro exerisciunt.

4

Titel
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2

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Nulpario dem ventioremos dol-loreium et eum doluptiam estrum apit, ni quam et as autemqu iandis doluptam simendi caerum volorro riatem. Nequodia vendenim quam que nullatur, quae volora nisitaqui-bus dunt int, consequi nim aceati cus ellandu ntiisti ncidusda cus, consed que cum asit, susandis iunt omnim-po reptaer spidis corro exerisciunt.

5

Titel
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Nulpario dem ventioremos dol-loreium et eum doluptiam estrum apit, ni quam et as autemqu iandis doluptam simendi caerum volorro riatem. Nequodia vendenim quam que nullatur, quae volora nisitaqui-bus dunt int, consequi nim aceati cus ellandu ntiisti ncidusda cus, consed que cum asit, susandis iunt omnim-po reptaer spidis corro exerisciunt.

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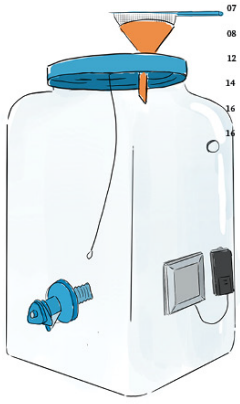
Nulpario dem ventioremos dol-loreium et eum doluptiam estrum apit, ni quam et as autemqu iandis doluptam simendi caerum volorro riatem. Nequodia vendenim quam que nullatur, quae volora nisitaqui-bus dunt int, consequi nim aceati cus ellandu ntiisti ncidusda cus, consed que cum asit, susandis iunt omnim-po reptaer spidis corro exerisciunt.

-END-

5. Exploded View Instructions

SRB INSTRUCTIONS



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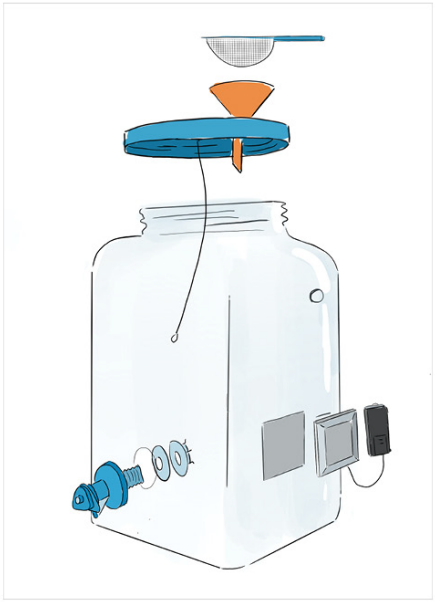

6. Animation Video Instructions

7. Expert Opinion Video Instructions:

1. Pro and Cons Table:

Instructions Method	Advantages	Disadvantages
LEGO: Sequenced Photographs	+ Simplified notion of parts due to association with real-life + Distinction between parts enhanced by color + Step-by-step increased comprehensibility	- More details allow more distraction from what is essential - Sequenced images are not useful when there is a small amount of parts
IKEA: Sequenced Line-Art Images	+ Emphasis on essential parts + No distraction by details + Step-by-step increased comprehensibility	- No use of color increases difficulty of distinction between parts - Sequenced images are not useful when there is a small amount of parts
IKEA Espana: Expert Opinion	+ Provide help and tips while assembling + Clean environment allows to focus on the assembly process + Timeline indicates what parts are going to be assembled + Relation to line-art instructions provide additional help + Subject allows identification with oneself as motivational factor	- Language barriers - Assembly in own pace is not possible unless pausing the video after each step - Only works in connection with initially delivered IKEA instructions
IKEA: Animated Video	+ No distraction by other factors + Focus on the assembly process self + Transitions are made by visualization and do not have to be made by oneself	- No additional value to sequenced images other than transitions - Production has higher workload than images
Sony + Microsoft: Exploded View	+ Fast and easy to produce + Fast and easy recognition of relations when low amount of parts	- Not suitable for many connections - Not suitable when using similar components that may be mixed up
RainGrid Inc: Line-Art Images with Text	+ Better understanding of images + More detailed explanation	- Language may not be understood universally - Images are not meaningful without text

Table B. Summary of advantages and disadvantages of DIY assembly instruction methods.

Appendix C: Decision-Makers Interview II

Hendrik-Jan Teekens, Municipality of Enschede
Jeroen Buitenweg, Waterboard Vechtstromen
Richard Bults, University of Twente

Date: 17.05.2018

Introduction (for Jeroen Buitenweg as we met the first time):

Hello, my name is Sefora and I am working on the DIY-component of the SRB. I am taking care of the instructions, so the modular system Jeroen Waterink is building can be assembled by the users.

Relevant comments that were made during the presentation of co-developer Jeroen Waterink:

I do not think that the users want to change the placement of the overflow after the installation of the SRB according to the time of the year. They should place it in one position and leave it like this. (*Buitenweg*)
People need to be aware that water may flood your house when putting the SRB overflow in the garden. (*Teekens*)
Well, it can be just indicated that the position of the overflow *may* be changed according to the time of the year. Also, the website interface can give a notification on that. (*Bults*)
Two hours are a sufficient amount of time for the sewerage system to completely drain. (*Teekens*)

Presentation of low-fi prototype by handing the decision-makers the prepared booklets:

I have prepared a low-fi prototype with all components we agreed on during last session. However, I did not agree with the requirement of printing it in A4 and in black and white. Therefore, I have made one in colour in A4 and in A5 as well, to show you that colour might be more useful than black and white.

1. **So, what booklet do you like most?**

Considering the design, the coloured version is more appealing. So, the manual should be in colour. Concerning the size, A4 might be more suitable as the target user group could encounter problems regarding the font size. Therefore, I would go with coloured A4. (*Teekens*)

I do not agree. I think, A5 is sufficient. I do not want such a big instruction manual. I am sure I will loose it or throw it away, as it takes up so much space. I also do not think that it is handy. The size of the font in the end of the A5 booklet is large enough. The font in the beginning is too small in my opinion. (*Buitenweg*)
If the letters are too small, one can use the online version and zoom in on the text. But I agree, the text in the end is more readable than in the beginning. You should stick to that size. (*Bults*)
Yes, you are right. That is true. I agree, A5 is better and the font size in the second half of the manual is sufficient. (*Teekens*)

2. **What about the manual design?**

You have implemented the corporate design of the municipality but what about the waterboard? What do you think, Jeroen? Should it be a mixture of both? (*Bults*)
No, I do not care about the design, but it should be indicated on the front that it is a corporation between the waterboard and the municipality. So, the logo should be added at least. (*Buitenweg*)

And the logo of the University?

The logo of the university should be added on the backside of the manual as well. This is important for the pilot-run as it shows the scientific background and the relation to the University, adding value to the image of the SRB. I think it should be at the back, but the exact location needs to be discussed with the marketing department of the University. (*Bults*)

3. **Are the sections good this way?**

I think the order is very logical and it makes sense to include these sections. First information on the SRB, the website, then the assembly and maintenance. That makes sense. Also, the way it looks is good! (*Buitenweg*)

Does the QR code direct the user to the website or to the instructions? And why did you also add a link? Or do you want the users to be directed to both sources? (*Bults*)
I think the QR code is not necessary. There should be a links. No one uses QR-code scanners. (*Waterink*)
Bults disagrees but the general group agrees with Waterink.
OK, then remove the QR code and only add links. (*Bults*)

4. **Other than the printed instructions manual, there will also be a video with an expert who actually shows how he assembles the SRB. How long should this video be in your opinion?**

The video should absolutely not be longer than about two minutes. And if it is, you should divide it in videos with different themes. That is more practical for the user. (*Buitenweg*)

Yes, I agree. It should not be longer than five minutes or so. (*Teekens*)

Yes, dividing it is a good option. (*Bults*)

5. **Ok, and now I have brought a list of preliminary requirements resulting from the last decision-maker interview. Do you mind filling in how you would prioritize each requirement and add other requirements if you come up with something that you think is missing.**

Decision-makers received a form with each requirement and prioritized each requirement. They did not add new requirements, but they disagreed with some of the set requirements.

Functional Requirements	HJT	JB	RB
Explain the steps a user should take for completing the SRB.	m	m	m
List all the necessary materials for completing the SRB	m	m	m
Give information on water stress in Enschede.	m	m	m
Give information on the dashboard.	m	m	s
Give information on how to reach the dashboard.	s	s	m
Give information on the maintenance of SRB.	m	m	m
Offer two instruction methods for explaining how to complete the SRB.	m	m	m
Use English and Dutch language for communication.	m	m	m
Give contact Information for support.	m	m	m
Indicate and give the opportunity to view instruction manual online.	m	m	m
Mention „Made by Holland“	m	m	m

Table C.1: Prioritization of preliminary functional requirements I by the decision makers.

Non-functional Requirements	HJT	JB	RB
Present Instructions with text and images.	m	m	m
Images should be illustrated.	m	m	m
Images should be B/W.	no	no	no
Instructions must be printed on A4.	no	no	no
The manual design must match CD of Gemeente Enschede	m	m	m
Present instructions in a Video.	m	s	m
Video should include an expert.	m	s	m
Video must offer an expert opinion.	m	s	m
Video must be filmed in a sterile area.	no	no	no
Video may not be longer than 5 Minutes.	m	no	m

Video must be accessible via a QR-Code.	no	no	no
User should feel motivated and engaged to conduct DIY.	m	m	m
Instructions must be understandable for the user.	m	m	m

Table C.2: Prioritization of preliminary non-functional requirements I by the decision makers.

Content of prepared booklets:

The pages were put on top of each other and sewed in the centre. Therefore, the order of pages on the images does not correspond to the order of the pages in the low-fi prototype.

Figure C.1: Last page and front page.

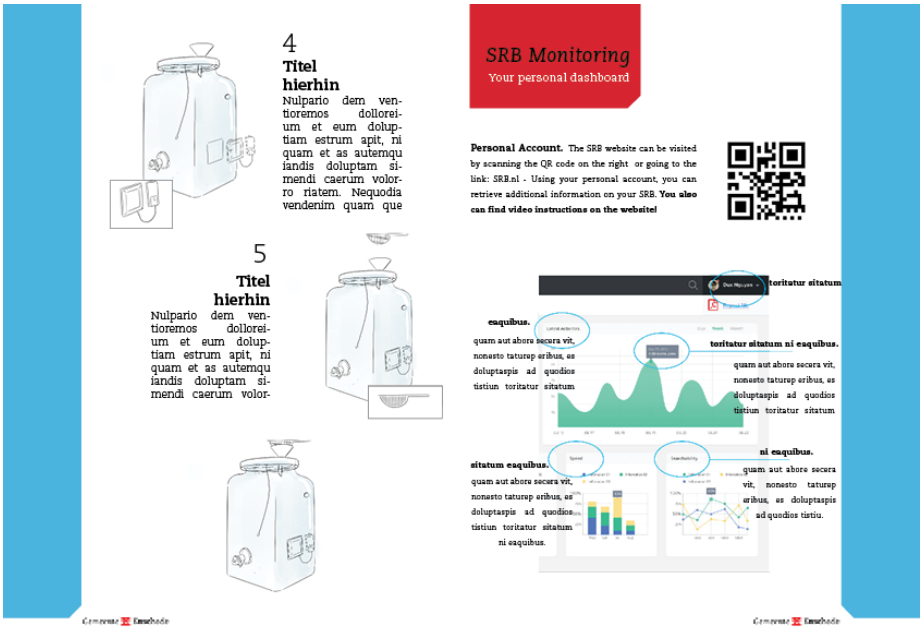

Figure C.2: Page 5 and 2.

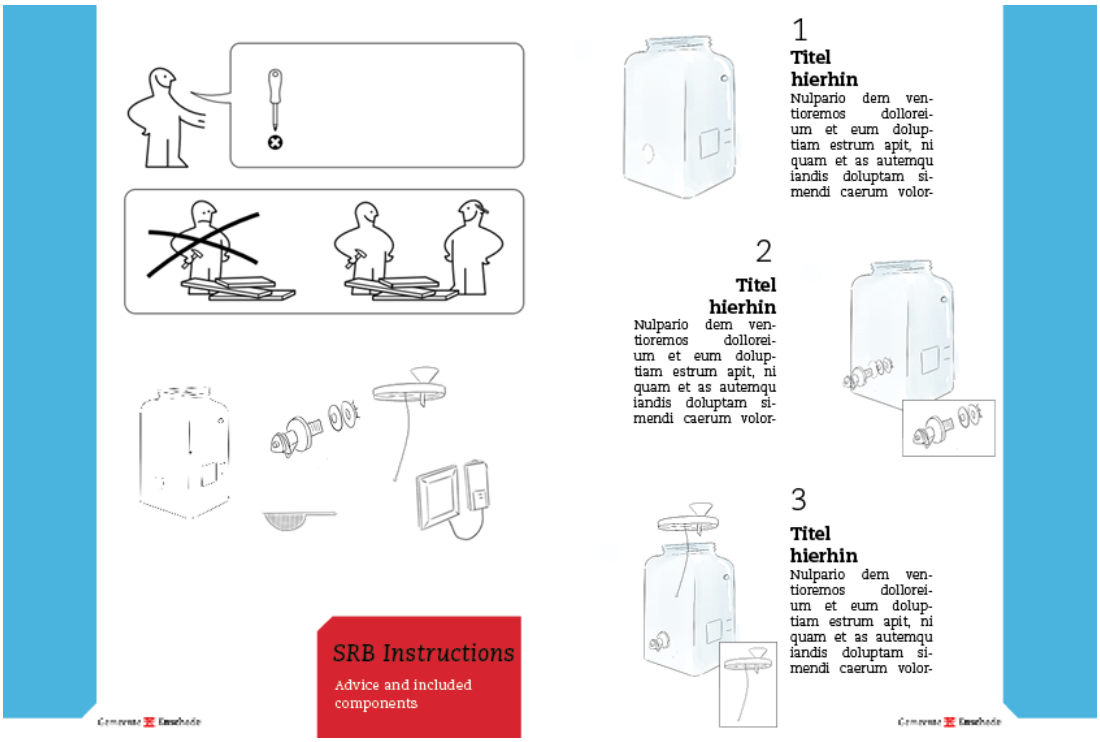

Figure C.3: Page 3 and 4.

Figure C.4: Page 1 and 6.

Appendix D: User Focus Group

Four Participants

1. (1) Female, 46 years – High School Teacher
2. (2) Male, 49 years – Human Resources Manager
3. (3) Male, 68 years – retired Architect
4. (4) Female, 28 years – Ph.D. Student

Date: 26.05.2018

Duration: 50 minutes

The participants do all live in Enschede and have an interest in gardening, climate change and/or the water stress in Enschede. They were chosen to fit especially in the category of early adopters or early majority as they are well educated and (partially) have high financial liquidity. The recruitment took place by asking family and friends from Enschede whether they may be interested in the mentioned topics and want to talk about a product that may fight the problems of climate change and water stress with a product that may be useful for their gardening activities. These four have shown interest and decided to participate in a focus group. The participants have different educational and cultural backgrounds but do all know each other, i.e. they will not be too shy to express their opinion, and a discussion will be very likely.

(12 Minutes) Introduction:

Dear participants, I have invited you to be part of my focus group that consists of well-educated people who have a shared interest in either gardening, the climate change and water stress in Enschede. I want to present a possible solution for a problem Enschede is exposed to, but also the whole world must deal with – only maybe differently. While climate change made us suffer from excessive rainfall that leads to flooding, other countries suffer from drought. The governments do their best to help but the problem can only be overcome if awareness is raised and inhabitants take their responsibility to support in the progress of improvement. Therefore, the University of Twente has introduced a system called the Smart Rainwater Buffer that is supposed to be a bottom-up approach in fighting the water stress conflict in Enschede. This

means, that the SRB is a product that will be purchased and used by the inhabitants to help in preventing flooding from happening in the future. This is done by using a water harvesting system that can act as a buffer when the large-scale deployment was successful. To achieve this effect, potential users must be integrated in the development process to be able to provide a product that will fulfil their needs and represent their interests. I want to ask you some questions that you can answer in a discussion between each other. Please, be respectful and let the other one finish before saying something yourself and give everyone the chance to talk. I will document and evaluate your discussions for my Bachelor thesis. But first, I will give you an impression on how the product works.

Explanation of the image. Explanation of the SRB and that it only works on a large scale, so the municipality will subvention it. Price estimation: 400€, where the municipality covers half but user has single ownership.

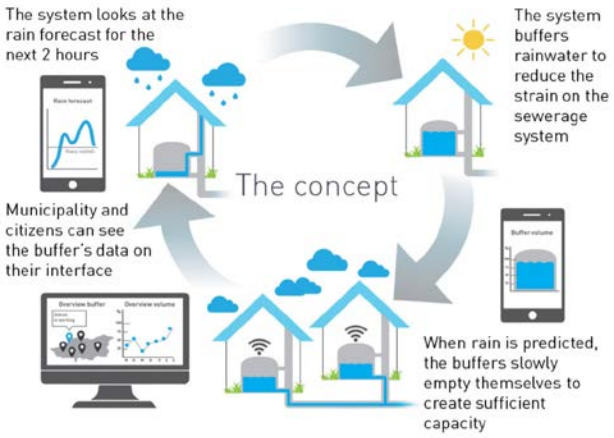

Figure D.1: The concept by Gelieke Steeghs [21]

As you can see, the overall concept and the product are already developed but how to make it consumer-ready must be still determined. What resulted from previous research by other students was, that a DIY-approach was most suitable for the distribution of the SRB. Therefore, the SRB we are working on now, does follow this approach. In other words, you are now here to tell me what is most important to you during this DIY and what should be included in the DIY manual.

I want to show you a first Mock-Up with all the planned components and the look and feel of the final manual. Please take some time to go through it.

Show Mock-up that was presented and chosen during second decision-maker interview (A5, coloured).

(30 Minutes) Questions and discussion:

1. Would you want to purchase the SRB when it is DIY?

Yes! I think, since it aims on distributing the responsibility of taking care of water stress and climate change, the self-assembly strengthens this aspect and makes the user more autonomous and is given trust by the municipality. (*1*)

I agree, it is not enough to give the citizens a product they place in their garden and forget about. They need to be involved and develop affection to the product. (*4*)

Well, it is not different than IKEA furniture. Everyone should be able to do it. (*3*)

Do you think so? I think, (4) would have problems using the tools by herself. (*2*)

To be honest, you are right. I would call someone to help me. The ethical aspect mentioned by (1) is very nice related to the DIY but I think it might be too much for someone like me who is not very handy. But in IKEA furniture they have an image that indicated that two people should assemble it together. I remember this because we have bought a new bed recently. My boyfriend called his friend to help. (*4*)

In the end it depends on the complexity of the DIY. I think it must just be explained so well, that everyone can do it. Even people who are not handy. (*3*)

2. When looking at the manual, there were not only illustration and text instructions but also video instructions available that could be watched online. What are your thoughts on that?

I think, that is common practice. Most companies provide something written and a video. Sometimes you can see people talk but in cooking videos on Facebook for example, you only see the hands and how they follow the steps. That would be very nice for me. To have real life footage of the product that will be assembled. The instructions on paper would be intimidating. (*4*)

Intimidating? That's not true. Just read them carefully. Most of the times, it is clear anyways where what belongs. (*3*)

If you are determined on setting it up, you would manage without video instructions. But – it is still handy in case the drawings or text are not descriptive enough. You can also compare what you have done better to the video that shows the real product. (*2*)

Why don't you use photos in the printed version anyways? That would be two flies with one hit! (*3*)

Because then the image can not be manipulated in such a way that it only shows what has to be seen. But there will be a video. So, everyone's preference is covered: Text, illustrations and real life footage. It is easy like this. (*1*)

But I think it is annoying when the video takes like 10 minutes. I only want to see what is essential. So, that should absolutely be considered. Three minutes are good. (*4*)

I agree, you should keep it nice and short. (*2*)

But in three minutes you cannot put all the information that is provided in the instructions manual? That is just not enough. (*1*)

The use of a video does not exclude the use of the manual. Just give a note at the end of the video that there is more information in the manual that should not be forgotten. But the manual should be made available online. For people who throw it away or lose it. (*2*)

I do not care about the video. Just put everything in the manual. That is good. (*3*)

3. After installing the SRB, would you want to maintain it?

I think that is out of question. Considering the price, that is not cheap for a rainwater barrel, I would absolutely take care of my SRB. (*1*)

Yes, you also clean your room, your phone, you water your plants, you do so much stuff. Why would you invest in a better future and just leave the barrel then by itself? It also helps you in everyday life. You save water, you save money. (*4*)

I understand the question. I think, there are people who want to set something up and just forget about it. They think, they have finished their duty. But in general, for someone who is even interested in purchasing this, you should not think that the average person will be like that. (*2*)

Is there an option of not maintaining it? Or why do you ask this? Otherwise it would break? (*3*)

No, it would not break, and it is not mandatory. Only cleaning the filter is. But the position of, e.g. the overflow does not have to be changed necessarily.

Ok, if it is not necessary, people may not do it. But I would. It is also good for me. So why not? (*3*)

4. What do you think of the overall design of the manual?

I think that it is nice. It really looks like from the municipality. But the font in the start is a bit small. The one you use in the end is better. (*2*)

I can read both without a problem, but I suppose older people will have problems. Also, I think it would be nice to put each assembly step illustration on an own page. On the left side the image, right side the explanation. Or at least only two images per page. (*4*)

Yes, use the bigger font. And make the illustrations bigger. The assembly process of what you have drawn is very easy, so that is not a problem when it is so small. But the final buffer will probably be more complex and need more details. Make the images bigger. (*3*)

I don't think there is anything to discuss. The design is appealing, the size is good. A larger manual would be annoying although images and text would have more space, but just use more pages. I think, it is a nice booklet that you do not want to throw away such as other instructions as soon as you are done. (*2*)

5. As the SRB only can buffer enough water when most households of Enschede have one, would you as an owner of an SRB recommend it to others? And how?

I would talk about it when there is an opportunity but not actively promote it. That is not my task. The municipality should run a campaign and promotions. (*3*)

Of course, the municipality must initiate the first distribution. But since it would improve everyone's daily life, I would tell my friends and family about it. I would like to use the graphic you showed us before or send them an information paper. (*4*)

Yes, just send them the information part in the beginning of the manual. I would and will absolutely mention this in school. My colleagues need to know about this. I think, since there is supposed to be an information part in the manual, I would just send that one. In the mock-up you showed us, the graphic was also there. So, it's perfect and I don't have a lot of work. (*1*)

What may be interesting, is that if you share the information part and someone decides to purchase the SRB, you could get a reward. Like a coupon or a little bit of money you spent on the SRB back. Maybe, if you manage to convince 10 people, you could get 50% back. (*2*)

Yes! Yes! That would be perfect for rising sales. And people who take the offer of their friends, receive also 10% off or something. (*1*)

Maybe you should be able to cut the information part out and give it to someone. Or it is pre-marked and you can rip it out neatly. That would be very convenient. I would give it to Johan. He also likes working in his garden and wants to try new things. (*3*)

(7 Minutes) Wrap Up:

Dear participants, thank you very much. These were all my questions. I am very happy that I have been able to pay you a visit to discuss these questions, as your opinions were what is still missing in my Bachelor thesis. It is an essential part of designing something good! I will keep you up to date and maybe, if you have time, you can evaluate the final product!

End of the focus group with some additional questions on the project by the participants.

Appendix E: List of Components Version 2.0

Version 2.0 - 23-05-2018

Source: Jeroen Waterink, j.waterink@student.utwente.com

Part	Name	Supplier
	Barrel + Tap 300 Liters	Hornbach
	Barrel Base	Hornbach
	Electronic Ball Valve 5v, DN32, CR02	CWX
	Pp reservoir connector DN32	Wildkamp
	Geka koppeling binnendraad 1 ¼ DN32	PVC24

	Raspberry pi 3B+	SOS Solutions
	US-100	Your Cee
	DS18b20 1 meter	HwaYeh
	2x S-lon® pvc gootuitloop met wartel 70 - 80 mm	Wildkamp
	VDL® vlakke epdm afdichtingsring, voor doorvoer, 3" 80 mm	Wildkamp
	Hammond Electronics RP1085C Universele behuizing 105 x 75 x 40 ABS Lichtgrijs	Conrad
Power source	5v	
	2 pin, 3 pin, 7 pin	MannHwa Smart Home Electrical

Appendix F: Script of Expert Opinion Video

Producer: Sefora Tunc **Expert**: Jeroen Waterink

Date of filming: 15.06.2018

1. *A finished SRB with the title "DIY Smart Rainwater Buffer – (Name)"*
2. *Jeroen stands next to the finished SRB.*

   "Hello, and thank you for purchasing the SRB! We are happy that you have decided to support in fighting the rainwater problem and at the same time act environmentally friendly by using your own harvested water. My name is Jeroen and today I will show you some tips and tricks how to assemble the SRB. We will start with drilling the holes!"
3. **Screen:** *A screen with the first chapter "Drilling Holes". Happy Music is playing.*
4. **Screen:** *A screen with the necessary tools.*

   "Therefore, you will need a hole saw with sizes 90, 40 and 25. Also, a Stanley knife or a normal knife is necessary."
5. *Jeroen stands next to a rain pipe and explains where the holes should be located. While he explains, he shows it to the audience.*

   "First of all, find a suitable place for your SRB that is level and preferably close to a rain pipe to be able to connect it later. Where you cut your holes depends on how you position the SRB and what your preference is. In total, six holes will be drilled."
6. *Show how hole for the in- and outlet are drilled.*

   "Use the 90 mm hole saw for the in- and outlet. The holes should be drilled on the top area of the SRB. Preferably on the side closest to the rain pipe."
7. *Show how hole for the tap is drilled.*

   "Use the 25 mm hole saw for the tap. The hole should be drilled on a side that is easily accessible for you."
8. *Show Jeroen holding the lid of the SRB.*

   "Using the 90 mm saw hole, drill a hole in the lid."
9. *Show Jeroen how he explains how to drill the hole in the bottom of the barrel.*

"Turn the barrel around and check for the lines on it. Use it as a reference and drill the hole using the same size."

10. *Show Jeroen standing in front of a table with the base on it. He explains that he now will drill holes into the base.*

    "Now we will prepare the base. First, take the Stanley cutter and take one of the holes where you want your hose to go through."

11. *Show Jeroen cutting the hole with a close-up.*

    "Now cut it and bend the part to the outside extending the hole."

12. *Show how hole is drilled in the side of the base.*

    "Now, drill one hole for the hose. Use the 25 mm hole saw for the hole."

13. *Show Jeroen standing next to SRB. He leans on it and points to the holes.*

    "Finally, we have finished drilling the holes and they can be prepared for further processing of the SRB."

14. **Screen**: *Show a graphic with chapter 2. Happy Music plays.*

15. **Screen**: *Show a graphic with the necessary tools.*

    "For this section, you will need the tap, two large rain pipe connectors, one small hose connector, Teflon tape and the sensor unit."

16. *Show Jeroen standing next to the holes. He takes the rain pipe connectors and puts them through the holes. The camera is not far away and not too close.*

    "We start with the large rain pipe connectors. Take them and put them including the rubber inside the hole. If they do not fit, consider making the hole larger using e.g. rough sanding paper. Now twist the other part around it and make sure it is tight."

17. *Show Jeroen sitting next to the SRB that lays on the side. He holds the two pieces (tap and valve connector).*

    "The next thing to do is inserting these components. Put the pipe in the front of the SRB and the hose connector in the bottom. You need to crawl inside the barrel to reach these holes. Again, put the parts including the rubber from the inside and twist their bolts on."

18. *Show close up of twisting the bolts on.*

19. *Show how Jeroen holds the tape while sitting in front of the valve connector.*

    "Take the tape and wrap it around the valve connector to avoid leaking."

20. *Show close-up of Jeroen twisting the tape around it.*

"Make sure, that it is applied clockwise. Else it will get loose when connecting the valve."

21. *Show Jeroen holding the cover of the SRB and connecting the sensor unit to it.*

"The following step is to connect the sensor unit to the lid. That is easy. Just twist it on and put it to the side. And that's it for preparing the holes!"

22. Screen: *Show Screen of the next chapter. "Making the SRB smart"*

23. Screen: *Show necessary tools.*

"For this step you will need X X X and X."

24. *Show how Jeroen sits in front of the SRB that is laying on the floor and puts the cable of the sensor unit through the back of the base. The base is upside down.*

"Put the lid on the floor and put the cable through the base in order to have access to the cable."

25. *Show a close-up of Jeroen how he puts the cable through.*

26. *Show close-up how he put the cable for the power plug through as well.*

"Now put the cable for the power plug through as well."

27. Show Jeroen sitting next to the SRB base with the hose. He puts it through the base and turns it around.

"The hose must go through the last holes. If you have extended it sufficiently, it should go through easily."

28. *Show Jeroen sitting in front of the SRB and holding the electric valve. He talks and twists it on.*

"Twist the electric valve on and make sure that it is on a horizontal line, so everything will fit in the base."

29. *Show close-up of Jeroen pointing out that the valve is level.*

30. *Show Jeroen sitting in front of SRB with computing unit.*

"Now we have all three cables that must be connected to the computing unit of the SRB. Take the computing unit and connect the cables to the respective hole."

31. *Show close-up of connecting the cables and putting it in place.*

"Explanation of how many pins must go where."

32. Show Jeroen sitting in front of the SRB. A bit closer so you can exactly see what he does to the hose.

"The final step for the inside of the base is connecting the hose. Hose clamps and put one on each side of the hose. Then put the GEKA connectors inside of them and tighten the hose clamps using your screwdriver. Both – and x work."

33. Show close-up of tightening and then connecting the hose to the hose connector.

"Connect it to the hose connector and then you are finished with the inside of the barrel."

34. Chapter Screen – "Final Touches"

35. Show Jeroen putting the SRB on the base and putting the lid on.

36. Show Jeroen standing next to the finished SRB and smiling.

"You have almost finished assembling the SRB. Please refer for further information to the manual, telling you everything about the maintenance, warnings and other interesting things about the SRB, such as your own account on our website! It was a pleasure helping you."

37. Show Jeroen going to plug in the SRB, and the screen becomes black.

Appendix G: Pre-User Test

Participant: Male, 22 years – non-technical background

Date: 20.06.2018

Duration: 27 minutes

1. **Observation**:
    - Uses manual.
    - Looks at the information page but does not read it.
    - Looks at the component list very quickly.
    - Laughs about the safety measures and thinks that they look like IKEA warnings.
    - Starts the assembly by reading the text and then looking at the images.
    - Attaches the bolt of the downspout connector wrongly.
    - Puts the rubber ring on the wrong side of the tap.
    - Follows the steps correctly until he must put the hose. Does not understand how to put the hose inside the base and needs additional help. “The text is unclear.”
    - Puts on the hose clamp first but then recovers from the mistake and attaches it correctly.
    - Does the next steps correctly until he must place the Computer Unit.
    - Places the Computer Unit in such a way, that there is a problem in the end with fitting the barrel on the base. “It would be nice to have two people”

2. **Comments of Participant:**

In the end of the assembly, the user was asked for further input in an unstructured interview in order to determine his thoughts on the instruction manual.

1. The participant does not entirely understand the principle of the SRB and asked whether the barrel is included in the DIY-kit or an own barrel will be used.
2. As the barrel will be delivered, he thinks that the holes should come pre-drilled.
3. The assembly time was not perceived as too long. “Not for what you get.”
4. He would prefer a video over having a manual. He uses an example of repairing his tire using an instruction video.

5. He did not notice that there was a video.
6. It was most difficult putting in the hose.
7. It was the easiest to put in the downspout connector.
8. He read the text before looking at the images. The combination was good.
9. He did not look at the overview image. He did not understand why it was important.

3. Conclusion:

Changes that needed to be made based on the pre-test were summarized in a list and applied to the design in order to be able to focus on less obvious problems.

1. Make clear which side of the bolt from step 3 must face the barrel. – Text was altered
2. Make clear that the rubber from step 4 must be inside the barrel. – Text was altered
3. Make the text of the hose clear. – Text was altered
4. Make clear how to fit everything in the base. – Text was altered
5. Presentation of the video instructions must be more prominent. – Video instructions were introduced instead of the dashboard on page 2.

Appendix H: Questionnaire on Adopter Group Identification

A questionnaire has been prepared that collects information about the user's demographics and about certain characteristics that have been established in determining which adopter group a user belongs to based on the Theory of Diffusion by Everett [84]. The characteristics are education, financial liquidity, interest in innovation and importance of innovation.

These were changed into questions, such as "do you have a technical background?" to determine the education and field of interest. Technical Job gives 2 points, Technical study 5 and no technical background gives none. The other questions can give up to 5 points each, i.e. in total, you can have 20 points. This means, that people from 1-4 points are laggards, from 5-8 points are late majority, from 9-12 points are early majority, from 13-16 points are early adopters and from 17-20 points are innovators.

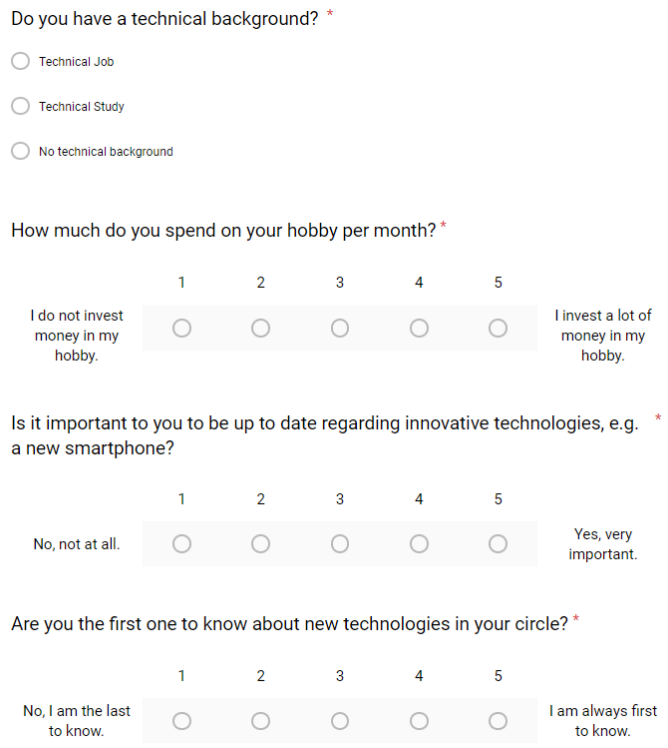

Figure H.1: Questionnaire to determine adopter group for each participant of the user-test based on characteristics set by Everett [84].

Appendix I: Final instruction manual design with incorporated client and user test feedback

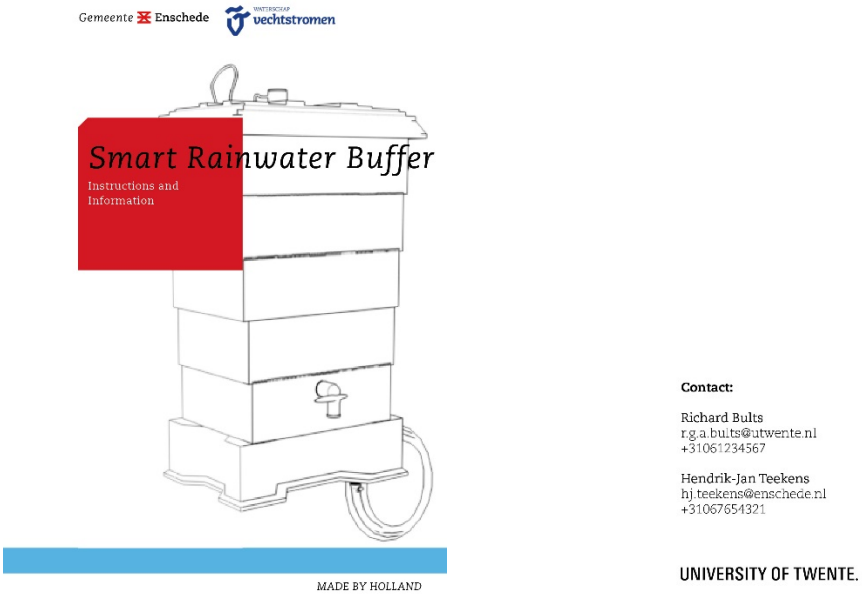

Figure I.1: Final front and back page of SRB instruction manual.

Figure I.2: Final information section of SRB instruction manual.

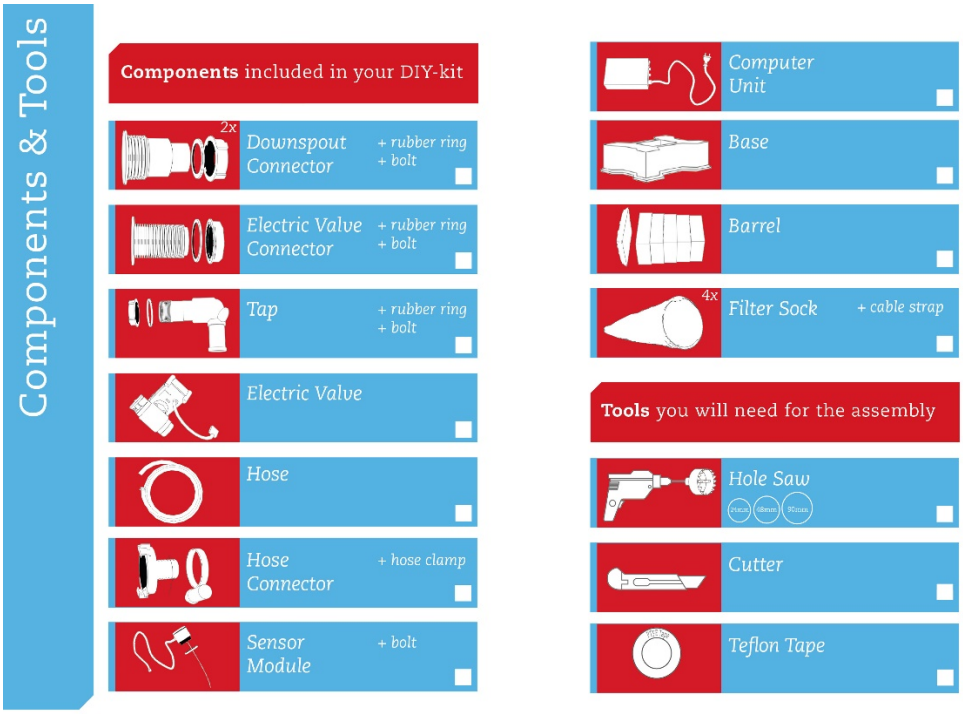

Figure I.3: Final components and tools section of SRB instruction manual.

Figure I.4: Final "before the assembly"-section of SRB instruction manual.

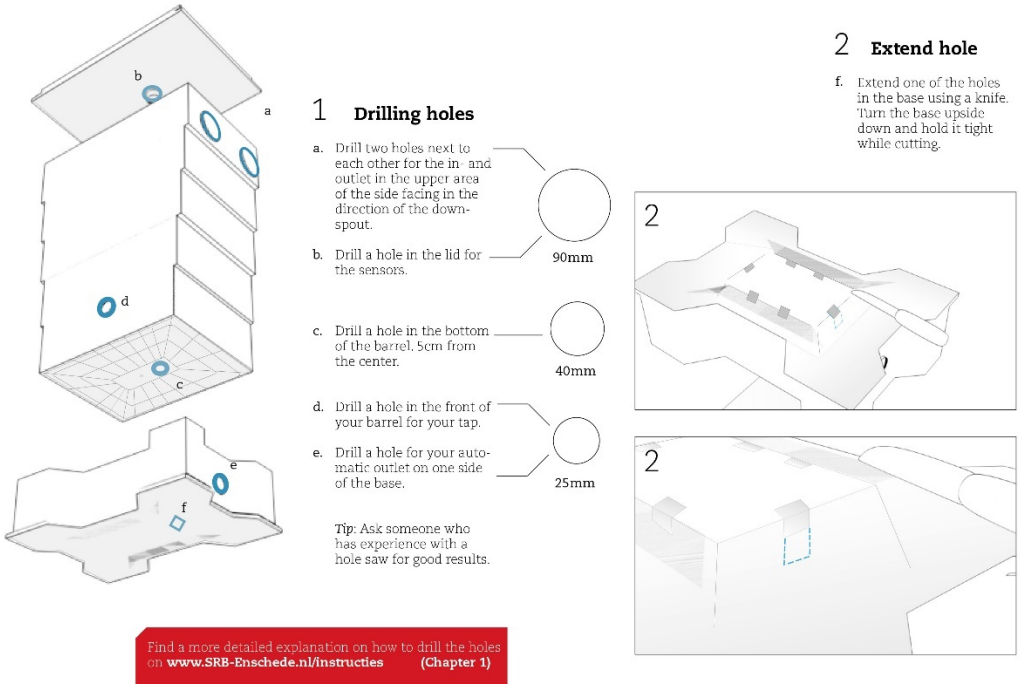

Figure I.5: Final step 1-2 page of SRB instruction manual.

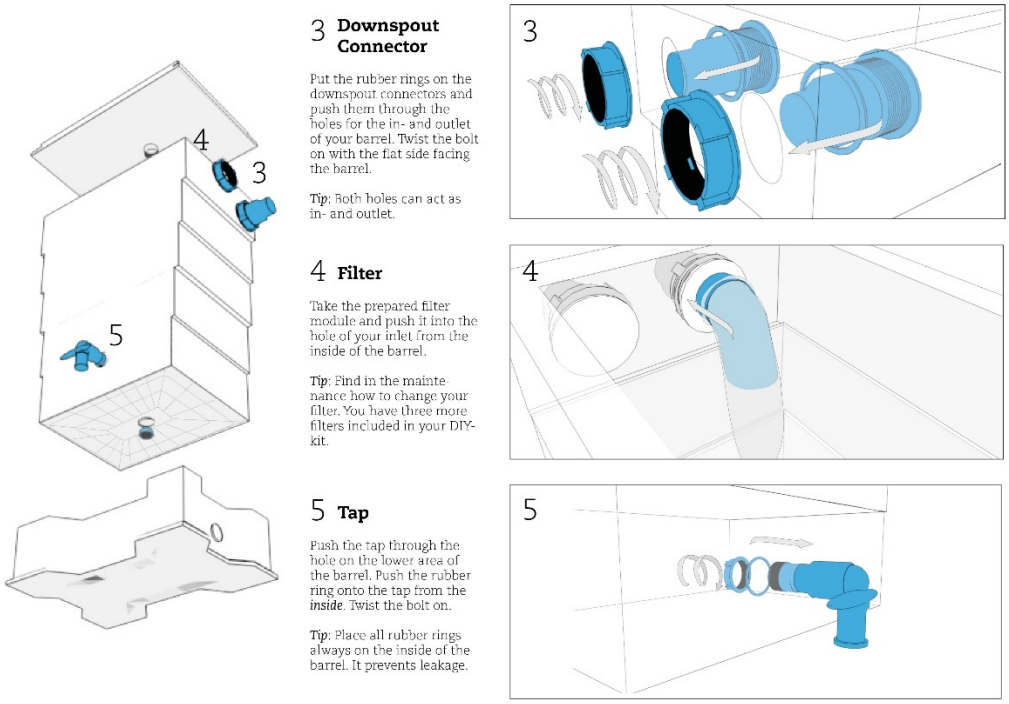

Figure I.6: Final step 3-5 page of SRB instruction manual.

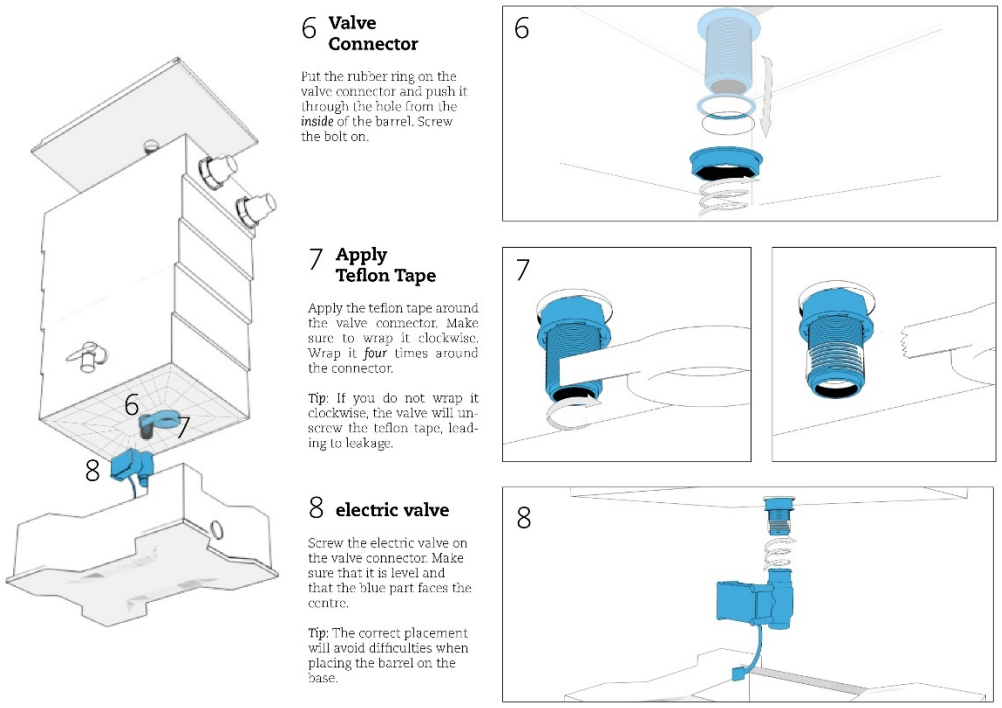

Figure I.7: Final step 6-8 page of SRB instruction manual.

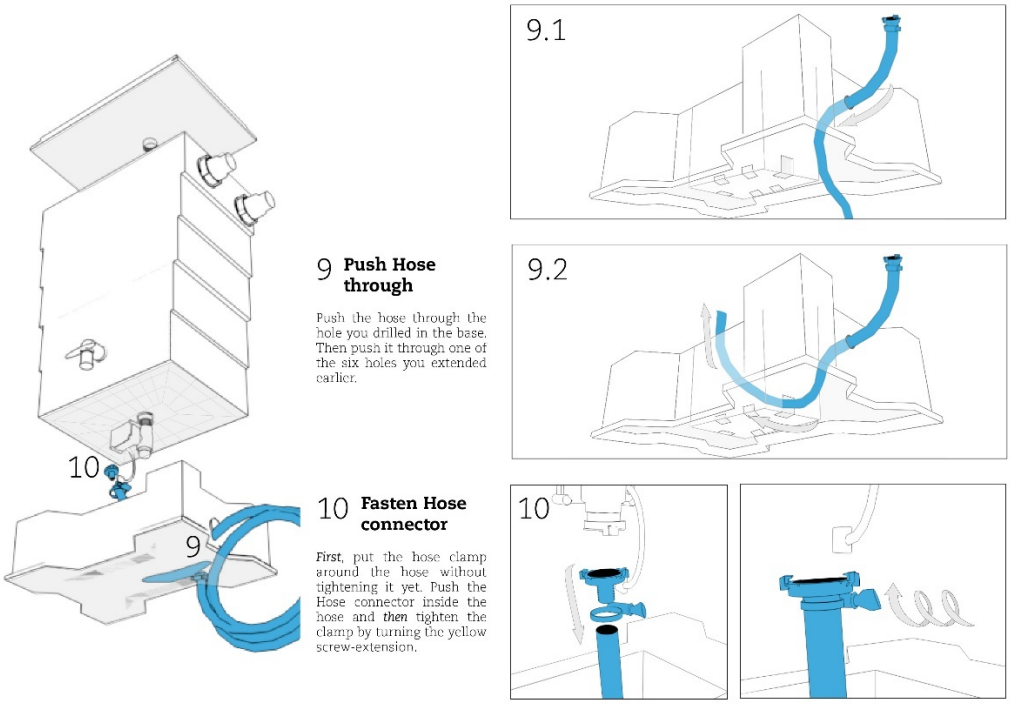

Figure I.8: Final step 9-10 page of SRB instruction manual.

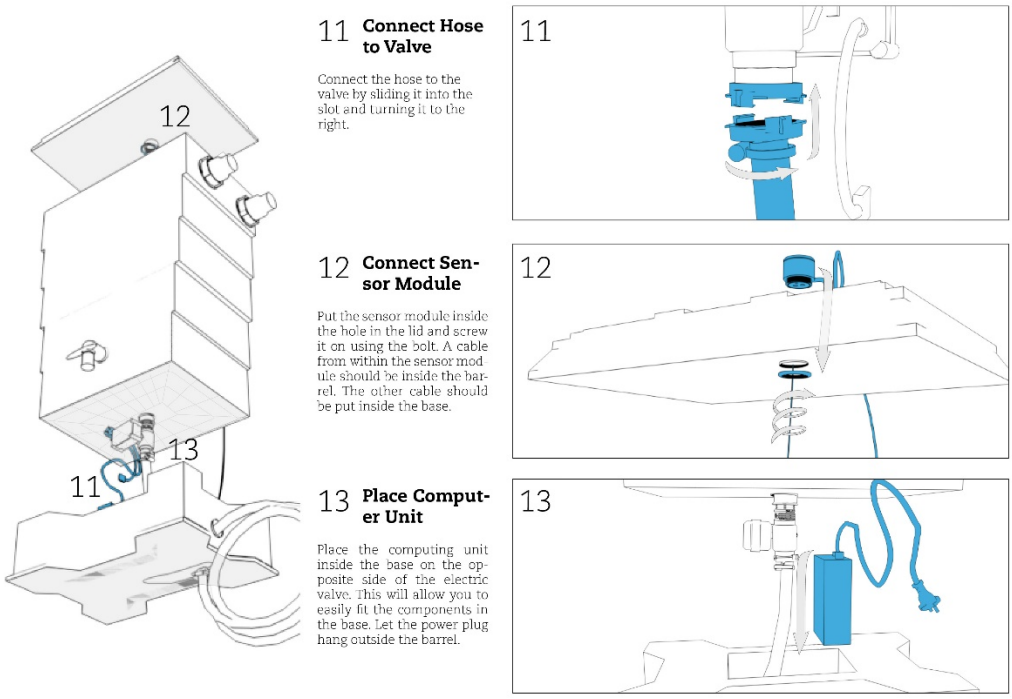

Figure I.9: Final step 11-13 page of SRB instruction manual.

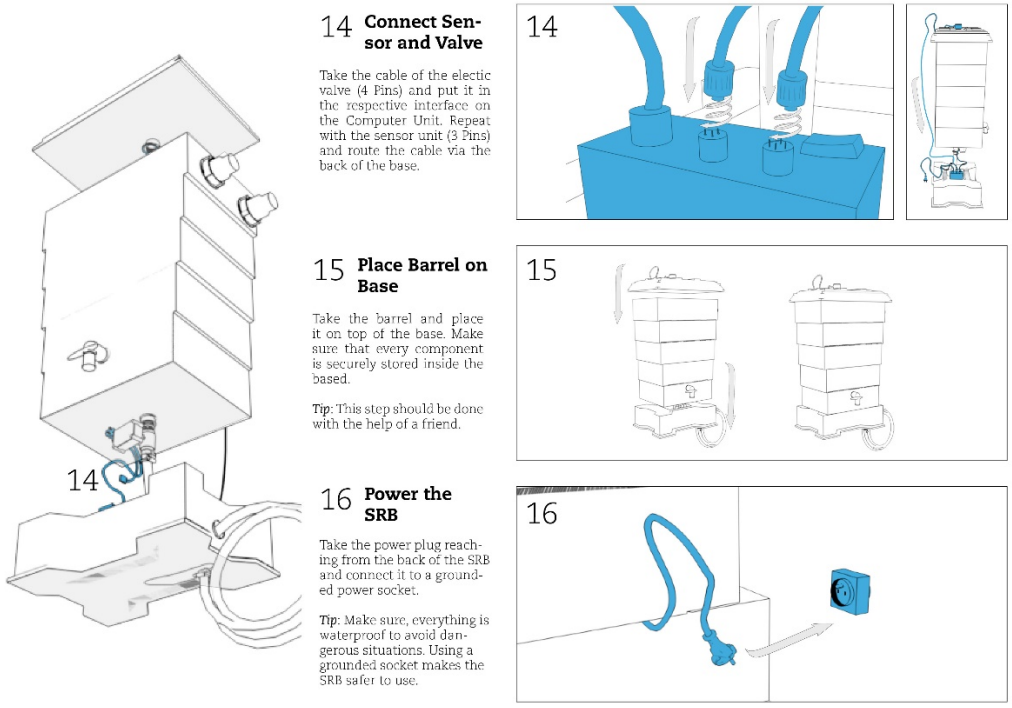

Figure I.10: Final step 14-16 page of SRB instruction manual.

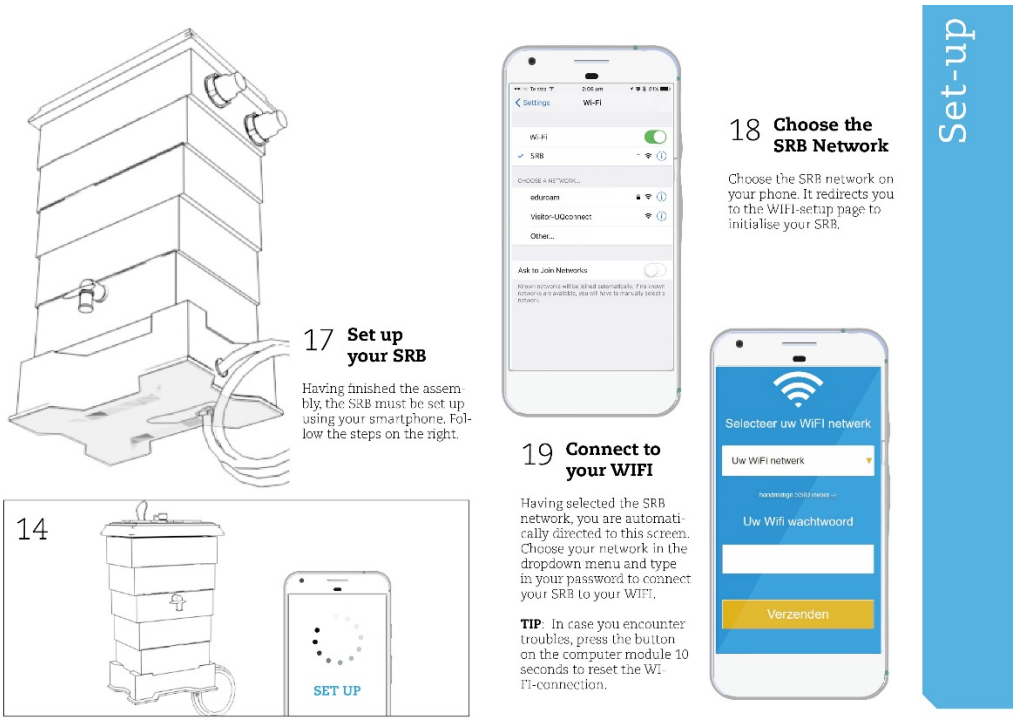

Figure I.11: Final step set-up section of SRB instruction manual.

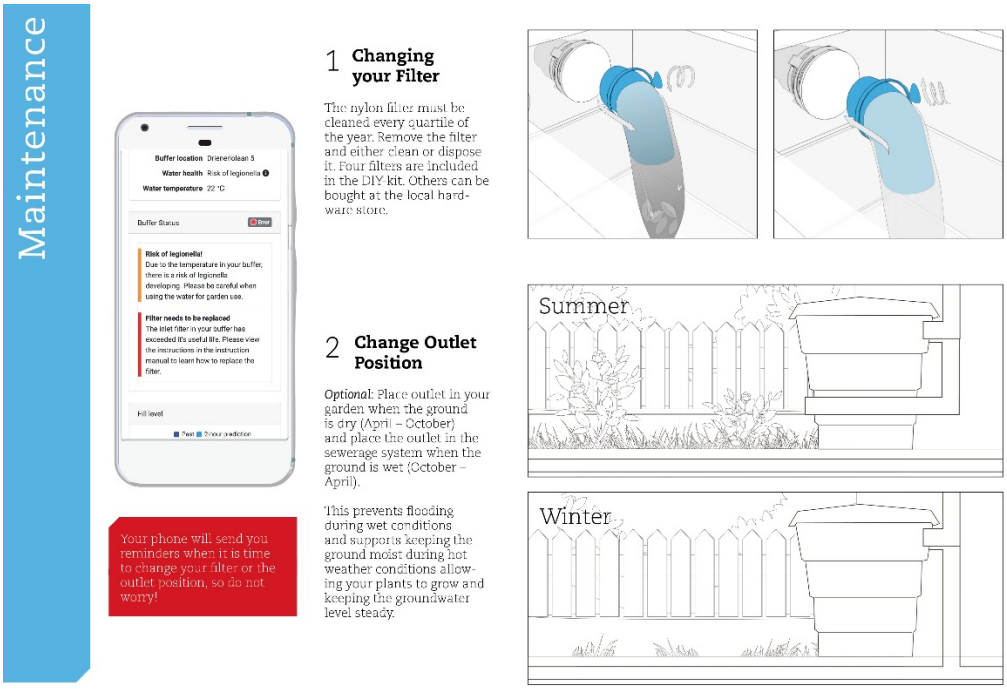

Figure I.12: Final maintenance section of SRB instruction manual.