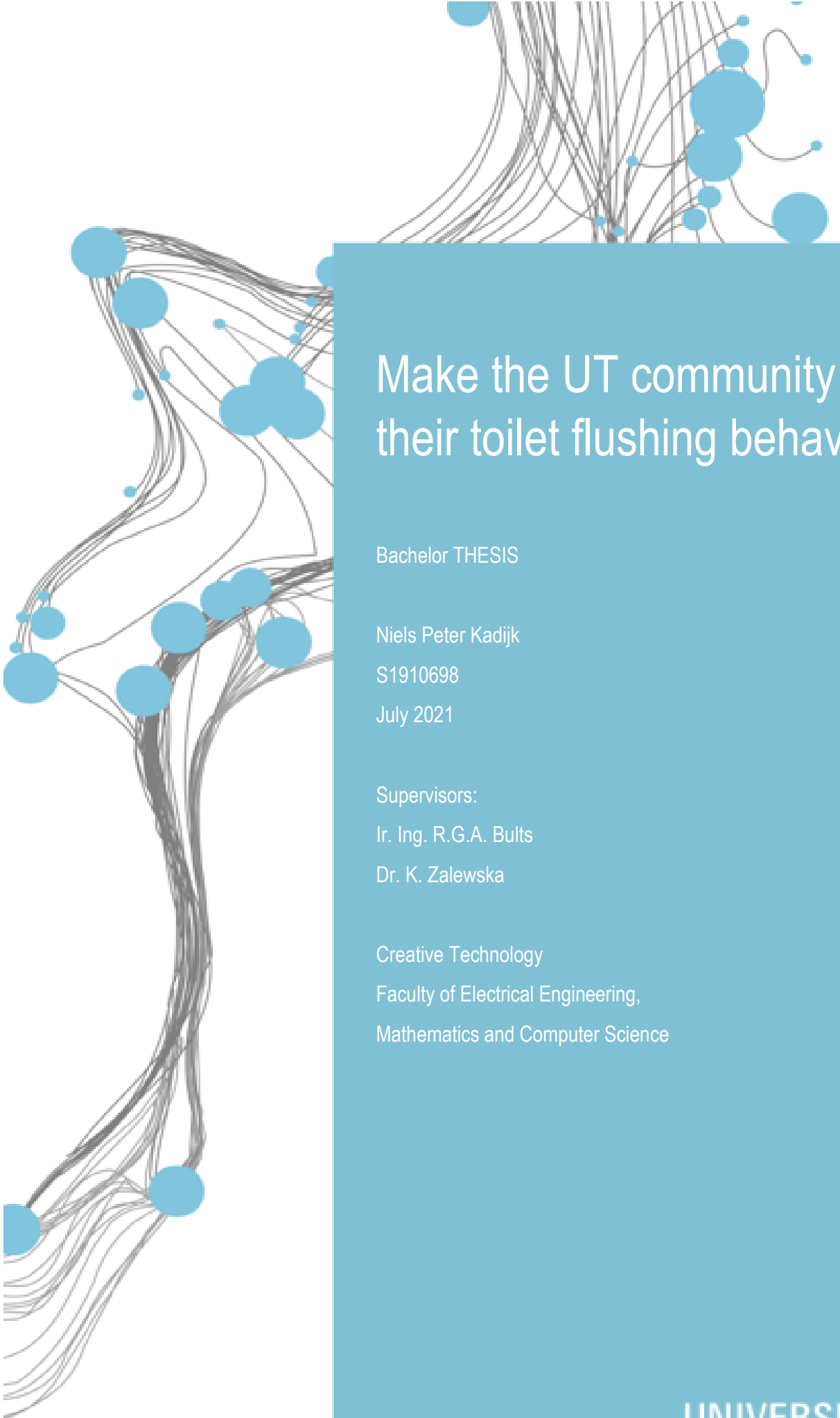

Make the UT community aware of their toilet flushing behaviour

Bachelor THESIS

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Abstract

Water shortages are becoming a more common problem, even in the Netherlands which is considered a “wet country”. Water should not be wasted and a possible method to save a lot of water is the dual flush toilet. This toilet allows for a large flush for solid waste and a small flush for liquid waste, by using this small flush a lot of water can be saved. However, not everyone always flushes correctly and water is still being wasted. This project focused on making the UT community more aware of their flushing behaviour which might hopefully lead to behaviour change.

A prototype system was developed that uses memes to provide feedback about the user’s flushing behaviour. Memes fit the target audience of the UT community well (80% students and 20% staff) and allows to provide contextual information to be provided in a fun way that can remain interesting. This contextual information can explain about proper usage, water usage, consequences and comparisons. The system consists of an instrumented normal dual flush panel, a micro-computer and a colour display. The micro controller uses the flush panel input to select an appropriate meme. This system was placed in both a male and female toilet in the UT’s Ziverling building were users were asked to fill in a questionnaire to see if their awareness has increased. From this survey with 19 respondents, it was concluded that it did raise people their awareness of their flushing behaviour and that some users plan to use the small button more often.

Acknowledgements

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1 Introduction

1.1 Context

Even in the Netherlands, which is considered a “wet country”, droughts still happen. Simply put, a drought occurs when there is not enough water to meet demands. These water shortages can result in damage to the agriculture sector and nature, difficulties for the shipping industry, and shortages of drinking water suppliers. Especially in the east of the Netherlands, this is already a problem due to climate change [1] and is expected to increase in the future [2].

To partially solve this issue, water waste should be limited. Per day a person spends on average 107 liters of water of which 32.7 (˜30%) liters is spent by flushing the toilet [3]. A solution to reducing this amount is the dual flush toilet which gives an option of a smaller flush (e.g. 3 liters) and a bigger flush (e.g. 6 liters) and can therefore save up to 67% of water used to flush [4]. However, research indicates that people don’t always use the dual flush system correctly [5]. Inappropriate use of the dual flush system results in unnecessary water use.

Educating people about the proper use of a dual flush toilet might improve water conservation [5]. Additionally, raising awareness of the consequences of their actions on the environment might help change their behaviour [6,7]. Therefore, this research focuses on raising awareness that aims to change the behaviour of people not using the dual flush toilet system appropriately. This project is done together with the campus facility management (CFM) who also focus on sustainability [8].

1.2 The challenge

To have people become more aware of their flushing behaviour there are two main challenges. Firstly, a solution must be developed to measure the amount of water used for a toilet flush. Current studies measuring the water use can be costly, invasive, and can disrupt workers [4]. This solution should be low-cost, non-invasive to a person’s privacy, and not disrupt anyone. Additionally, it should be able to work in different toilet designs and use little electrical energy.

Secondly, people need to be more aware and educated about how to use a dual flush system properly and be given feedback about their behaviour. The challenge is to develop the best way to communicate with the toilet user. The information about how to use the dual flush toilet will need to focus on what is necessary to know and how to comprehensively provide this information. The feedback will need to be applied at the right moment with the right feedback message to the actions of the user. Both the information and the feedback will help to raise the

awareness of the user and potentially influence their behaviour. This awareness raising will be focused on the University of Twente community which has multiple dual flush toilets on the campus. While this is a specific target group the results could still give insights in saving water at other non-domestic "public" buildings.

1.3 Research questions

To raise awareness and potentially change the behaviour of toilet user at the University of Twente the main research question of this paper is:

How to make the UT community members aware of their toilet flushing behaviour?

With the following sub-questions:

1. *How to provide information about the proper utilization of the dual flush option?*
2. *How to measure and store flush water usage?*
3. *How to provide timely and effective feedback on flush water usage?*

1.4 Outline

This research is structured in eight different chapters. Chapter 1 introduces the problem and outlines the context, challenge and goals of this paper. Chapter 2 provides background literature information and looks at the state of the art products related to this project. Chapter 3 explains the methods and techniques that are used during the research. In chapter 4 preliminary requirements are obtained, ideas are generated and a final idea is chosen. Chapter 5 then specifies how the final product interacts with the user and what the functional and non-functional requirements are. In chapter 6, with the requirements in mind, a prototype is finalized and build. Chapter 7 then evaluates the prototype based on the functional and non-functional requirements from chapter 5. Finally, in chapter 8 a conclusion will be made together with future recommendations.

2 Background Research

To get a better understanding and an answer to the research questions mentioned earlier a background research has been conducted. First, a model is discussed to better understand behaviour change. Second, different feedback design dimensions are considered. Last, the technology acceptance and possible side effects will be discussed.

Afterwards a look will be taken at examples of existing technologies in the state of the art of the existing technologies will be presented in section (2.2) including different measurement techniques and examples of feedback installations.

2.1 Literature research

2.1.1 Transtheoretical model

The goal of this research is to make the University of Twente community more aware of their flushing behaviour. Hopefully, in the long term this can lead to a behaviour change. According to the transtheoretical behaviour model change does not happen at once but in multiple stages [9]. Even though the model focuses on health behaviour, it is also applicable for changing the sustainable behaviour of people and has been used in this approach by research as well [9,10].

The first stage is the pre-contemplation stage in which people do not intend to take action since they do not have the information or are underinformed about the consequences of their behaviour. Afterwards, people will be in the contemplation state in which people intend to take action in the next 6 months and know the pros and cons of their behaviour. The third stage is the preparation in which people will try to change their behaviour in the immediate future. The fourth stage is the action stage in which they have recently changed their behaviour. Lastly, when this new behaviour lasts and people try to maintain their (new) behaviour people they are in the last maintenance stage.

Looking at these five stages, the most relevant stage for this research is the pre-contemplation stage. It seems likely that the major reason for people not using the small flush option appropriately is that they are not aware (enough) of the consequences of their actions. In a sustainable context He et al. refers to this stage as: "*Plant the seed to acknowledge problematic unsustainable behaviours*" [9,pp.5]. This is also in line with research done by Cellina et al. [10] about apps to improve sustainable behaviour, which gives the following definition: "Increase

awareness for causes, consequences and cues about a behaviour" [pp. 6]. For this stage, they suggest the following techniques: Provide general information, provide information on consequences, provide feedback on performance. How to provide this information and feedback will be discussed more in-depth later on.

Some people might also be in the contemplation stage, where they plan to change their behaviour at some point in the future. The contemplation stage is also relevant for this research since it focuses on "*tipping the behaviour in favour of change"* [9, pp.5.]. Here Cellina et al. [10] suggest to providing instructions and model/demonstrate the desired behaviour. Hopefully, this results in people moving to the preparation stage where they plan to change their behaviour in the immediate future.

By focusing on the pre-contemplation, contemplation and preparation stage it should be possible to move people to the action stage where their behaviour is changed. The focus of this research is to bring people to this stage by focusing on the first three stages. This should move people to the action stage which might result in people changing their behaviour.

2.1.2 Feedback & information design

To design feedback on sustainable behaviour to users, an overview is needed of the different dimensions that are important. A review done by Sanguinetti et al. [11] gives a comprehensive overview of multiple dimensions that can be used to design feedback. In their review, they focus on eco-feedback for which they use the definition by McGalley and Midden [12]: "information presented during the product-user interaction which prompts the user to adopt energy saving strategies". This definition seems to fit the aim of this study, although this study focuses more on awareness instead of behaviour. The review of Sanguinetti et al. distinguishes three different mechanics related to behaviour change: attention, learning and motivation. Hence, this paper has been chosen as the main source for determining the design dimensions. For every dimension provided the advice given by Sanguinetti et al. in combination with additional sources when necessary will be discussed.

In their paper, three main questions are discussed regarding feedback:

- What information is presented?
- When is the information presented?
- How is information presented?

This gives three different categories: information, timing and display respectively. These categories are again divided into more specific dimensions as seen in Figure 1. By looking into the different dimensions more insight should be gained about how and when to provide information and feedback. [11] Besides these dimensions, a look will be taken at technological acceptance and possible side effects of eco-feedback.

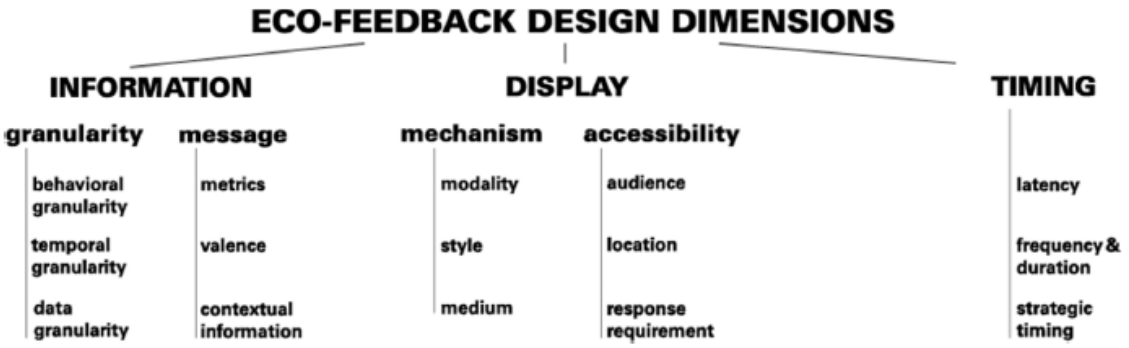


Figure 1: Eco-feedback design dimensions according to Sanguinetti et al. [11]

2.1.3 Information: Granularity & message

The first category, information, focuses on the information provided with the feedback. This information is divided in three different dimensions; in the amount of detail in the information, the complexity of the data and the what time frame is represented in the data.

2.1.3.1 Behavioural granularity

One type of granularity (the degree of detail of information) is behavioural granularity which is about user behaviour represented in the data. For example, this could be individual user data but also data on how the UT community performs as a whole i.r.t. appropriate use of dual flush toilets. In general, Sanguinetti et al. argue that a more specific approach to the individual user and its specific behaviour is more useful [11]. However, they also mention that while being more specific improves the learning of one person, it is difficult to reach multiple people with this approach. Additionally, providing data about the community's performance might also be beneficial but will be discussed more later on (2.3.6).

2.1.3.2 Temporal granularity

Another type of granularity is the temporal granularity which focuses on in which time frame the data is represented. An example of this is immediate feedback on certain user behaviour. If related to toilet flushing behaviour this could be the immediate feedback of how

much flush water the users uses versus how much water is used by one person flushing a toilet on average. Sanguinetti et al. [11] suggests that when the data presented is closely related to the behaviour it improves learning. This is related to immediate feedback which is discussed more in depth later (2.5.1)

2.1.3.3 Data granularity

Besides the target behaviour, it is also important to look at how complicated the data is. Sanguinetti et al. describe this as data granularity, an example is the difference between a feedback system with a flashing light versus one where numerical data is provided to the user. They suggest that if feedback that catches the attention is combined with more simple data it can trigger further investigation at which point you can provide more complicated data to support learning.

2.1.3.4 Metrics

Besides the granularity, the message is also an aspect that falls under the information category. Again, several dimensions are described, first of all, the metrics. Metrics are numerical data that is shared with the user, for example how much water is used exactly. Sanguinetti et al. [11] mention that one of the difficulties in communicating about energy (electricity) usage is that it can be difficult to understand. However, Sanguinetti et al. argues that this is not the case for metrics about water usage since they are easier to understand. Another difficulty can be that metrics, and especially scientific ones, may not motivate users. A solution is to talk about the direct consequences of their actions, for example, the number of trees saved. Last of all Sanguinetti et al. mentions that offering different metrics is also a promising way of dealing with these difficulties. [11]

2.1.3.5 Valence

Second, a message can be displayed phrased either positive, negative or neutral. For example, water usage (neutral) can be described as water waste (negative) or water savings (positive). Additionally, a distinction can be made by targeting and rewarding good behaviour or bad behaviour. Both of these will be discussed in an attempt to gain insights into what approach fits best. Firstly, the advantages and disadvantages of negative feedback, will be discussed. Sanguinetti et al. [11, pp. 60] argues that: *"... negative valence may be appropriate for eco-feedback to increase awareness of the consequences of consumption (which are negative), thereby increasing motivation via moral/pro-environmental norms."*. Additionally, this is

supported by the concept that people want to avoid loss. However, they also argue that positive feedback gives a better user experience and acts as positive reinforcement. This view is also supported on an experiment where positive points resulted in 2.5 times more logins on a website providing feedback on people their sustainable behaviour. [13] On the contrary, another research looking at the difference between positive, neutral and negative modality found that while they work equally well while the feedback is given, negative feedback has a more long-lasting effect. While positive feedback enhances the user experience negative feedback might be more effective at changing the behaviour of the user. This effect seems to make sense if a look at the impact on emotions is used.

Positive and negative feedback has a direct influence on how someone feels which again influences on how they will act. A study observed that stronger negative emotions such as guilty, upset, embarrassed and annoyed stimulated more sustainable actions [14]. In contrast, positive emotions like satisfied, proud, interested and joyful increased the perception of the user. They evaluated the aesthetics, usefulness and overall quality higher. On the whole, this is similar to the results found in the findings discussed earlier. However, several studies also claim that positive reinforcement is the only right option as opposed to negative reinforcement [9,15,16]. Reinforcement is slightly different from feedback since it focuses more on rewarding or punishing right or wrong behaviour while feedback can also be neutral or more informative. Nevertheless, reinforcement is an aspect of feedback that is still useful to discuss.

Positive reinforcement is the rewarding of an action performed right, for example giving your dog a treat if he listens to you. Geller. argues that: *"the popular common sense believe that we learn more from our mistakes than our achievements is wrong."* [16, pp. 528]. Specifically, it is explained that when positive recognition is delivered correctly it changes not only the behaviour but also the attitude of the user. In addition, recognizing people's environment-protective behaviour will stimulate more learning then criticizing their destructive behaviour. In short, multiple sources claim that positive reinforcement should be used instead of negative reinforcement. A possible solution might be combining both positive and negative feedback and tyring to get the benefits from both. In a review on using feedback through digital technology 55 studies out of the 72 researched studies delivered feedback so that both negative and positive feedback could be given [17]. Another 12 studies provided neutral feedback, 4 used negative and only 2 used positive, so a mixture of both is clearly the preferred option for most studies.

A potential benefit of neutral feedback might be that it has less effect on the emotions of people. On the other hand, it might also have less of an impact then positive and negative feedback. Unfortunately, no good comparison of neutral feedback with negative or positive feedback have been found.

2.1.3.6 Context

Last of all, the information that is provided can be given with additional context. Sanguinetti et al. [11] found that an effective strategy is showing comparative data. Examples of these are social, historical and goal comparisons. One study found that goal comparisons are most effective followed by historical comparisons and social comparisons. These can also be combined to provide, for example, a historical comparison from yourself and others. While a history of an individual's own performance will not work in the case of an office building, competition between different buildings or departments might stimulate more sustainable behaviour. Besides comparisons, different contextual information could be given, for example explaining more about how water usage effects the environment. This is also supported by a review done on water conservation interventions [18]. The authors argue that when tips are presented in a drought context these tips are more effective at changing behaviour.

2.1.4 Display: mechanism and accessibility

Besides knowing what information should be given it is important to know how this is delivered. First a look is taken at different mechanisms to communicate and second, if the information is accessible to the right target group (audience).

2.1.4.1 Modality

Modality is about how the feedback is given to the user, for example by using visuals. Besides visuals, feedback could also be provided by using different senses like audio or tactile. Even smell and taste could be used to give feedback, but this is a method that is used less in eco-feedback [11]. A type of feedback that makes use of visuals is ambient feedback. This type of feedback is a more subtle and aesthetically pleasant method of giving feedback. Ambient feedback often uses lights to display a message, for example green for sustainable behaviour or red for unsustainable behaviour. Deciding what suits best for an intervention mostly depends on factors earlier discussed, like the granularity or message. For example, ambient feedback can help people but lack in the amount of information that they can give.

2.1.4.2 Style

When providing data this can also be done in multiple styles, for example, numbers, text graphics, etc. Three different types are identified by Pierce et al. [19], the two main ones are pragmatic and artistic visualizations. Pragmatic visualizations are focused on informing an user by providing data and numbers while artistic visualizations are abstract and can be used to persuade and convey a certain point of view. A mix between this is also possible with informative art which stands in the middle of pragmatic and artistic. Again, a combination of both artistic and pragmatic visualizations is also possible and might even be beneficial. Indeed, prior research about giving either numeric (pragmatic) or ambient (more artistic) feedback about shower usage, the recommendation was to provide either both types of feedback or find the "sweet spot" of a hybrid design [20].

2.1.4.3 Medium

Another dimension that should be considered according to Sanguinetti et al. [11] is the medium. This focuses on how the data is presented, for example, digital or paper. Nowadays digital eco-feedback (e.g. laptops, screens, monitors, etc.) has become more popular and is argued to be more effective than paper feedback. However users also prefer to have the flexibility of using multiple mediums.

2.1.4.4 Audience

When designing feedback, it is important to take into account who the feedback is given to. Additionally, who has access to the feedback is something that will need to be considered. In this study the target group is the UT community as a whole consisting for the biggest part of students but also teachers and other staff. Sanguinetti et al. [11] discuss the benefit of the ability to share your performance on social media but because of the private setting, this seems undesirable for this research [11].

2.1.4.5 Response requirement and location

If it is known who can access the information the difficulty of getting to this data, or response requirement, should be low effort. This also relates to the last dimension, the location of the feedback given. The knowledge can either be accessed in real-time at the place where the behaviour took place or in a more central place where the data gets shared with multiple people and could spark discussion.

2.1.5 Timing: latency, strategic timing, frequency and duration

Besides knowing what information to display it is also important to know when to give this information. First, it is important what the best moment is to provide feedback which is called strategic timing. Second, the delay between the feedback and the action will be discussed concluding with a short discussion about the duration and frequency of the feedback.

2.1.5.1 Strategic timing and latency

Timing can be interpreted in multiple ways and depend mostly on the context. Fogg [15] compares timing with the so-called 'Kairos', which means finding the opportune moment to present your message. He continues to explain that timing depends on elements in the environment like mood and feelings. This view is supported by Sanguinetti et al. [11] with their description of strategic timing: "Feedback presentation can occur at strategic times, when consumers are most able or likely to attend to and respond to it, rather than continuously/on-demand or at regular intervals". An example given by Sanguinetti et al. is a shower meter that is only activated when the shower is turned on which makes the relation between the behaviour and the action very clear. Since giving feedback about flushing behaviour is similar to this example immediate feedback might be appropriate. Immediate feedback says something about the latency, the delay between the action and the feedback. If immediate feedback is given there is no delay between the action and the feedback or the feedback is even given during the action.

The alternative to immediate feedback is to have a delay between user behaviour and feedback given. An example of this would be if after flushing the feedback would be given a minute later instead of immediately after pushing the button. Another example is the electricity bill at the end of the month which is a delayed feedback of the consumption by a user. In [17] 72 studies were reviewed of which 20 delivered feedback with a delay and 52 studies gave concurrent feedback, so feedback during or directly after the action. One study compared both and suggest that a combination of both immediate and delayed feedback could be the most beneficial since it provides additional information [17]. However, research indicates that immediate feedback is more effective than feedback with a delay [21,22]. In fact, research by S. Darby [21] showed that direct immediate feedback reduced energy usage by 5-15% while feedback that took longer and was first processed resulted in 0-10% increase. Additionally, immediate feedback can better support learning, especially when looked at from an education

perspective [23]. A reason for this is that users can directly relate the feedback with the action they are performing or just performed [11]. Lastly, when positive reinforcement is given research [9,15] suggests that this should also be done immediately. In other words, most research done seems to support the use of immediate feedback over delayed feedback.

2.1.5.2 Duration and frequency

Another important question is to see for how long and how often feedback has to be provided. Frequent feedback is suggested to work more effective for learning and is also preferred by users. Additionally, if a lot of data needs to be shared a possibility might be to alternate different information so users do not feel overwhelmed. [9]

Another factor to take into account is to see how long the feedback should be prevented. An option is to do this continuously, so without pause. Unfortunately, no research could be found on the effect of the duration, this could be a focus of future research. [9]

2.1.6 Considerations

Besides the feedback dimensions it is important to take some additional factors into account. Firstly, some possible (negative) side effects will be discussed. Secondly, since the toilet is a private place, technology acceptance will be considered. By looking at both the side effects and the technological acceptance from the start and including them in the design phase potential problems can be identified and solved before they become a problem.

2.1.6.1 Side effects

While the goal is activation towards more sustainable behaviour of the UT community, unintentional side effects might happen because of the intervention. An example of this is an intervention that was supposed to save water by making people more aware of how much water was wasted by using a particular water tap [20]. The device existed of a light that would turn orange and then red if the tap was open for a longer time (Figure 2). Additionally, it would also show the water used during the day. However, instead of saving water, more water was used by participants because they wanted to see the different coloured lights. Another example is that when users find out how cheap energy is because of the feedback they receive they actually start spending more, this is called the rebound effect [22]. While hard to predict, it is important to take these possible side effects and potential rebound effects into consideration for the design phase.

Figure 2: Water tap intervention that shows individual and total water use [20]

2.1.6.2 Technology Acceptance

In order for the technology to have any impact, it will need to be accepted first, this might be especially difficult in a private setting like a toilet. When looking at a smart toilet, a toilet fitted with technology and multiple sensors, it was found that while most people trusted the application it was still the variable "trust" that was rated the least positive [24]. A similar intervention is the implementation of a smart meter, which tells the owner how much (electrical) energy is used in the whole household. While most often focused on energy consumption it still measures people's behaviour and deals with similar problems in acceptance as this research. People generally have positive expectations about smart meters, but a significant amount of people have concerns about privacy and loss of control [25]. This is why a non-intrusive design is needed and that the risks regarding privacy and safety need to be communicated to the user [25]. A model that can be used to better understand technology acceptance is the updated version of the Unified Theory of Acceptance and Use of Technology (UTAUT) [26]. This model was also used to look at acceptance of smart meters in Malaysia [27]. Here they found that the most important factor for acceptance was the performance expectancy, in other words if the users expected more of the performance of the smart meter it was also accepted more. Additionally, environmental awareness and electricity-saving knowledge improved the acceptance of smart metering devices. This suggests that raising awareness and providing information can also increase the acceptance of smart metering devices. While the research focused on electricity-saving the expectation is that for water-saving it works the same. The last positive effect was habits; if people were habitual users of smart phones, they would also accept the smart meter more. Since the audience (UT community) is familiar with using technology on a daily basis they might accept new technologies easier. In contrast, the effort expectancy was found to have a

negative influence on acceptance. In other words, if more effort was expected the technology was less likely to get accepted.

Something that can also influence the acceptance negatively is technical issues or inaccurate feedback [28]. This can negatively influence the interest or perception of the feedback from the user. In conclusion, privacy concerns might influence the acceptance negatively, but this could be countered by communicating about it. Additionally, acceptance can be increased by increasing performance expectancy, environmental awareness, water-saving knowledge and by reducing the effort expectancy. Last of all it is important that the accuracy of the intervention is high and no technical errors occur.

2.1.7 Conclusions

While the goal of the research by Sanguinetti et al. [11] was more focused on behaviour, they still give a comprehensive overview of how to design a feedback and information system. In Table 1 (on the next page) the main conclusions for ever dimension are listed which will be used to design a feedback system during the design phase.

These dimensions, together with the considerations give a comprehensive overview of what will need to be taken into account for the design phase. The focus will be on the pre-contemplation, contemplation and preparation stage of the transtheoretical model. The considerations of acceptance and negative side effects are useful to take into account while designing instead of encountering them as problems when testing. To improve acceptance high accuracy is needed and no errors should be taken into account.

In short, with the recommendations and considerations, it will be possible to design an intervention that raises awareness and potentially changes the behaviour of students at the University of Twente.

Dimensions	Conclusions
Behavioural granularity	Target individual specific behaviour.
Temporal granularity	Immediate feedback is better suited than feedback about a time period.
Data granularity	Mix simple data to draw the attention with more complicated data to give more insight.
Metrics	Show different metrics and relate them to consequences.
Valence	Both positive and negative feedback have advantages and drawbacks, a combination might work best.
Contextual information	Provide consequences to the environment and comparative data (goals, historical, social).
Modality	Ambient feedback might be a possibility but gives only little information. Besides that, different senses can be stimulated: Visuals, Auditory, Feel, Smell,
Style	Use both numeric (pragmatic) and ambient (artistic) feedback or a hybrid of both.
Medium	Providing digital information works best but adding paper information might be beneficial.
Audience	Audience needs to be taken into account when designing a solution.
Location	The data can be placed at the location of the behaviour itself or in a more public space where it could spark discussion.
Response requirement	The data should be easy to access.
Strategic timing & latency	Immediate feedback (during or within a few seconds after the action) works best.
Frequency & duration	Frequent data better supports learning and is preferred by users.

Table 1: Overview of feedback design dimensions and main conclusions.

2.2 State of the art

In this part, an overview will be given of existing relevant technologies that might help answer the questions provided in the introduction. In the first part, a look will be taken at how the flushing and water usage of a toilet is currently measured. In the second part, the focus will be on existing methods of giving feedback about energy and water usage and how to provide information about these. For both these parts, a look will be taken at solutions mentioned in academic papers and solutions that can be readily bought which are not academically researched.

2.2.1 Measuring toilet flushing behaviour

In this section a look will be taken at different possibilities to measure what flush is used on the dual-flush toilet.

2.2.1.1 Sound logger

Until now, not much research is done specifically about appropriate usage of dual flush toilets. One method used was a sound data logger that could differentiate between the sound of a small flush and big flush [5]. This sound data logger was reported as a low-cost, non-invasive method to measure which button was used. A sound sensor has also been used in a similar application for providing feedback about water use of sinks and showers [20]. Here they translated certain frequencies into water flow and minimized ambient and human sounds. However, a disadvantage might be that a microphone like this can raise more privacy concerns for the toilet user. An example of a datalogger can be seen in Figure 3.

Figure 3: Sound Data logger [5].

2.2.1.2 Waterflow meter

Another option is to measure the water flow going into the toilet since a small flush uses less water than a big flush. This method has been used by two studies looking into the efficiency

of a dual-flush toilet [29]-[30]. For one study, successive flushes that were within 300 seconds were considered one flush [30]. Multiple commercial sensors exist that are suitable for measuring water flow. A good example is the Pani Flow sensor, as seen in Figure 4 it can be easily installed in different places [31]. Additionally, it shares the data about how much water you use through Bluetooth with your phone and provides tips to reduce water usage. With this solution you could not only see if a big or small flush was being used but also how much water was exactly flushed down.

Figure 4: Pani flow sensor installed on a shower [31].

2.2.1.3 Water level sensor

Instead of measuring flow, the water level in the tank could also be measured. This is for example done by the LeakAllertor 6000, which uses a sensor that measures how fast the water rises or falls in order to detect if a toilet is leaking (see Figure 5) [32]. The disadvantage is that while relatively easy to install they might not fit well in all toilets. For instance, the toilets at the University of Twente are often build in the wall with less space for a bigger sensor like the Pani flow sensor. Nevertheless, it might be a sensible technique to detect flushing behaviour and should be explored.

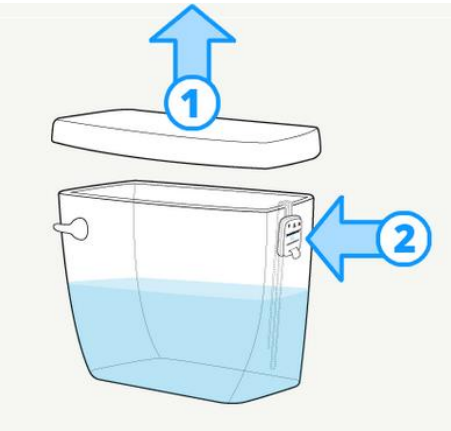


Figure 5: LeakAllertor 6000 measuring the water level [32].

2.2.1.4 Sensor behind the button

The last option might be to measure only if the button is pressed by for example using a flex sensor (Figure 6)[33]. A flex sensor gives a different resistance based on how much it is flexed, this could be put behind the buttons to know which button is pressed. A similar sensor that might be even more suitable is a Piezo sensor which works similar but gives an electrical signal when it is vibrated or flexed [34]. The benefit of this is that the sensor does not require any energy to work which could save energy for the installation.

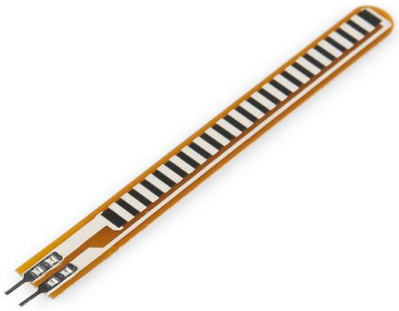


Figure 6: Example of flex sensor from sparkfun.com [33].

2.2.1.5 Conclusions

In conclusion, multiple sensors are currently used to detect water usage of a toilet. While they all work some will be harder to install while others might be more intrusive. A sensor will need to be selected that avoids these issues and works reliably. Since every toilet is different, multiple sensors should be tested to determine which sensor is most reliable.

2.2.2 Giving feedback and information

As discussed before, a lot of different design dimensions exist to design eco-feedback. A view examples of eco-feedback will be discussed here which might later be useful to use as inspiration. The examples have been limited to interventions that aim to change the behaviour of using one specific device since this is more similar to the goal of this research.

2.2.2.1 Shower water conservation

The first example is focused on the water conservation of specific appliances. This research was already discussed earlier since they had one application that actually increased the water usage instead of reducing it [20]. Nevertheless, they also had success with two applications targeting shower behaviour. They tried both an ambient display and a display with metrics giving more information on how much water was used (see Figure 7). The ambient display (right) worked more effectively than the metric display (left). However, the research suggests the use of a combination of both metrics and ambient feedback. Especially since ambient feedback is effective in getting the attention but provides less information. Even though, it is still interesting to see that a simple red or green light can already make a significant impact. Something very similar was done in another study where lights were used to indicate how much water was used [35]. In this example, every light would correspond to a certain amount of water. In the beginning, results fluctuated but later they stabilized and a water reduction was achieved.

Figure 7: Intervention aimed at reducing water usage of a shower with metrics being used on the left and ambient feedback on the right [20].

2.2.2.2 Power-aware cord

Another example of ambient feedback is the power-aware cord. By glowing, this cord shows real-time if energy is flowing through the cable which makes people more aware of the energy being used [36]. This example shares only limited information (low data granularity) which it provides during the behaviour of the user. It provides a neutral message, so it does not

indicate a good or a bad choice, it just makes people aware that energy is being used.

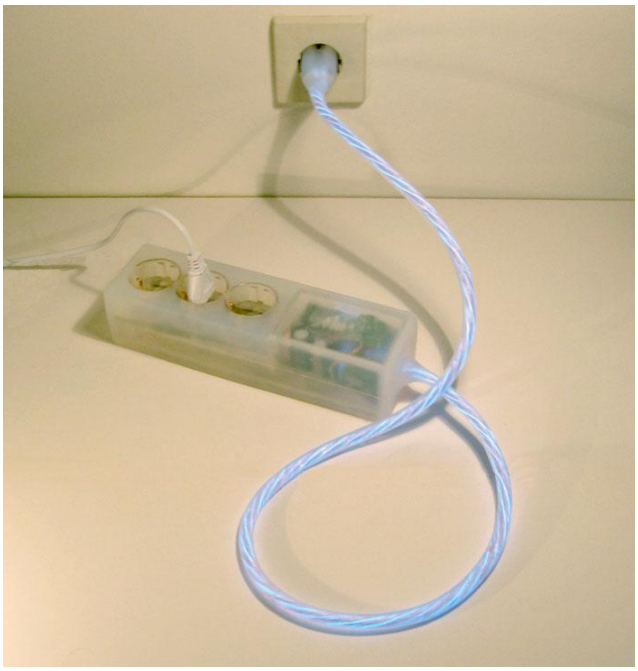


Figure 8: The power-aware cord [36]

2.2.2.3 Environmental orbs

Another example of ambient feedback are ambient orbs (see Figure 9) which display energy usage of dormitories on the hallways [37]. The difference, compared to the power-aware cord, is that instead of focusing on a single behaviour it displays the total energy usage. Another difference is the location, by placing it in the hallway (public place) the ambient orbs could potentially spark discussion [11]. Additionally, these orbs have proven to improve awareness and motivation to change behaviour [37].

Figure 9: Environmental orbs

2.2.2.4 Coral representing energy

In a study that tried to make people more aware of how much energy they were using on their Mac computer, a different approach was taken [38]. They used coral to depict the consequences of the energy usage of the mac computer (see figure 10). The benefit of this approach could be that it makes people more aware of the consequences. Notably, when compared to numeric data the researchers found that the metaphoric feedback raised awareness through emotional attachment.

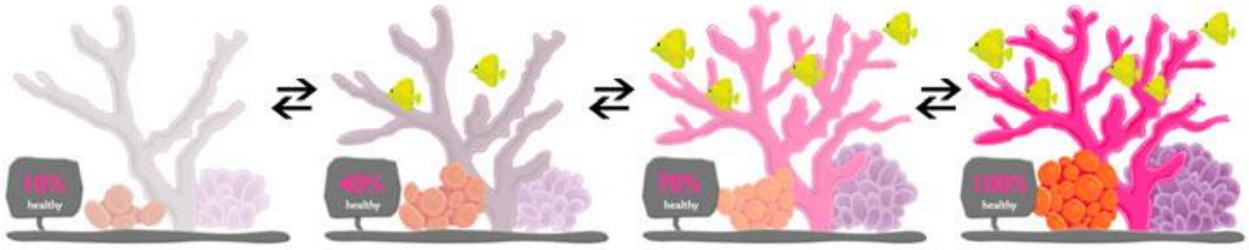


figure 10: Gradual change of coral reefs and fish according to energy usage

2.2.2.5 Waterbot

Another solution focused on saving water at taps is the waterbot [39] which gives feedback in multiple ways (see Figure 2). Firstly, it uses light to show what the temperature is, this allows people to waste less water since they can immediately see when the water is at the right temperature. Second, it shows comparative data to other users (social comparison) which can motivate people to start saving more water. Third, it gives positive feedback if the user saves water with auditory feedback. Waterbot is a great example of combining ambient feedback with metrics that even use social comparison. The system is made so it can be fitted on existing taps without modification.

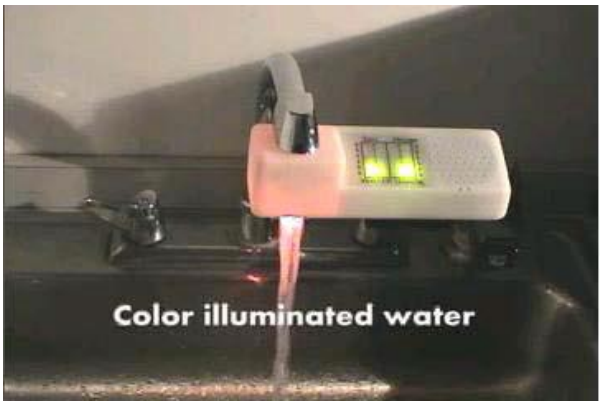


Figure 11: Waterbot giving feedback to the user [39].

2.2.2.6 WWF paper dispenser

Not all feedback needs to make use of technology, an excellent example of this is a campaign run by the WWF [40]. Here the paper used has created its own low-cost data visualization (see Figure 12). Since you are forced to interact with this feedback it makes sure it catches your attention.

Figure 12: paper dispenser aimed to save paper waste by WWF (world wildlife foundation) [40].

2.2.3.7 Conclusions

All these solutions provide good examples and can be used in addition to the design dimensions. The power-aware cord and the ambient orbs are great examples of how ambient feedback could be implemented. While the power-aware cord shows how to do this for one specific case the ambient orb is placed in a different location that could spark more discussion. The intervention focusing on water saving at the shower clearly shows two different options; using metrics or giving ambient feedback. They also suggest combining both ambient and metrics which was done by the waterbot intervention. The waterbot even includes social comparison and auditory feedback.

A totally different visualization is the coral example, which uses a metaphor that immediately makes the consequences clear. The idea of a metaphor should be further investigated in the ideation phase. Last of all, the example of the WWF shows that something without any technology can also work very well in visualizing usage. The examples in this state of the art show the relevance of the dimensions mentioned by Sanguinetti et al. [11] and can be

used as further inspiration for generating ideas during the design phase. Especially waterbot can be used as an example since the use case is relevant and correlates with the conclusions made at the end of the previous chapter (see Table 1).

Together with the literature research, this state of the art gives enough information to start generating and designing different ideas on how to provide feedback.

3 Methods and techniques

In this chapter the methods and techniques will be discussed that are used in order to design a solution to make the UT community more aware of their toilet flushing behaviour. The product design method discusses the approach taken which is based on the paper by Mader and Eggink [41]; A design process for creative technology. This model is depicted by Figure 13 and is divided in four phases; the ideation, the specification, the realisation and the evaluation phase. Ideally, the process consists of multiple iterations where you sometimes take a step back to the previous phase to rethink about certain aspects or ideas. Next, these different phases and how they relate to this design are briefly discussed. Additionally, the techniques used in every stage will be explained.

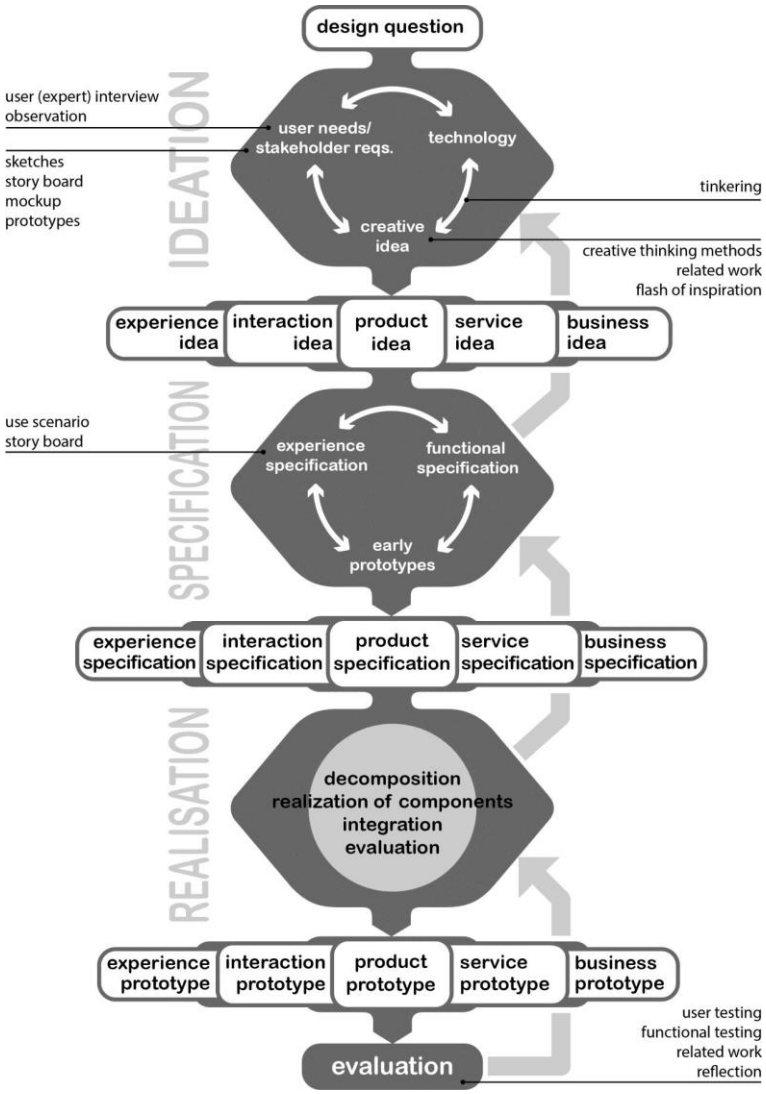


Figure 13: A creative Technology Design process [41]

3.1 Ideation

The ideation starts with a design question, in this case the main research question of this project. From here on, three different starting points are present to start coming up with many creative ideas. The ideation starts from the stakeholder identifications and elicitation of their requirements and users needs. From here the goal is to generate multiple creative ideas and possible technologies which is called the divergent phase. Afterwards, these ideas are narrowed down to a final idea by filtering and discussing them with the stakeholders. This is the convergent phase and delivers the input to start with the next phase, the specification.

3.1.1 Value identification Matrix

As said earlier, the starting point of the ideation phase is identifying the needs of stakeholders. Afterwards these ideas need to be filtered down to one final product of which specific functional and non-functional requirements can be determined for the specification phase. To do this a value identification matrix has been made as described by Pessôa and Trabasso [42]. This method allows for more general wishes and needs from stakeholders to become more specific and giving them a certain importance rating. This importance rating is calculated by looking both at the importance of the stakeholder and how important a stakeholder finds a certain aspect of the product.

First the stakeholders need to be identified and categorized on importance. Here Pessôa and Trabasso [42] distinguishes between primary, secondary and tertiary stakeholders. First, the primary stakeholder is the most important and defines having the right or wrong product. The secondary stakeholder contributes to the design process and can cause a disruption if not satisfied. Last, the tertiary stakeholder has minimum power to really impact the design but is affected by it. The first step is to find out who the stakeholders are and what the needs and wishes. These are called values and are often to general to really start designing. These values can be translated into more specific value items as seen in Figure 14. All these value items give a comprehensive overview of how the system should work.

Value		Value items	
1	Be comfortable to the baby	1.1	Be light on the baby's body
		1.2	Be small on the baby's body
		1.3	Provide soft touch to the baby
2	Easy to use by parent or caretaker	2.1	Be intuitive to apply
		2.2	Be easy to remove by parent or caretaker

Figure 14: example of values translated into specific value items [42]

The second step is to make these more general needs from the stakeholders more explicit. An example of this can be seen in Figure 14, where a value is split up into multiple more specific value items. The importance of these value items can then be calculated by using Formula 1:

$$IMP_{VIi} = \sum_{j=1}^{k} SR_j * IS_j$$

Formula 1: Formula to calculate the importance of a value item [42]

Where:

SRj = Relevance of stakeholder where: primary = 9, secondary = 3 and tertiary =1

- 9 = primary stakeholder
- 3 = secondary stakeholder
- 1 = tertiary stakeholder

ISj = Importance of value item to the stakeholder where:

- 9 = high importance, must have
- 3 = medium importance, should have
- 1 = low importance, item relates to stakeholder but is of no interest
- 0 = not important for this stakeholder at all

Thus, by looking how important the stakeholders are and how important they find certain value items the importance score can be calculated. An example of this can be seen below in Figure 15. This score can then be used to make certain decisions if conflicts arise between value items or if certain ideas need to be filtered down. The scores can be used in a weighted decision matrix which will be discussed in 3.2.2.

		Client	Enterprise - Owners	Enterprise - Business Unit	Enterprise – Quality	Enterprise – Industrial Engineering	Enterprise – Production	Enterprise – Homologotion	Enterprise – Commercial Department	Enterprise – Logistics	Suppliers – Piece and Parts	Suppliers – Labs and Testing	Importance
Value	Value Item	Pri	Pri	Pri	Sec	Sec	Pri	Sec	Sec	Sec	Ter	Ter	
1 Realign the aircraft	1.1 Quick response to triggering	h	m	h	m	m	m	m	m	m	I		360
	1.2 Return to normal flight attitude	h	m	h	m	m	m	m	m	m	I		360
	1.3 Eliminate aerodynamical effects on the aircraft after use	m	I	I	I	I	I	I	I	I	I		108
	1.4 Eliminate electrical effects on the aircraft after use	I	I	I	I	I	I	I	I	I	I	I	90

Figure 15: Value item importance example [42]

Last, during the specification phase the measures of effectiveness can be added. These are specific requirements which can be tested to see if a value item has been achieved. Some of these give specific dimensions like size and some focus on measuring participant satisfaction.

Value item		Measure of effectiveness	
1.1	Be light on the baby's body	1.1.1	<45 g
1.2	Be small on the baby's body	1.2.1	<25 cm^2
1.3	Provide soft touch to the baby	1.3.1	Focal group rate > 8

Figure 16: example of measures of effectiveness

In short, making a value identification matrix consists of four steps:

- Identify the stakeholders
- Analyse the value items
- Prioritize the value items
- Define measures of effectiveness (MoE)

Last, this tool should be continuously updated when new insights arise which fits the approach of the design model for Creative Technology by Eggink and Mader [41]. By implementing these steps more general needs can be translated to specific functional requirements for the solution which can be tested as well.

3.1.2 Interview

To get more information the client will be interviewed to get more insights in their needs and wishes. This is done by a semi-structured interview where there is a list of pre-determined list of questions for the interview in combination with additional questions that will be asked during the interview. A semi-structured interview has been chosen since it allows for pre-determined questions to be answered in addition to gaining more in depth insights that might have been overlooked otherwise.

3.1.3 Brainstorming and mind map

After the initial values of the stakeholders are achieved multiple ideas need to be generated. This is done with a brainstorm, both alone and together with other people, with the help of a mind map where as many ideas as possible are generated. This will be done by looking at already existing ideas of Chapter 2, thinking outside of the box and discussing with peers. All of these approaches are focused on getting as many ideas without judging them already. The ideas are categorized in a mind map to create a clear overview of all the different ideas. In the centre the research questions will be dividing different categories of ideas. With this overview of already generated ideas more ideas can be come up with by using these as inspiration or by combining the existing ideas.

3.3.4 Weighted decision matrix

The importance levels that are calculated in the value identification matrix can be used to filter down on certain ideas at the end of the ideation phase. This can be done by creating a table with the value items with their corresponding importance and give them a score based on how well the idea achieves the value item. This score ranges from 1-3 where 1 means that the idea does not help at all while 3 means that the idea fulfils the value item perfectly. By multiplying this score with the importance a total score is calculated, by adding all the total scores together a final score is calculated which can be compared with different ideas. The idea with the highest score is the most suitable solution and can be used as a start for the specification phase. This all gets written down in a table as seen in Table 2.

Value items	Value importance (weight)	Score	(Total) Score * importance

Table 2: Example of weighted decision matrix

3.2 Specification

With the input gained from the ideation phase the specification phase can be started. Here, a user scenario is first created to get more insights in the experience specification which includes a description of the user-system interaction. Based on this a functional diagram of the system interaction will be made and memes will be specified. Last, both functional and non-functional requirements are obtained to guide the realisation phase. These requirements are based on the value items created during the ideation stage. These requirements will be ordered based on the MoSCoW method which is explained in section 3.2.3. This gives a comprehensive overview of what needs to be achieved in the realisation phase.

3.2.1 User scenario

To better understand how users interact with the system a user scenario will be created. A story will be created where the user interacts with the installation where the user is an imaginary student who visits the toilet. A student has been chosen since 80% of the UT community consists of students [43]. The story should be as complete as possible including the thoughts and the feelings of the user before, during and after the interaction has been taken place.

3.2.2 Functional diagram

To better understand how the user interacts with the system and how the system works a UML Diagram will be used

3.2.3 MoSCoW

To prioritize the requirements in the specification phase the MoSCoW [44] method will be used. A short overview can be seen below in Figure 17, where the different prioritization can be seen. By prioritizing the requirements it helps in making decisions of what must first be done and what can be done if more time or resources are available. Prioritizing will be done with the help of the

importance of the value items that was calculated during the ideation stage.

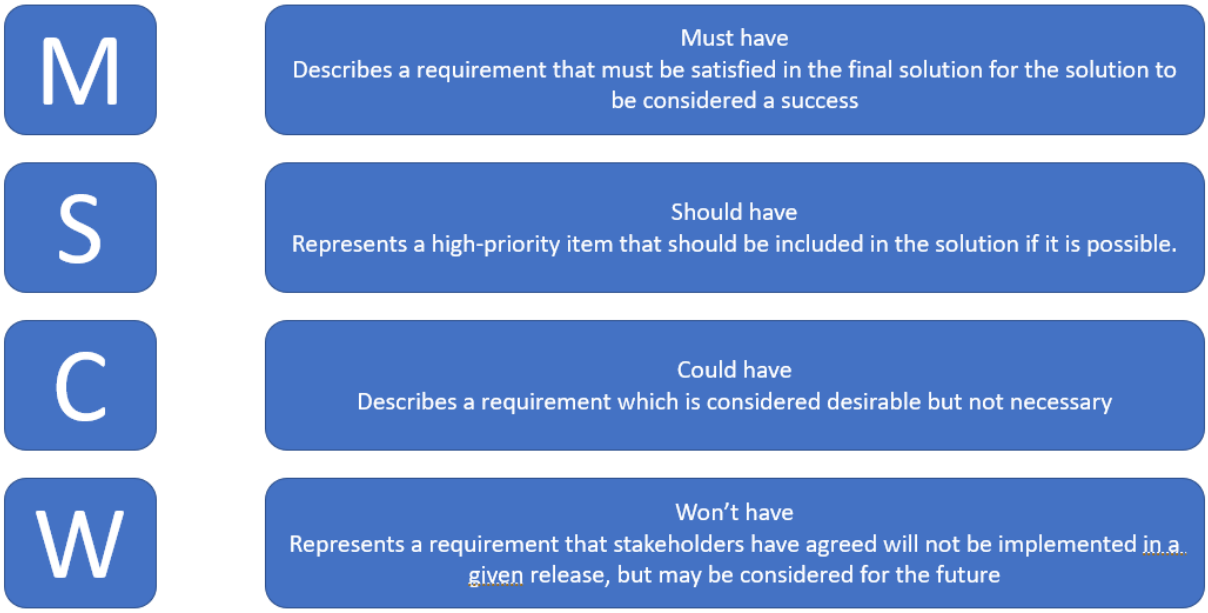


Figure 17: Overview of MoSCoW prioritization from volkerdon.com [44]

3.3 Realisation

During the realisation phase the specifications from the previous chapter are used to construct a prototype. Here the requirements will be used as a guideline for the building process where first the most essential requirements are fulfilled following by the others if there is time left. First, the system will be split up in multiple sub-systems which will first be made and tested individually. When these sub-systems work individually they will be integrated in one installation.

3.4 Evaluation

In the evaluation phase the requirements made during the specification phase will be used to see if the prototype fulfils the requirements that were made. The non-functional requirements will be tested with the help of a survey which will be distributed to the users participating in the evaluation. Additionally, it will be checked if the prototype fulfils the functional requirements with the help of the measurements of effectiveness defined earlier. Additionally, potential problems or improvements can be identified for further research. The evaluation will then be used in the conclusion to try to answer the main research question.

3.4.1 Survey

To validate the non-functional requirements, a survey will be given to users to evaluate their experience. Most questions will be answered by using a 5 point Likert scale [45] which allows people to fill in how much they agree with a particular statement. Here people can choose from “fully disagree” to “fully agree” which gives an indication to the extend they agree with the statement. Additionally, some multiple choice questions and open ended questions will be asked.

4 Ideation

This chapter starts off with identifying the different stakeholders of which the pre-liminary requirements will be defined. Afterwards, different ideas will be generated in an attempt to come up with a solution to the main research questions. Last, the final product idea will be selected.

4.1 Stakeholder analysis

First, the different stakeholders are identified together with the relation to this project and their importance (see Table 3). The primary stakeholder is the most important and is defined by by Pessôa and Trabasso [42] as the stakeholder that defines having the right or wrong product. In this case the primary stakeholders are the UT community, the UT and CFM since together they define having the right or wrong product.

Stakeholders	Relation to project	Importance
CFM	Client	Primary
UT community (users)	Users	Primary
UT	Supervisors	Primary
Cleaning staff	Needs to clean the toilet stalls	Tertiary

Table 3: relevant stakeholders

The UT represents the supervisors of this bachelor graduation project and has the most influence and power. They are the final decision-makers and can put a stop to the project if needed. However, CFM and the users are also primary stakeholders since they also define having the right or wrong product. Last, the cleaning staff will need to be considered since they also interact with the installation when cleaning the toilets.

4.2 Interview CFM

To better understand the stakeholder's needs and wishes a semi-structured interview was conducted with an employee from CFM. During the interview, it became clear that the University of Twente wants to become a frontrunner if it comes to sustainability and one of their focuses is on saving water. Regarding water, there are three main focuses of the University of Twente; 1) Reducing water consumption, 2) re-use water, and 3) use sustainable sources of water

like rain water. The most relevant for this project is water reduction, here the aim is to have a 5% reduction between 2020 and 2022. This project aims to can contribute to that goal by reducing water used in toilets.

To create awareness the most important wish from CFM would be that the envisioned system needs to be fun and have some element of humour in using it. Additionally, it should remain interesting, even after repetitive use. What should be avoided is that it should not be judgemental since that can annoy people. Especially since CFM noticed a shift from “a clean environment starts at yourself” to “a clean environment starts at the big companies”. If individuals feel judged too much they can reject the advice given. In short, the final idea should be fun, not repetitive and not judgemental.

4.3 Value identification matrix

Below in Table 4, the value identification matrix can be seen which was made in three steps. First, different key values have been identified for this project which are visible in the first column in Table 4. These are based on the needs of all the identified stakeholders. Some of these have been the result of discussions with the University of Twente, some on the preliminary research and some by looking at the problem from the perspective of the stakeholders.

Second, the values were split into more specific value items as seen in the third column. These are partly taken from the preliminary research, an example of this is at value item 9 about raising awareness where a lot of the value items are based on the work by Sanguinetti et al. [11]. Additionally, some specific requirements have been added based on the interview done with CFM (e.g. value item 9.1: It should not be repetitive).

Last, the importance was determined of every value item and for every stakeholder. For the UT and CFM, these are based on the discussions and interview that was done. Besides this, the importance has been determined by trying to see things from the stakeholders perspective together with the literature research done earlier. Finally, the importance was colour coded to see the most important value items more clearly. Any score above 180 is coloured dark green, anything above 100 is light green and below 100 remains grey. This gives the most important value items:

- Has a high reading accuracy
- It should not be repetitive
- Information is easily accessed
- Does not provide judgemental feedback
- It should catch the attention
- It should fit the target audience
- Information is provided in a fun way

The most important value items help prioritize in case of conflict between value items or to make other decisions. However, all the other value items should still be included in the design.

	Value		Value Item	Measure Of Effectiveness	Primary			Tertiary	Importance
					CFM	UT	User	Cleaning staff	
V1	should not be intrusive	1.1	No technology is visible		M	H	M		135
		1.2	Sensor has to be small		M	H	M		135
V2	should require little energy	2.1	Energy spend while operating is low		H	H			162
		2.2	When operation is not necessary, energy is saved		H	H			162
V3	should be low maintenance	3.1	Battery is easily replaced		M	M			54
		3.2	Has a long life cycle		H	M			108
		3.3	Notifies if anything goes wrong		H	M			108
		3.4	Can run independently		H	M			108
		3.3	Is protected against water		H	H		H	171
V4	shoudld be able to share usefull data	4.1	Can send data over wifi		H	H			162
		4.2	Sends data in a workable format		H	M			108
		4.3	Can send what button is used and at what time		H	H			162
V5	Is reliable	5.1	Has a high reading accuracy		H	H	H		243
V6	Should be able to easily install	6.1	No modificiations to the toilet are needed		H	H			162
		6.2	Can be installed fast		M	M			54
V7	It should work on any toilet	7.1	It can be fitted to most toilets		L	H			90
		7.2	The data can be send to any client		L	H			90
V9	It should raise awareness	9.1	It should not be repetitive		H	H	H		243
		9.2	Communicates water usage of big and small flush		M	H	M		135
		9.3	Shows consequences of water usage		M	M	L		63
		9.4	Sparks discussion		M	M	L		63
		9.5	Information is easily accessed		M	H	H		189
		9.6	Feedback is given immediately		M	H	M		135
		9.7	Combines artistic with pragmetic approach		M	M	L		63
		9.8	Does not provide judgemental feedback (no negative feedbac)		H	H	H		243
		9.9	It should catch the attention/be surprising		M	H	H		189
		9.10	Provides comparitive data		M	M	M		81
		9.11	It should fit the target audience (students)		H	H	H		243
		9.12	It should be aesteticly pleasing		M	H	M	L	136
V10	Educates people	10.1	Clearly shows what button should be used		M	H	M		135
		10.2	Information is provided in a fun way		H	H	H		243

Table 4: Value identification matrix where H, M, L stand for high, medium and low priority respectively.

4.4 Brainstorm with mind map

Now the needs and wishes of the stakeholders are known, multiple ideas were put in a mind map (see Figure 18). The mind map consists of three different branches which correspond with the different sub-questions introduced in the introduction. From every question, different starting points were identified, for example, ambient feedback. From these starting points, several ideas were generated that can be seen in the rectangles.

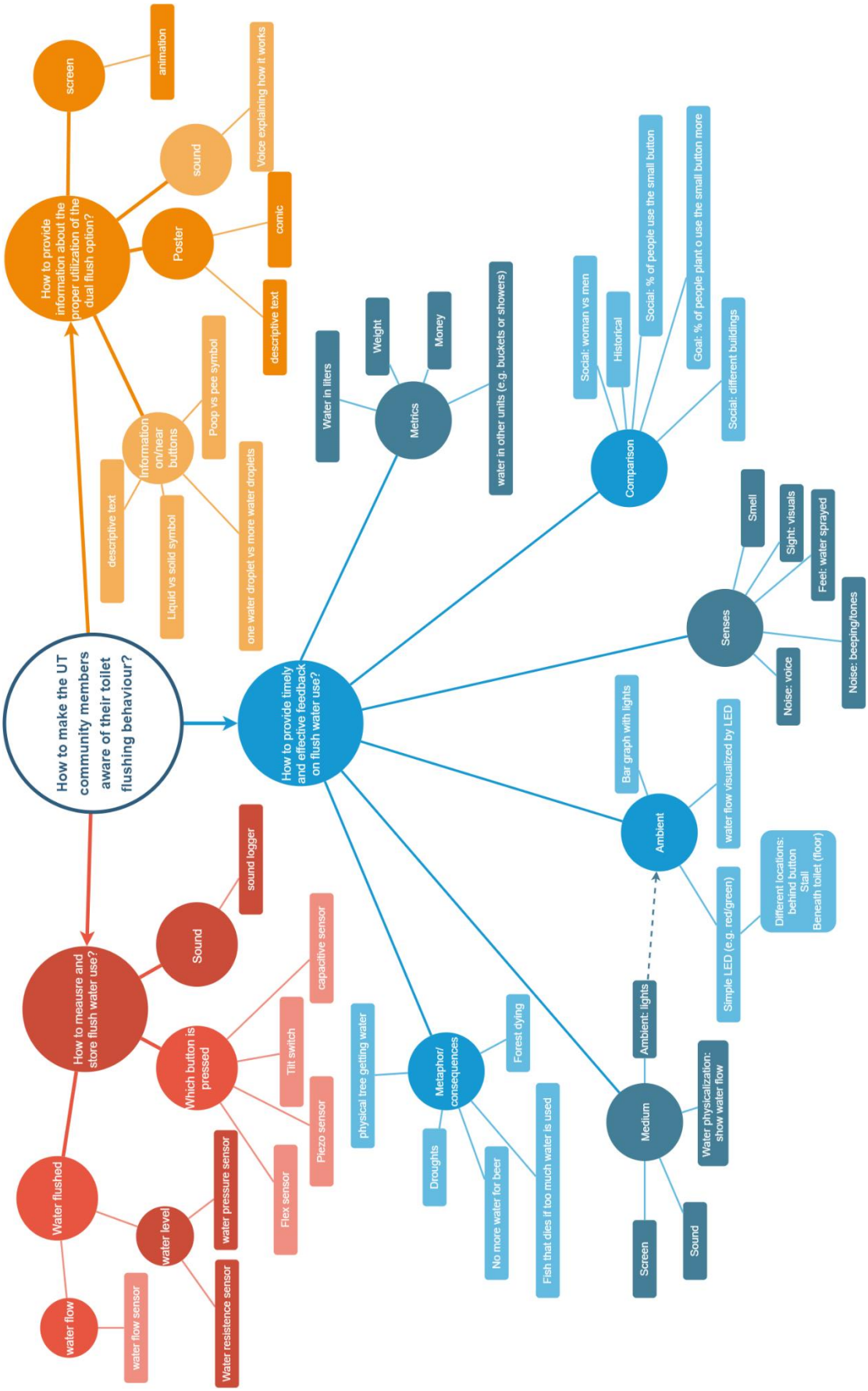


Figure 18: Mind map with ideas

4.5 Concepts

From the mind map, several ideas were chosen to explore further. First, rough ideas were sketched (see Figure 19). based on the results of the mind map that was made Second, more detailed drawings were made which will be discussed later. Besides these ideas, extra ideas were generated after discussion sessions with peers and supervisors.

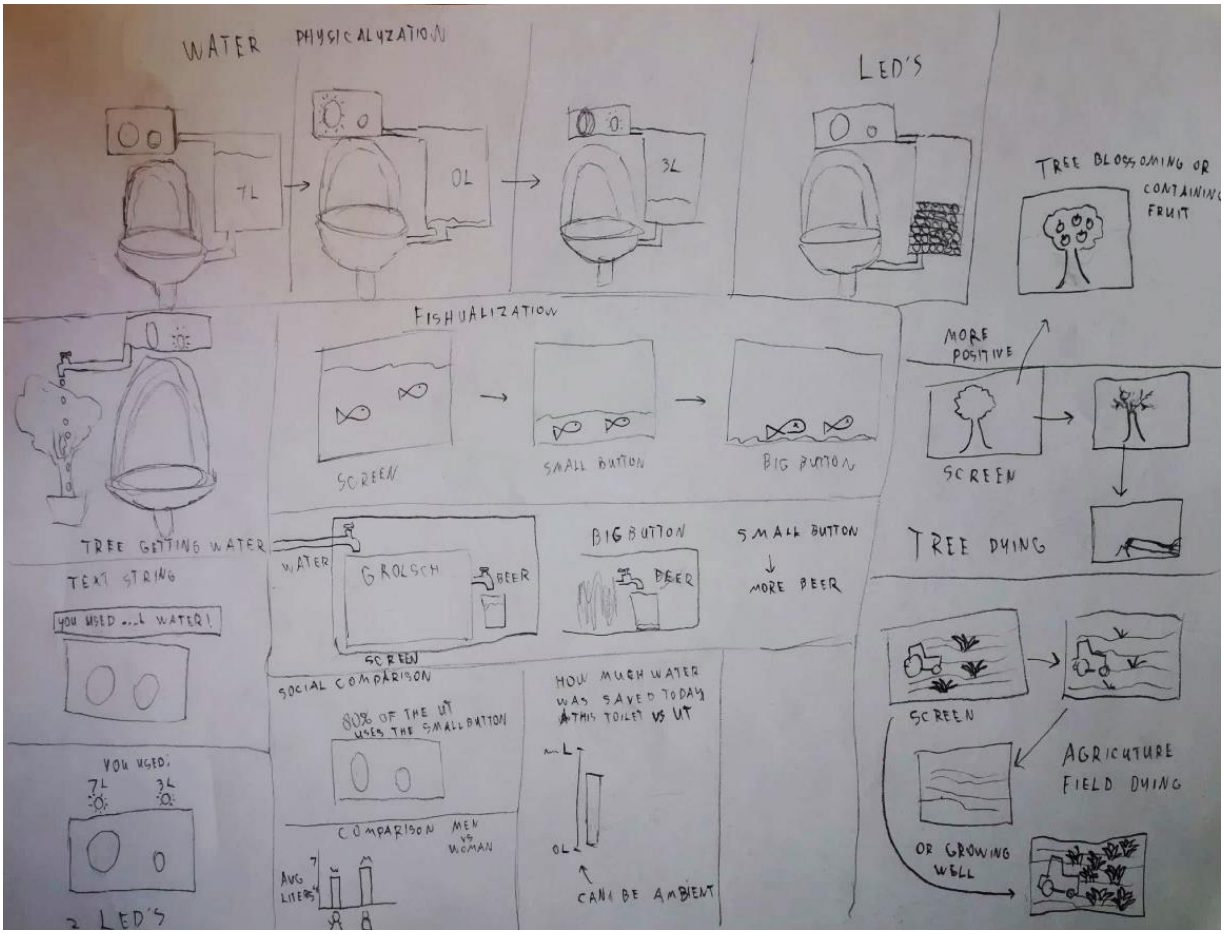


Figure 19: rough sketch of different ideas

4.5.1 Water physicalizing

The first concept, seen in Figure 20, focuses on making the exact water usage visible. By adding a transparent container with water users can see exactly how much water is being flushed during each flush. When a small flush is used, less water (e.g. 3 litres) is used while for the big flush all the water disappears (e.g. 6 litres). The system could be attached to the toilet reservoir but it can also work independently by using a separate water supply. By using a separate water supply less modifications to the toilet are needed.

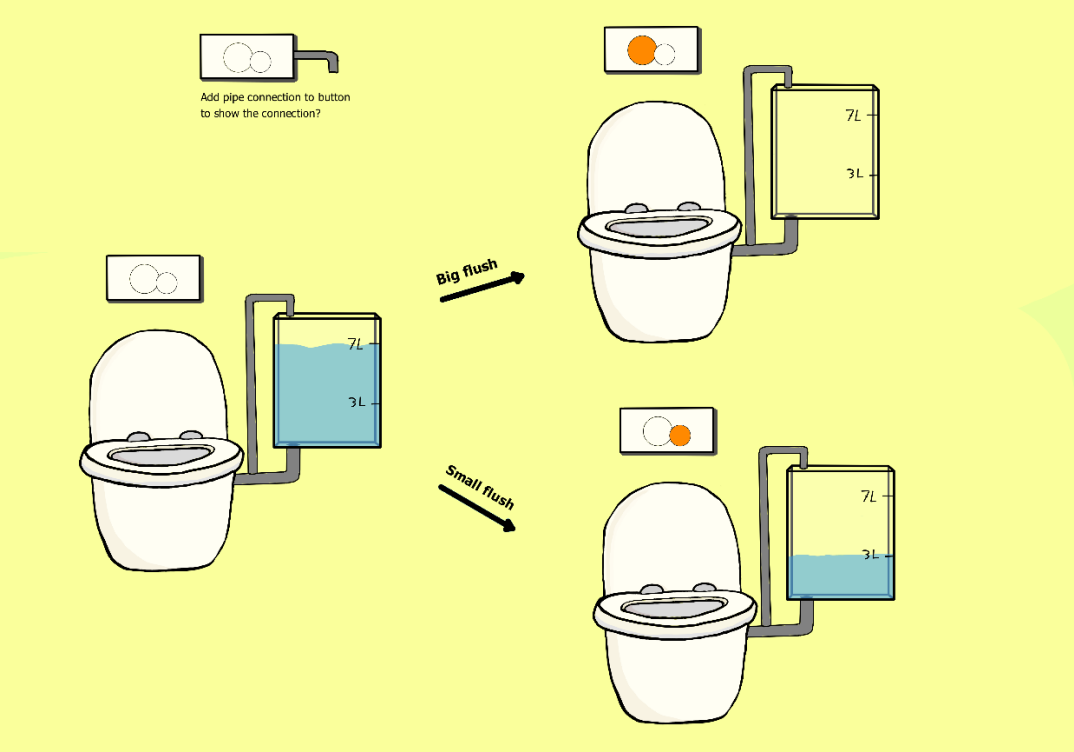


Figure 20: water physicalization

4.5.2 Water visualization with LEDs

Something similar to the previous concept could also be achieved by adding LEDs to simulate the water (see Figure 21). This could be easier to install compared to using actual water.

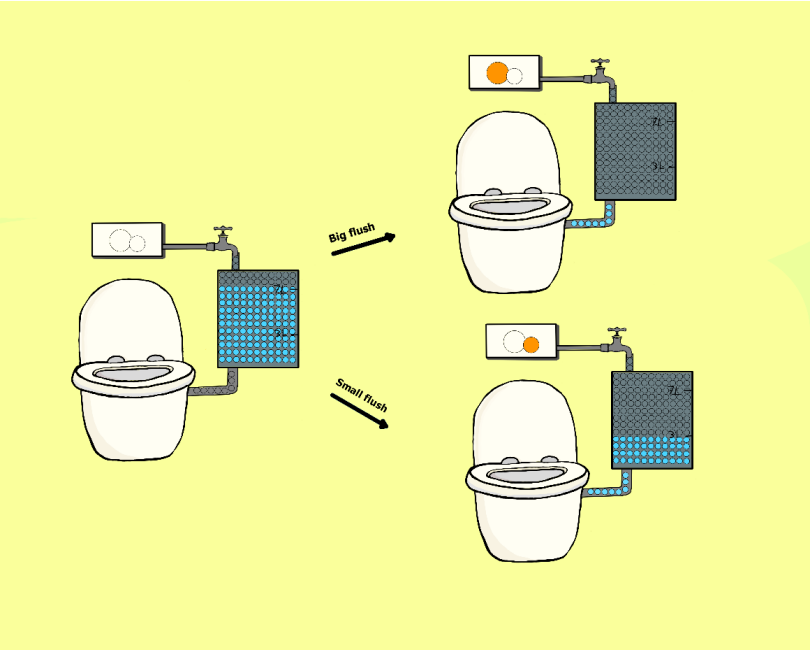


Figure 21: Water visualization with LEDs

4.5.3 Giving water to a plant

The previous idea with a screen showing a tree or plant grow could also be made as a physical installation (see Figure 22). An actual plant could be placed that gets a tiny bit of water every time the small flush button is used and no water when the big flush was used. Unfortunately, it would be difficult to regulate the right amount of water to the plant and it will likely die. An alternative might be to make an artificial plant that looks like it withers when it does not get enough water.

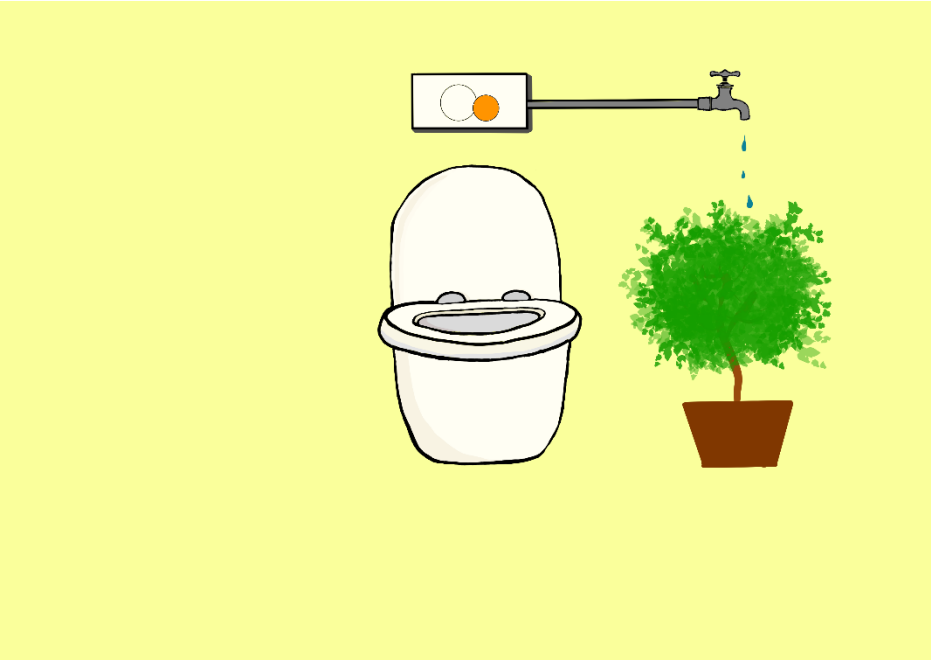


Figure 22: actual plant getting water

4.5.4 Screens with consequences

A method to make people more aware might be to show the consequences of their actions. A way to do this might be through a screen. Several ideas can be seen in Figure 23. The first one clearly shows both a negative effect but also how much water is used. It can even be possible to have the fish display certain messages to educate people about which button they should use for flushing.

In the second example, the Grolsch factory can be seen which produces less beer when the big button is used. This could make people more aware of what their water is used for. In the third example, a farm can be seen which gets dryer depending on water usage. This example is

the closest related to the consequences of draughts in the Netherlands which already happened. The last example, the tree, also explains in an easy way why water should be saved.

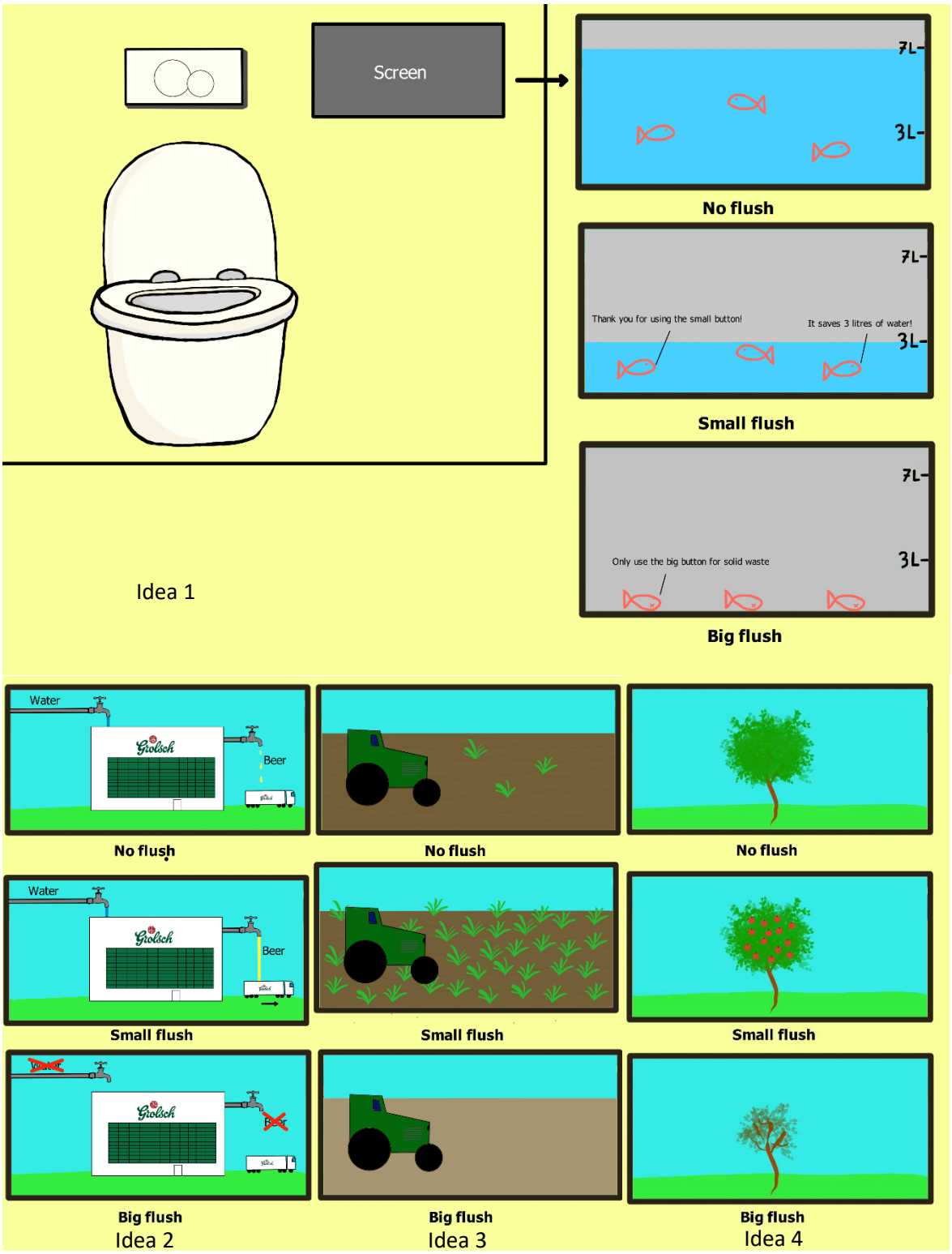


Figure 23: Four different ideas that use a screen to show the consequences of water shortages.

4.5.5 Ambient lights

A more subtle way of providing feedback could be through ambient lighting. The light could be placed behind the buttons or the button panel as can be seen in *Figure 24*. However, there are a lot of different options possible for adding lights. The light could for example be added below the toilet seat or the toilet itself as can be seen in Figure 26. Alternatively, the lights could be implemented on the door or walls or even existing lightning could be used which might be more surprising. The lights can be used to get the attention but also to inform. A legend as seen in Figure 24 could for example be added or a bar graph as seen in Figure 25. Last, if the light catches the attention of people one of the other feedback ideas could be shown to make people more aware of their flushing behaviour. In this way, the ambient lightning might enhance or work together well with one of the other ideas.

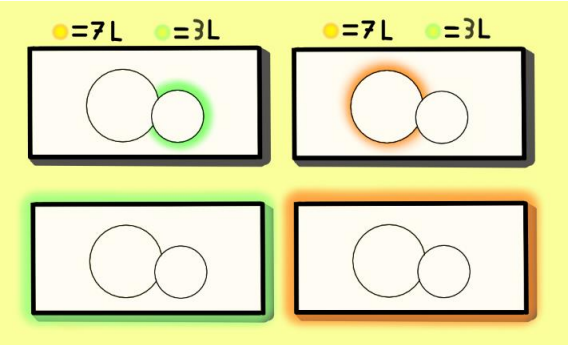


Figure 24: ambient lights behind buttons/panel

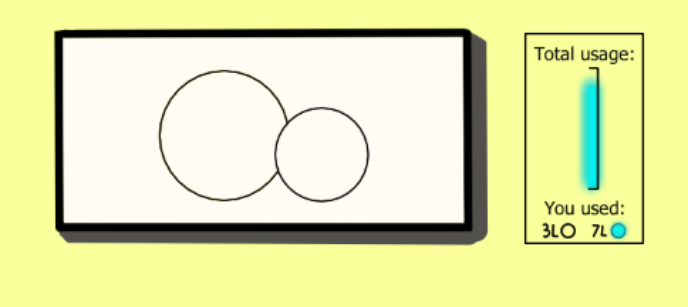


Figure 25: Use light as a bar graph

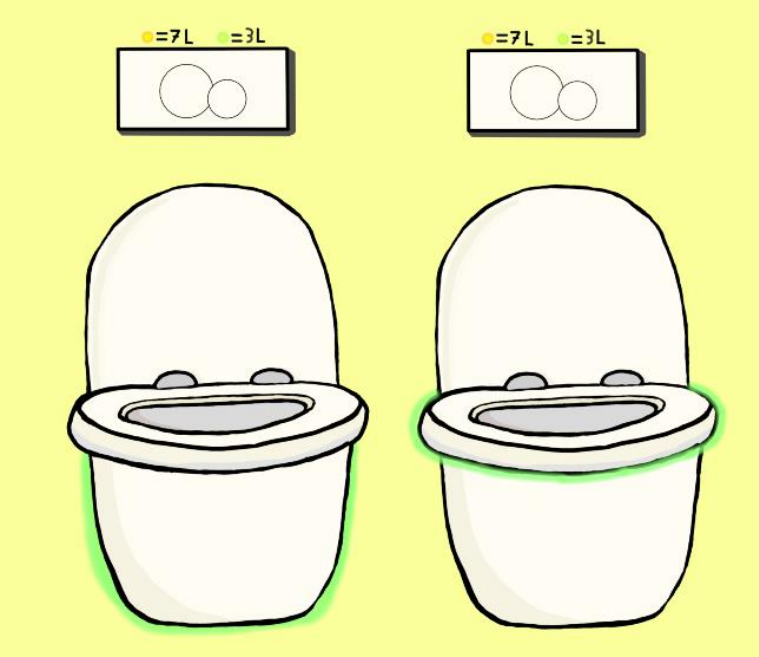


Figure 26: ambient lights behind the toilet

4.5.6 Multiple flowers blooming

Another idea that would be very aesthetically pleasing would be flowers that open up after pressing the small button. Every time a different flower can open up displaying a different message. The vines could be made of LED tubes to illustrate water going to the plants.

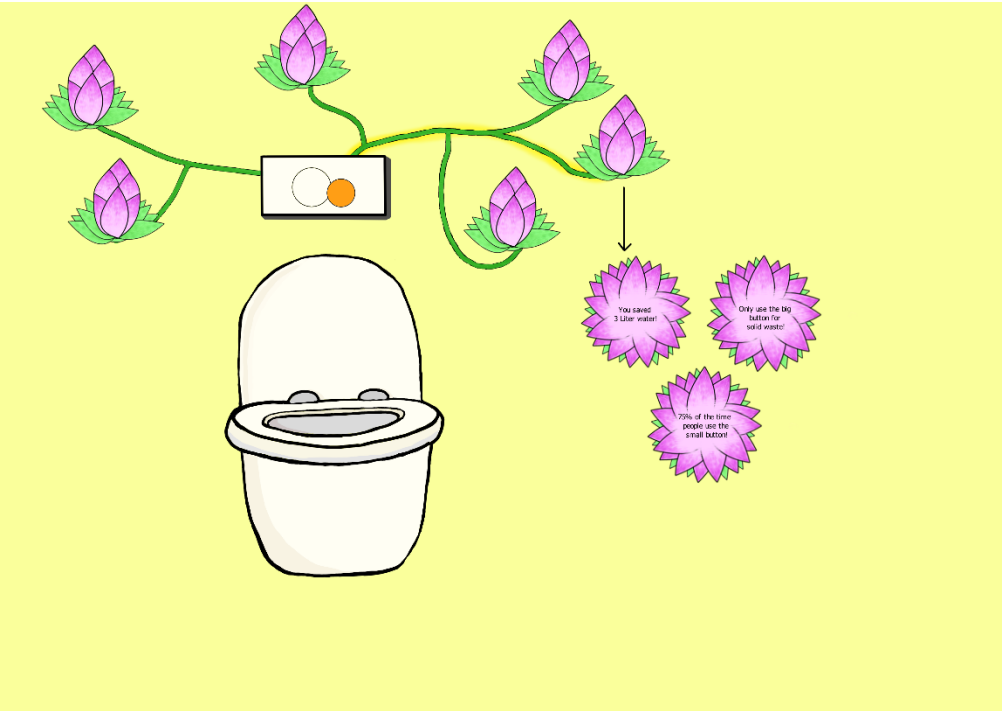


Figure 27: Multiple flowers blooming

4.5.7 Memes providing information

A common way that students communicate over the internet with each other is through memes. Memes are funny images or videos which often contains alternating text to make a specific joke or talk about a certain topic. These memes could be used to provide information to students in a humorous way. This information can be different and based on examples found in the background research. As an example, the information could be about different consequences, historical data, comparisons or social context. These memes could suddenly be let down after the small button is pressed to achieve the element of surprise (see Figure 28). Another option might be to have panels that open up from the ceiling displaying different memes as can be seen in Figure 29. However, this idea is a bit less surprising since the user already sees that something is off. Both ideas have the potential to also become shared over the internet and even spread more awareness.

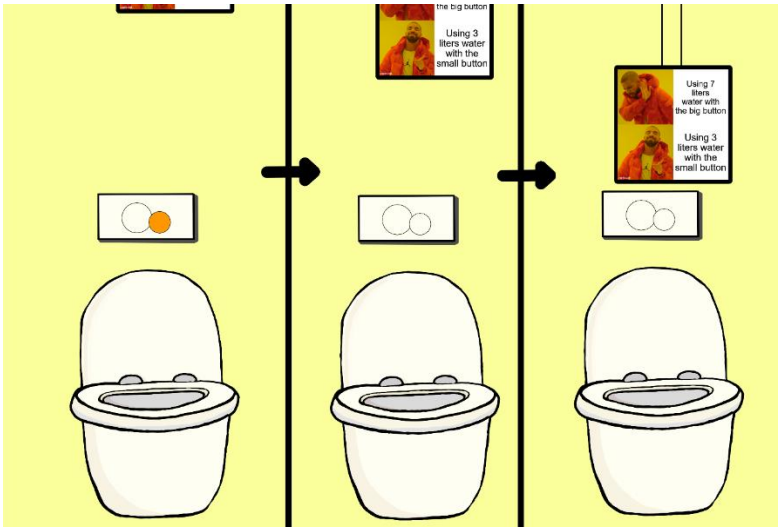


Figure 28: Feedback through memes coming out of the ceiling

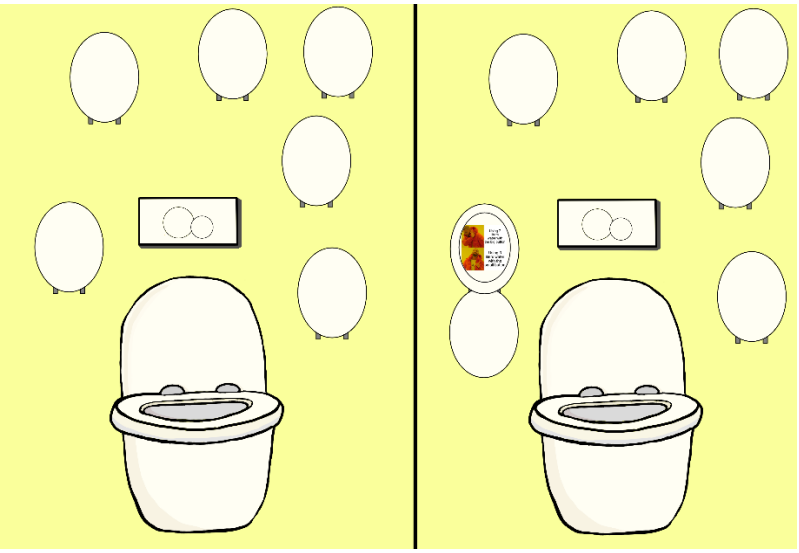


Figure 29: Feedback through memes with panels

4.5.8 Information on the buttons

Another way to make people more aware could be by adding information to the buttons to make it more clear what each button is used for (see Figure 30). Even text could be added to make it even clearer what button is used when as can be seen later in Figure 30. The only question is if this really makes people more aware of their normal behaviour and also start using the small button more when no icons are provided on the buttons.

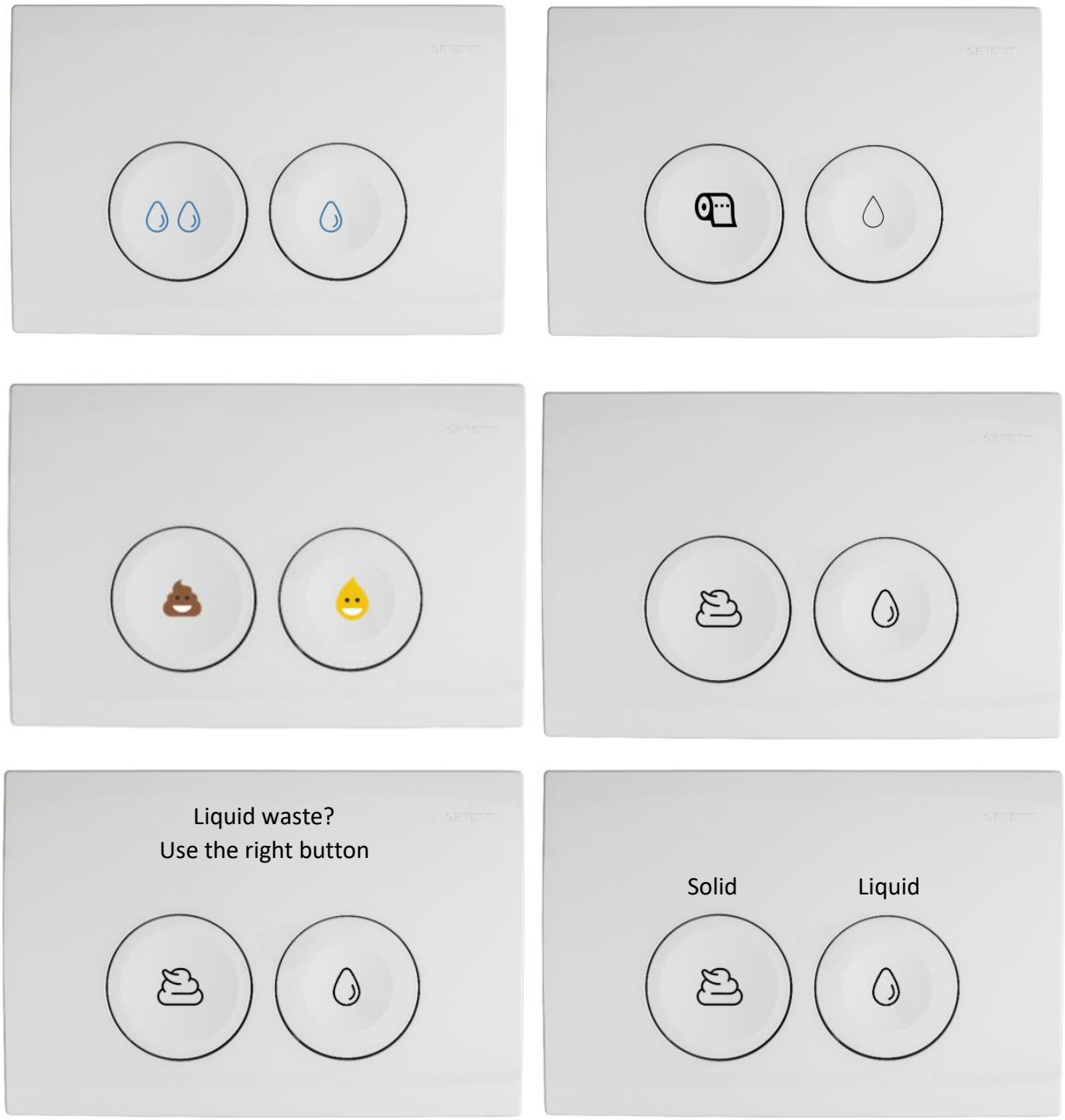


Figure 30: Information provided on the button in different ways

4.6 Sensing

Different options exist to find out which button is pressed. These can be seen in the red circles in Figure 18. In short, they could be detected by:

- Sense which button moves
- Sense how much water is used by sensing the water level in the basin
- Sense how much water is used by sensing the water flow

- Sense what flush is used by detecting the sound

Some ideas on how to sense these different things will be discussed more in depth in the specification phase.

4.7 Final concept

Now different concepts are generated the best one needs to be chosen. This was done with a decision matrix which can be seen Appendix A. Here, for every value item I gave a certain score on how well the solution answered to the specific item ranging from one till three. For example, the concept of providing information of memes scored a three on the value item "It should remain interesting" since it can show different memes per day and per button in order to remain interesting. I selected the relevant value items and rated all the concepts were rated on how well they fulfilled the value item. The top 4 concepts with their corresponding scores can be seen below in Table 5.

Concepts	**Score**
Providing information with memes	6238
Flowers opening-up	5709
Ambient lighting	5222
Fishualization	4879

Table 5: Best concept based on scores

4.7.1 Memes providing information

As seen above, the best idea is to provide information with memes. This idea scored especially well since it provides information in an easy and fun way. It fits the target audience, who are mostly students, perfect and since multiple memes can be shown it remains interesting. The text displayed on the images can be used to display different kind of messages explaining the consequences of water usage or how much water someone is using. It has the potential of being shared over the internet and thus reaching even more people. Additionally, if people could upload their own memes the content can remain interesting.

When the idea was discussed with CFM the idea was well-liked since it fitted very well with their wish of having humour in the solution. Additionally, the idea to host a competition for the best meme uploaded was suggested and some budget could be made available for a small

prize. By linking this competition to the sustainability program of the UT, CFM can also gain visibility for the projects that they are doing. The prize winner could potentially be announced in the newsletter about sustainability. In conclusion, this idea seems a fitting solution and will be specified further in the next chapter.

Memes can be presented through different media. Some ideas were already be discussed during the ideation phase and some additional ones have been thought off. The five main ideas for the medium are:

- Present memes on a screen
- Present memes through a beamer
- Memes coming down out of the ceiling
- A panel opening, revealing memes
- Printing out memes as a take-home sticker

When discussed with the UT, we decided that the screen was the best fit for this project. Mainly because it is more scalable, easier to use and it can be easily cleaned. In comparison with the beamer it is also less intrusive and requires less power.

5 Specification

In this chapter the final product will be further specified so it can be made into a prototype during the realisation phase. First, a scenario story and functional architecture are made to get a better overview of the interaction of the final idea. Then, memes themselves and the medium in which they will be presented will be discussed. Last, the technological components used and the final requirements are described.

5.1 Scenario story

This scenario was created to get a better understanding on how a user interacts with the prototype and see what interaction would be necessary.

1. Sam is a 20 year old guy who is currently in his second year of studying Creative Technology. He is listening to his teacher talk about statistics for one hour already when finally a five-minute break gets announced. It is Friday 14:45 and the last lecture of the week. Bored, but happy that he can take a short walk he heads over to the nearest toilet to fill his water bottle.
2. Sam fills his water bottle and decides to go to the toilet just in case. He opens the door to the right toilet cubicle and walks in. He sees a screen inside displaying the text “wait for it…”, he is curious what he should wait for. He starts taking a pee all the while dreading to go back to the math lecture. When he is done he randomly presses the small button, his mind distracted by other things.
3. Suddenly, the image on the TV changes from “wait for it…” into a meme. It is the “drake meme” in which a preference between two choices is indicated. Feeling surprised, confused and amused he reads the text and sees that it has to do something with saving water. Apparently pressing the small button saved 3 Liters of water, that is quite a bit! He tries to think about what button he usually presses but he does not know. He thinks, next time I will pay a bit more attention to it.
4. Sam quickly grabs his phone out of his pocket to take a picture of the meme to show to his friends back at the lecture. While taking the picture Sam sees the text: “upload your meme with the QR code and win a prize”. He looks next to the screen and sees the QR code. With the phone still in his hand, he quickly scans the QR code and saves the link for later.

5. Before Sam goes he considers pressing the button one more time to see if something happens. However, above the meme it says: “meme of the day” so it will likely be the same meme. The lecture is starting soon again so Sam leaves the toilet.
6. Back in the classroom Sam is happy the lecture has not started yet. He quickly sits next to his friends and tells them about the meme he saw on the toilet. He shows the picture on his phone and they all laugh about it.
7. In whispers, since the lecture started, they discuss what other memes might be shown and what memes they could submit himself. Sam also shares the meme in a group chat on Whatsapp with a different friend group from his home town where they regularly share memes.
8. Sam has to pay attention to the lecturer now since math is not his strongest skill. The teacher keeps writing formulas on the whiteboard for another hour when another five-minute break is announced. Sam, feeling exhausted, picks up his phone and starts browsing some memes on Reddit. He remembers the meme competition and quickly opens the link which leads him to a google form. Here he sees another meme explaining that he can also upload memes that might appear on the toilet. The memes have to be about the small button saving water and using the big button only when appropriate. He looks at some of the examples provided and thinks it should be easy enough. Sam thinks that it would be funny to have his meme on the toilet.
9. Sam types “meme generator” in google and finds a funny picture that fits the situation and adds his text. He goes back to the link and uploads the picture in the form. He also fills in his email address to have a chance to win the prize. A description tells that the meme will first be checked, it might only appear in a few days. Sam clicks on the button “submit” and tells himself that he will need to use the meme toilet again in a few days to check. For now, the lecture starts again.
10. The lecture is finally over, Sam feels relieved. He bikes back to his home thinking about the plans for the weekend. When he arrives home he quickly goes to the toilet. When finished peeing he has a quick flashback to the memes about the small button. With a small smile on his face he presses the small button so he saves 3 litres of water. After all, it is not difficult to do. When he is finished he joins his housemates on the couch where they talk about their day. Sam quickly explains the memes on the toilet and that you can

upload your own for a small price. The housemates laugh about the idea and two of them ask for the link to also upload a meme.

5.2 Functional architecture

A functional architecture was made (see Figure 31) to get a better overview of all the different components in this solution. It is split into three different components. First, there is device 1, which represents the sensor in the toilet button panel. Second, a signal gets send to device 2, which is the component displaying the meme. These memes also need to be uploaded, which is the third block where (with a QR code) the meme can be uploaded by a user.

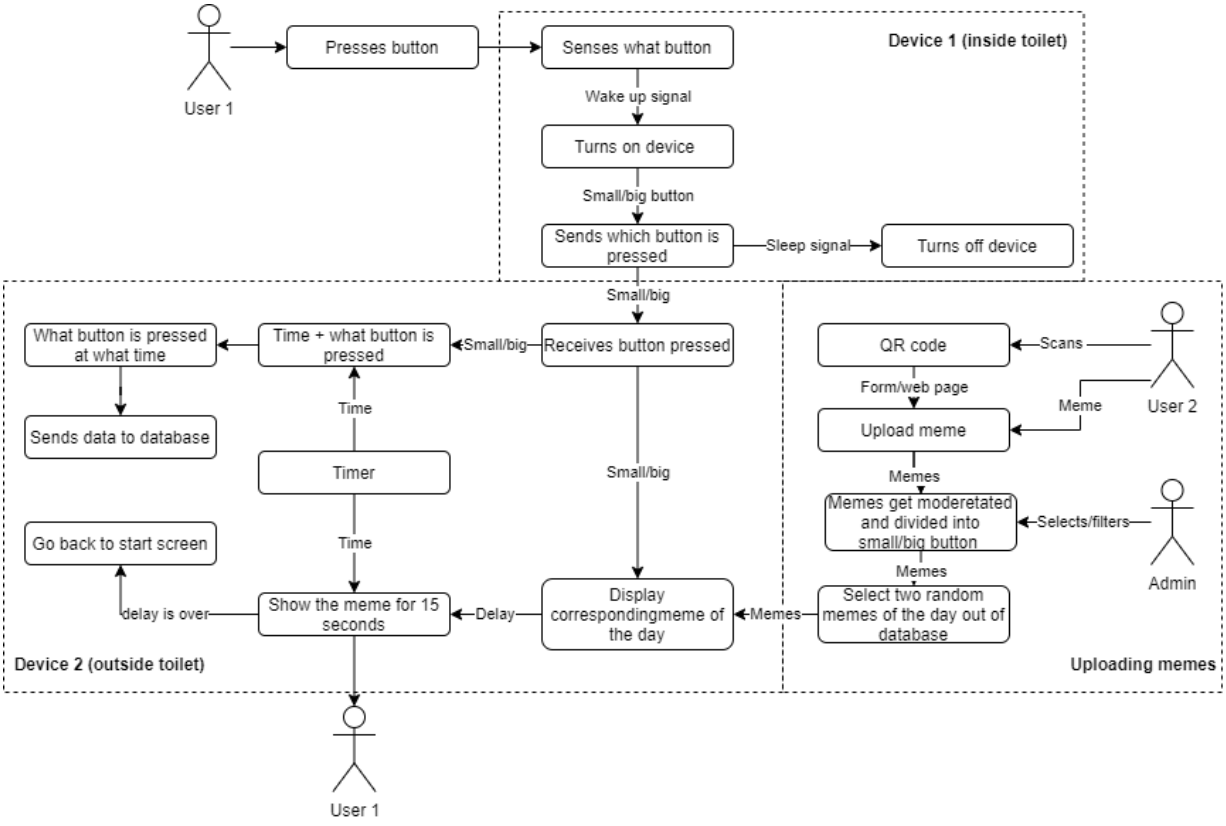


Figure 31: functional diagram

5.3 Memes

A lot of possibilities exist to display information through memes. However, the most effective messages should be chosen. Memes typically do not contain much text so the messages given should be short and concise but still convey meaning to the user. From the preliminary research done earlier it was found that certain information works well in motivating people to change their behaviour. These messages are:

- Providing comparative data (historical, social, goals)

- Communicates water usage
- Shows consequences of too much water usage

In addition, the memes should explain in which case what button should be used. Each of the three message types will be shortly discussed with an example of a meme.

5.3.1 Providing comparative data

Firstly, historical data could be provided in a meme. After the solution has been used for an extended period historical data could be shown about the water usage of the University of Twente. An example of this can be seen below in *Figure 32*. Another option might be to show social comparison, here it can help to establish a social nom. For example, telling that a certain percentage of people use the buttons correctly (see *Figure 33*)

Figure 32: Historical comparison

Figure 33: Social comparison

5.3.2 Communicating water usage

Another aspect that help in raising awareness is by letting people realize how much water they actually use. In the UT the water usage is 3 and 6 litres for the small and big flush respectively. An example of a meme giving this information can be seen in Figure 34.

Figure 34: Showing water usage

5.3.3 Shows consequences of water usage

Another option is to show different consequences of using too much water. Possible consequences could be water shortage leading into draughts (see Figure 35).

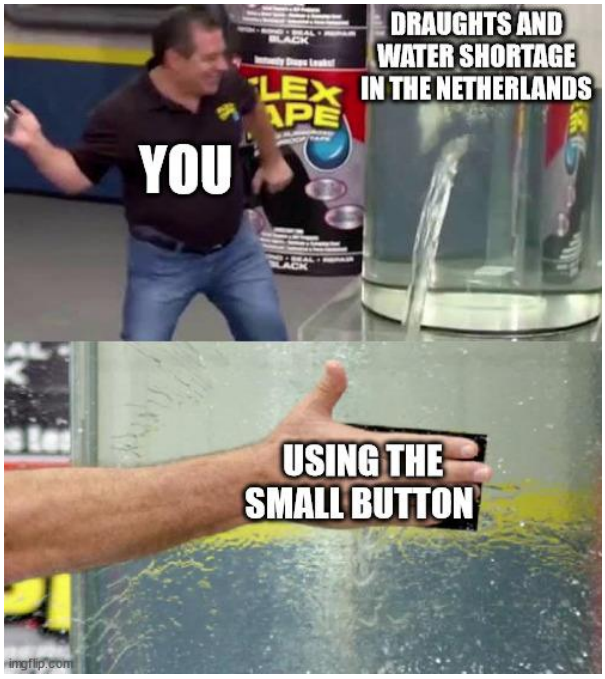


Figure 35: Consequences of water waste

5.3.4 Educating about correct use

Besides raising awareness of the consequences and water usage of using the small and big flush it is also important to know when to use what flush. An example of a meme showing this can be seen below (Figure 36).

Figure 36: educating people about how to use the buttons

5.3.5 People sending in their own memes

To keep having new memes and to motivate people they can upload their own memes through an online form. To guide this progress better, memes should be provided as an example with some text or facts that they can use as well. For this the examples in 5.3.1 till 5.3.4 can be used. After that the memes should still be moderated to ensure the content is relevant and not offensive. A few questions should be answered with yes before memes are uploaded:

- Does the meme motivate people to use the small button?
- Is the meme **not** offensive or racist?
- Is the meme original and new?

Besides these questions the meme should also not be judgemental towards using the big button. However, this is most important when the big button is used. When the small button is used it matters less if the meme is judgemental towards the big button. Nevertheless, the meme should focus more on praising the use of the small button instead of judging the use of the big button. After these questions are taken into consideration the meme should be add to the button that fits the context best. For example, some memes will work better after people used the small button instead of the big button.

5.4 Requirements

An updated version of the functional value items has been made and can be seen in Table 6. Additionally all the non-functional requirements can be seen in Table 7. Together with the MoSCoW method an overview is given of what must be in the final prototype, what should be

there, what could be there and what will not be there. Lastly, measures of effectiveness have been added to verify if the value items (requirements) have been fulfilled.

Value Items	**Must**	**Should**	**Could**	**Will not**	**Measures of effectiveness**
Detects which button is pressed with high accuracy	X				Error margin < 5%
Communicates which button is pressed	X				Sends signal to raspberry pi
Displays a meme of the day (different for the big and small button)	X				Randomly selects a meme of the day for each corresponding button
Can be (easily) cleaned	X				Is water and soap resistant
Memes can be submitted when scanning a QR code	X				When a QR code is scanned it leads to a form where memes can be submitted
Memes can be uploaded with an usb stick	X				When USB is plugged in the Raspberry Pi memes get selected automatically
Sensor has to fit behind the button	X				Sensor is smaller than: 23 cm x 16 cm x 3 cm
Can run on its own (without human interference needed)	X				Battery lasts for at least half a year, no other maintenance needed.
Saves the time which button is pressed in a workable format.	X				Saves a time stamp with corresponding button pressed which can be analysed in excel.
No technology is visible	X				No components or wiring are visible
Has a long-life cycle	X				All components should have a minimum life cycle of two years
No modifications to the toilet are needed		X			No permanent choices are made to the toilet

It can fit to most toilet systems		X			It fits to 80% of all toilet systems
Can be easily installed		X			Can be installed within half an hour
Battery can be easily replaced		X			Battery can be replaced in under 10 minutes
People can vote for their favourite meme			X		A voting system is in place on which people can vote on their favourite memes
Memes could be uploaded through Wi-Fi instead of a USB			X		Memes can be send over Wi-Fi to the raspberry pi
The data can be sent over Wi-Fi to a server			X		The system can connect to any Wi-Fi system and send the data to a server
Will detect if people went to the toilet to pee or to poop				X	

Table 6: Updated value items, MoSCoW and measures of effectiveness

Value Items	**Must**	**Should**	**Could**	**Will not**
It is not intrusive	X			
It should raise the awareness of users about what button they should press	X			
It should get people to the preparation phase to change their flushing behaviour	X			
It should catch the attention/be surprising	X			
It should fit the target	X			

audience				
It should remain interesting (not repetitive)	X			
Information is provided in a fun way	X			
Information is easily accessed	X			
It should be aesthetically pleasing		X		
Pressing again should be discouraged		X		
Provides information about water usage		X		
Clearly shows what button should be used in what situation		X		
Sparks discussion (people discuss the memes)		X		
Provides comparative data			X	
Shows general consequences of water usage			X	

Table 7: Non-functional requirements

6 realisation

First an overview will be given of all the different technological developments of this project. Afterwards, the final prototype will be shown and discussed.

6.1 Sensing unit

The sensing unit consists of three main components, the microcontroller, the sensor and the communication device. For the microcontroller, the SparkFun ESP32 Thing [46] was selected. The ESP32 has been chosen for its size and its ability to enter different sleep modes to conserve power. Additionally, it could connect to Wi-Fi and Bluetooth if that was desired.

The ESP32 is connected to two Grove Piezo Vibration sensors [47] which measure which button has been pressed. These sensors can measure vibrations or flexibility and when moved it creates a voltage. This voltage gets translated by a voltage comparator which translates this into a high or low signal. This voltage comparator' sensitivity can be changed with a small screwdriver to higher the sensitivity. This signal is then used to determine which button is activated. The sensor is attached in such a way that when one of the buttons is used the Piezo sensor gets flexed and sends out a signal (see Figure 37).

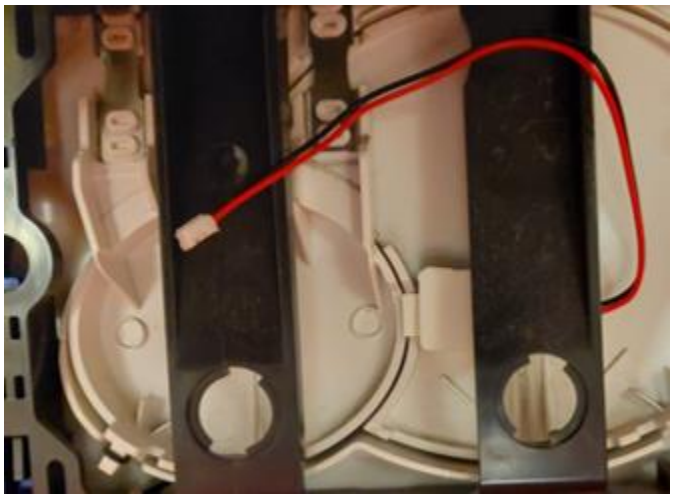


Figure 37: Piezo sensor that scans if the small button is pressed

Last, an RF Link Transmitter of 434 MHz [48] is connected to send a radio signal with which button is being pressed. This transmitter has been chosen, instead of the already present Bluetooth, since it has the lowest power consumption of all conventional wireless communication devices [49]. This is done with the help of the RadioHead [50] library for Arduino which handles the sending of a string with which button is being pressed. The code for

the ESP32 can be seen in Appendix B. The electrical components and how they are attached can be seen below in Figure 38:

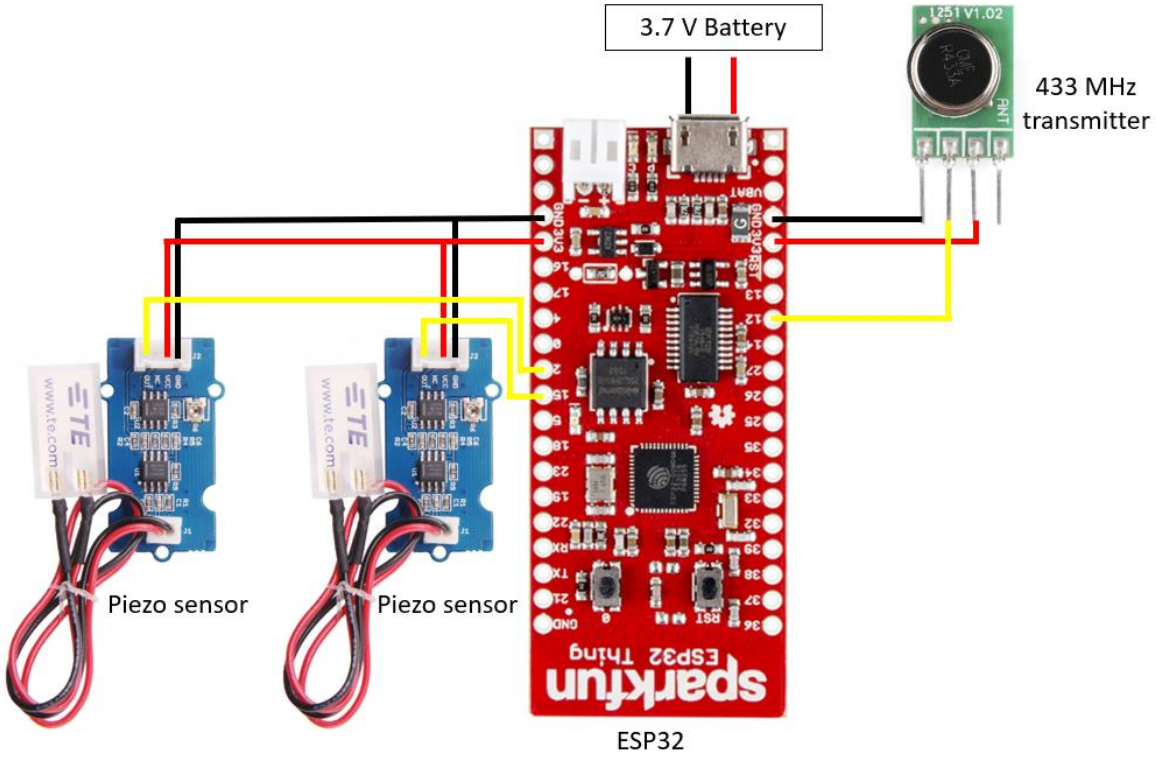


Figure 38: Electrical schema with components of the sensor unit

6.2 Power consumption

Since the sensor in the button panel will not have any access to electricity the energy consumption should be as low as possible to run on a battery. In the datasheet [46] of the ESP32 multiple power saving options are described which can be seen in Table 8. To save power the ESP32 can be put in deep sleep mode to save energy. In deep sleep mode, it uses only 0.19 mA. The ULP co-processor is still powered on and can be used for sensor readings. When the sensor that detects the small or big button is pressed it sends a signal to the ESP32 that it should turn on.

Power mode	Description	Power consumption
Active (RF working)	Wi-Fi Tx packet 13 dBm ~ 21 dBm	160 ~ 260 mA
	Wi-Fi / BT Tx packet 0 dBm	120 mA
	Wi-Fi / BT Rx and listening	80 ~ 90 mA
	Association sleep pattern (by Light-sleep)	0.9 mA@DTIM3, 1.2 mA@DTIM1
Modem-sleep	The CPU is powered on.	Max speed: 20 mA
		Normal speed: 5 ~ 10 mA
		Slow speed: 3 mA
Light-sleep	-	0.8 mA
Deep-sleep	The ULP co-processor is powered on.	0.15 mA
	ULP sensor-monitored pattern	25 μA @1% duty
	RTC timer + RTC memory	10 μA
Hibernation	RTC timer only	2.5 μA

Table 8: Overview power consumption

Once the ESP32 turns on it requires more energy, the ESP32 itself does not use any Bluetooth or Wi-Fi so uses around 11 mA. Additionally, the RF transmitter uses 8mA which gives a total system current usage of 19 mA when active. The ESP32 is active for roughly 2 seconds before going back to sleep mode. It is unknown how often the toilet will be flushed exactly but even for 500 flushes a day the system should (theoretically) still last around 255 days on a 2500 mAh battery. However, the battery also loses power over time, even when passive, so this will likely also play a role. The best is to measure how quickly the battery runs out which will be done during the evaluation.

6.3 Displaying the meme

The memes were shown with the help of a microcontroller, a Raspberry Pi 3B+ [51], which was connected to a 7-inch touch screen with a case [52]. This raspberry received signals with a 433 MHz receiver with a message indicating if either the small or big button was pressed. To decode the messages that were received the pigpio [53] was used with an example that worked well with the Radiohead library that was used to send the signal from the ESP32. Then a random meme was chosen from two folders corresponding with either the big button or the small button. All this is done in a python script with the use of several libraries, the code can be seen in Appendix C. The electrical schematic with the different components can be seen below in Figure

39 where the screen adapter board connects and powers the screen.

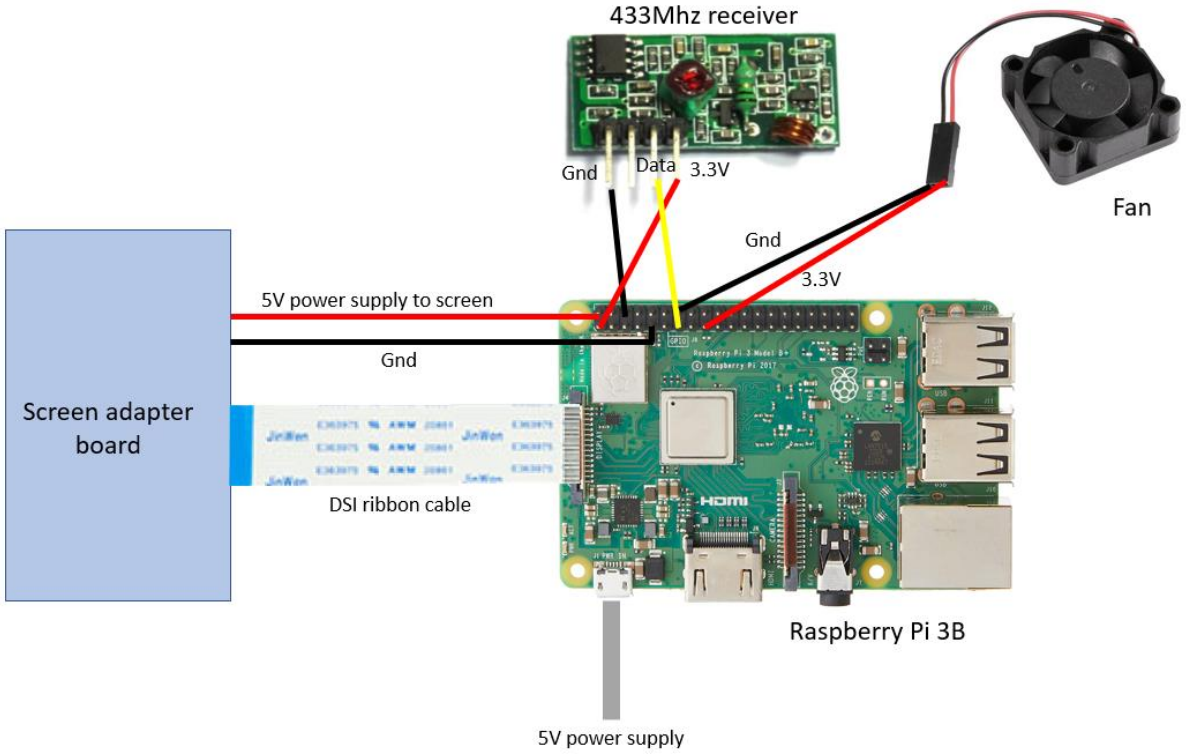


Figure 39: Electrical schema with components of the displaying unit

6.4 Casing

To protect all the different components cases were made to protect them as much as possible. All the different components of the sensor unit cases were 3D printed (see Figure 40) and most of them were fitted with some silica gel to prevent moisture from gathering inside the cases.

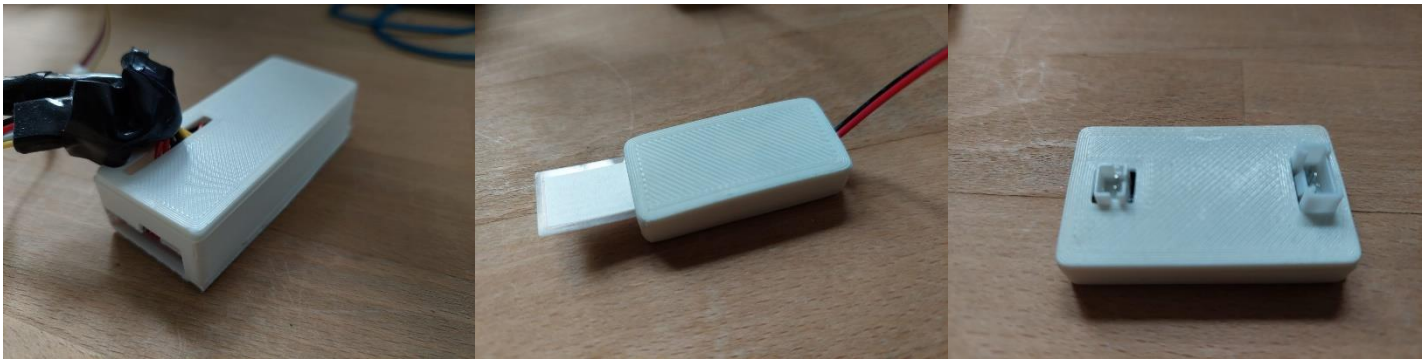


Figure 40: 3D printed cases for the ESP32, the piezo sensors and the voltage regulators

The screen and Raspberry Pi were protected by a box made with a laser cutter which can be seen in Figure 41. The front of the case is made of acrylic to allow people to see the screen. Underneath the screen contains the following rhyme: " We do not want to spoil it, but watch the screen when you flush the toilet". This was done to encourage people to watch the screen as soon as they visit the toilet.

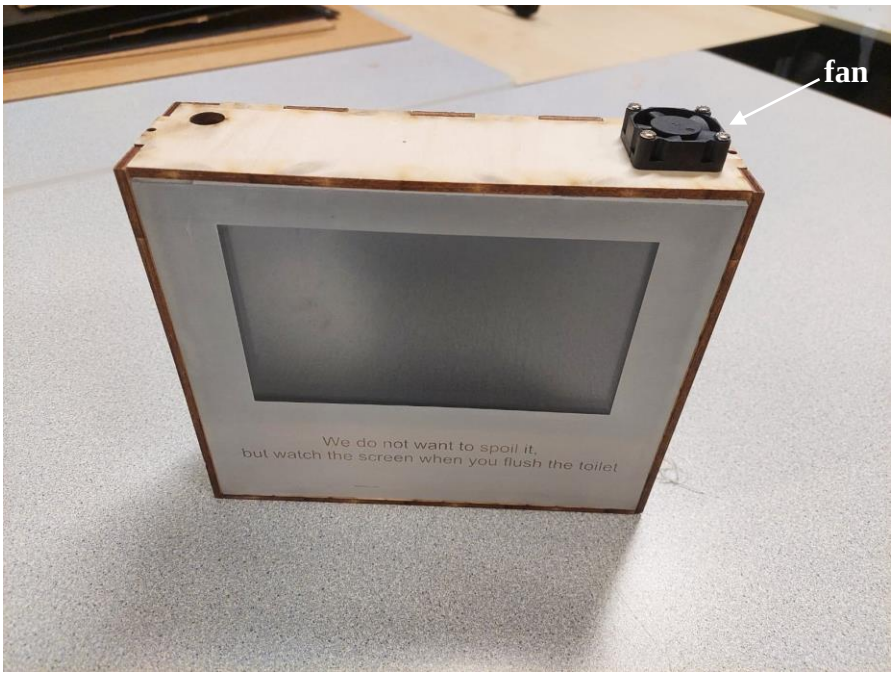


Figure 41: final case with screen and fan

6.5 Technical issues

Two major issues were encountered when the installation was installed on the toilet. First, the Raspberry Pi and the Screen kept overheating since hot air inside the casing could not escape. The Raspberry Pi lowers its performance to prevent hardware damage but this is not ideal.

Part of the reason was that the code was inefficiently written. Due to some unnecessary while loops, some functions kept being called while they were not necessary to do over and over again. This already solved the issue partially but after a while, the system still overheated. As a final solution, a tiny fan was added to blow air into the case which solved the issue completely. However, this fan also allows for water to get into the case so it might not be the ideal solution.

The second problem was the electricity supply in the toilet stalls. The system was plugged in the same socket as the lights. However, when the lights turned off when no one visited the toilet the installation would also turn off. A temporary solution was to have the python script

executed on start-up, this was done by modifying the crontab file [54]. However, this is not ideal since it takes some time for the Raspberry Pi to reboot. On a positive note, this solution does save energy when the installation does not need to be on but there are likely better methods of achieving this. What would have been ideal is the Raspberry Pi being powered by batteries that would automatically be charged as soon as the electricity did go on.

6.6 The final prototype of the installation

All the parts previously described allowed for the building of the final prototype. Below in Figure 42, the sensor unit can be seen with the cases around the different technical components. Number 1 contains both the ESP32 and the radio transmitter and is protected by waterproof and non-conducting tape (the black wrapping surrounding it). The battery (2) is a 2500 mAh LiPo battery that can easily be charged by connecting the ESP32 to another power source. Numbers 3 are the voltage comparators which give a high or low signal to the ESP32. Last of all, the numbers 4 represent the piezo sensors that are attached to the buttons which was shown earlier in Figure 37.

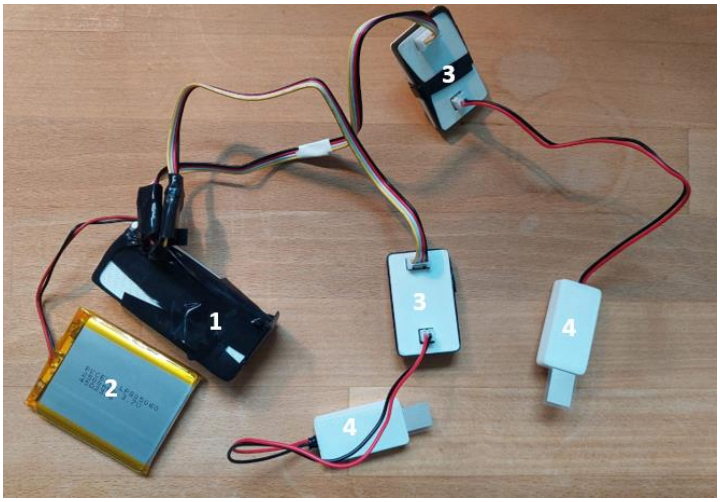


Figure 42: Overview of all components of the sensor unit

Below the installation can be seen as it was installed on the toilet, to the left the normal "wait for it message…" is being displayed. To the right, a meme is being displayed after the toilet has been flushed.

Figure 43: The final prototype in idle mode (left) and displaying a meme (right)

6.7 Consent

The EEMCS ethical committee [55] approved the testing of users on two toilets at the University of Twente if they were informed that an experiment was taking place. To inform the users a consent form was placed on the front of the toilet stall door informing people that an experiment was taken place. The exact nature of the experiment was not explained to avoid influencing the users. If people did not want to participate they could use the toilet next to the toilet with the installation. On the inside of the toilet and the inside of the bathroom door a QR-code was placed asking people to fill in a survey. A more in depth explanation of the test setup can be found in Chapter 7, the evaluation.

7 Evaluation

In this chapter the engineering evaluation and user evaluation will be discussed.

7.1 Functional evaluation

The functional requirements made earlier in Chapter 5 have been mostly achieved. Unfortunately, some must-have functions were not fully working in the prototype. First, while it was always accurate which button was pressed, it was not always detected that a button was pressed. This was partly due to people flushing the toilet with less pressure than what was used to test the solution at first. It was also made more difficult since the buttons used for the first testing were different from the buttons that were eventually used on the toilet.

Another issue was that the prototype was not connected to the Eduroam, the UT Wi-Fi network, which resulted in the clock being set at the wrong time. Especially since the solution often rebooted when the lights went out the time stamp was not correct. First, this resulted that the meme of the day could not be shown since the Raspberry Pi did not know the exact day. For the testing, a random meme was displayed when the button was pressed which might result in people pressing the button more often. Second, since the time was not correct the data file that saved which button was pressed at what time was also no longer correct which makes it difficult to know how many people flushed during the day. Especially since the buttons were also often pressed to test if the installation was still working or to change the sensitivity.

Another big problem was the battery not lasting as long as expected. After 2 weeks of operating the battery stopped while it was expected to last much longer. The power was then measured to see where the problem could lie but the measurements were even lower than the theoretical power consumption. The reason for the battery being empty might be the natural drain of the battery but further research should be done on how much power the installation uses exactly. Because of these issues, the installation could not run fully independent.

Besides these “must-haves”, some “could-haves” have also not been fulfilled. People could not vote for their favourite meme and since the system was not connected to Eduroam all the data transfer happened with a USB stick.

Last, another issue took place when the installation was placed at the women’s toilet. Here the installation sometimes fell off the wall while it was attached with the same tape that was used in the men’s toilet. When removing the installation from the men’s toilet it was almost impossible to get it off the wall in one piece so it was strange that it fell of the wall in the

woman's toilet multiple times. It might be better to find a different way to attach the system to the wall.

Regardless of these limitations the installation still functioned well for one and a half weeks. All the other functional requirements have been fulfilled and intervention was only needed to get the prototype attached back to the wall in the woman's toilet and to replace the battery once. The sensor, communication and screen all worked well and could be easily installed.

7.2 User evaluation

Despite some of the functional requirements not being met the whole sytem could still be tested successfully. As explained before, a survey (see Appendix E) could be filled in by scanning a QR-code which was done by a total of 19 participants. The first and most important question, "did it raise the awareness of the user?", has been filled in positively (see Figure 44) with an average score of 3.9 where 1 is "fully disagree" and 5 is "fully agree". A reason for some of the lower responses could be that people already feel like they are aware of their flushing behaviour and do not feel they could become more aware. However, it might also indicate that the installation did not work as well for everyone.

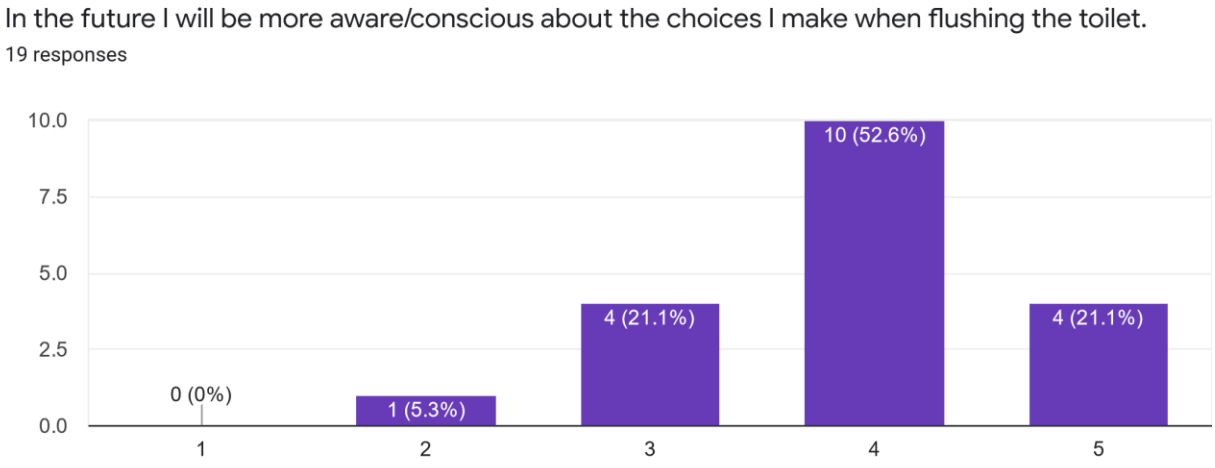


Figure 44: Question one on the survey about awareness where 1 is "fully disagree" and 5 is "fully agree"

The other answers to the questions are also promising as can be seen in Figure 45 where the average score for different statements can be seen. The full statements and scores can be seen in Appendix F. The score for attention is so high because people don't expect a screen in the toilet. Additionally, users found the installation fun, interesting and easy to understand. Some of the scores are a bit lower. One of them, about if the memes surprised the user can be explained since some users were the designer's friends and already had some knowledge as to what would happen. How well it fits the target audience was also not agreed on by everyone. While most people agreed that memes fit very well some people seem hesitant if employees at the UT also like the memes. This should probably be explored further to also see what the employees think themselves. When asked if people discussed the meme some people explained that they certainly will while others do not plan to. Nevertheless, even if some people discuss the meme or the installation it already makes the reach of the installation much bigger which could improve the impact. Lastly, privacy was not an issue for most, but some people did not feel comfortable and three people even filled in a 2 on the Likert scale. This is an issue that might need to be addressed in the future.

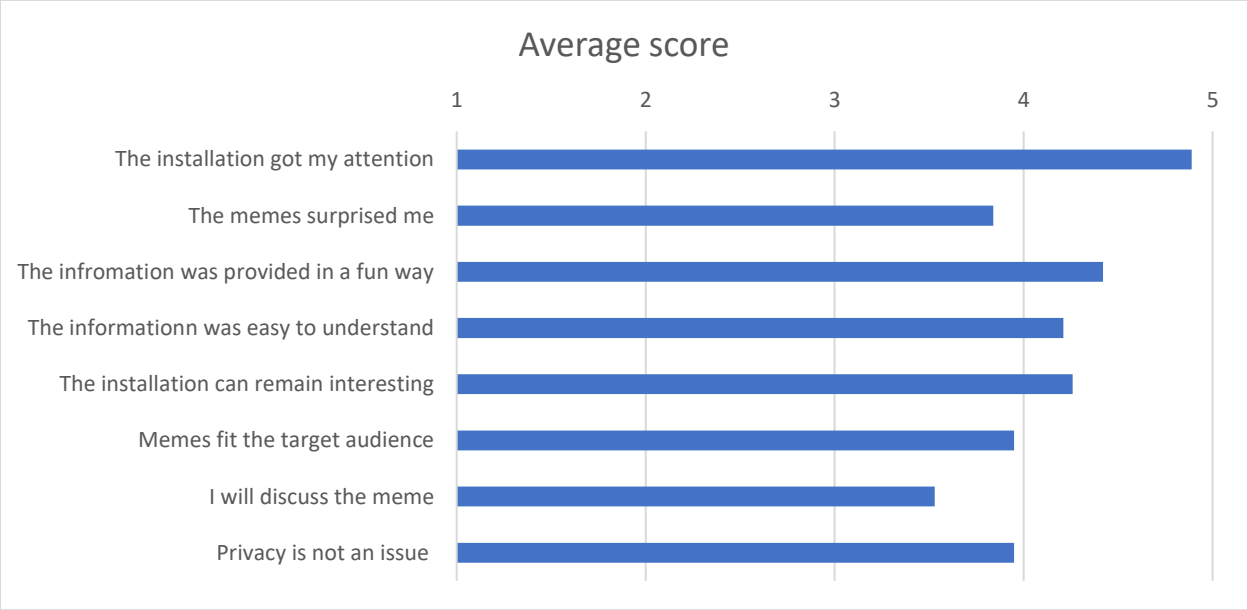


Figure 45: Average score to multiple statements where 1 is "fully disagree" and 5 is "fully agree"

As stated in the introduction, the goal was to move people to the preparation phase of the transtheoretical model. In other words, they should plan on changing their behaviour in the near future. The results of this question can be seen in Figure 46. While 10 people already indicate

that they are in the maintenance phase of the transtheoretical model and use the small button every time they urinate, six people indicate that they plan to use this button more often and two people filled in a maybe. The two people that filled in that they might change their behaviour can be considered to be in the contemplation phase where they know the pros and cons and they plan to change their behaviour in the coming 6 months. However, it is less likely that they change their behaviour compared to the people in the preparation phase. The six people who filled in yes and plant to change their behaviour have moved to the preparation phase since they plan on changing their behaviour in the near future.

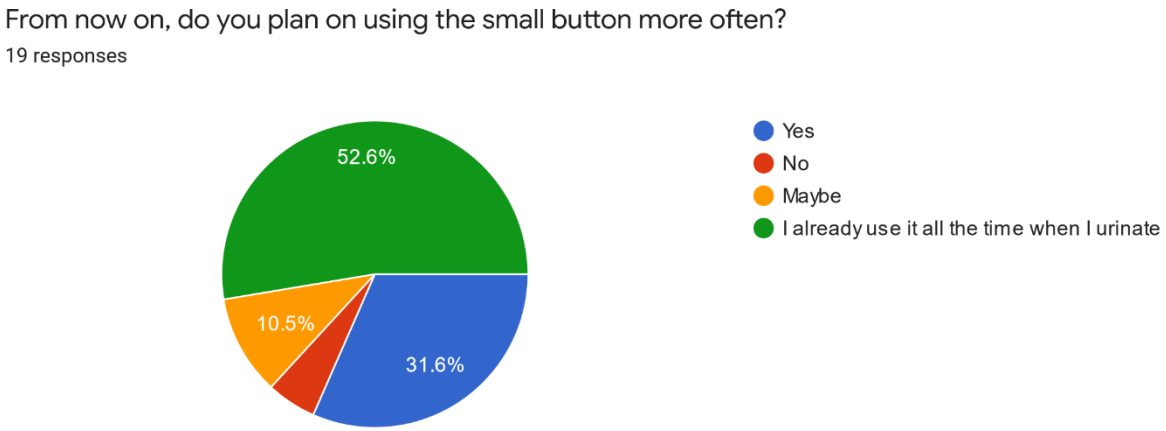


Figure 46: Did people move to the preparation phase?

In conclusion, all the must-have non-function requirements from chapter five have been fulfilled. Additionally, it is also likely that some people will discuss or share the memes with their friends which could make the impact of the installation even bigger which was one of the should-haves. All the other should- and could-haves have not been measured to keep the survey as short as possible but might have been fulfilled nonetheless. For example, some memes do show the water usage, comparisons or some consequences but it is unclear if people understand these and what impact they have.

7.3 Remarks

Users were asked if they had any other remarks regarding the solution. Some comments were made about the text that asks people to fill in the survey. It was too small and people did

not see it that easy. For future research, this could be improved. Additionally, someone commented that memes might be appropriate for students but they doubted if UT employees would also appreciate it. One of the users did say that he/she wanted to flush more often to see more memes. This could be prevented by a meme of the day system. Last, memes should be shown a bit longer to make it is easier for people to take a picture of the meme in case they want to.

8 Conclusion

During this chapter, a look will first be taken at the complete research and an attempt will be made to answer the main research question. Second, future recommendations will be discussed regarding the solution.

8.1 Raising awareness

The focus of this research was to make the UT community aware of their toilet flushing behaviour and move them to the preparation phase where they plan to change their behaviour in the near future. Research shows that people's behaviour change can be characterised by five different stages: pre-contemplation, contemplation, preparation, action and maintenance [9]. The goal of this research was to move people to the preparation phase where they plan to change their behaviour in the near future. To do this people need to become aware of what they are doing which gives the following research question for this paper:

How to make the UT community members aware of their toilet flushing behaviour?

As an answer to this question, a solution providing feedback by the means of memes was designed. Memes are funny images with text that students already send to each other so they fit the target audience. These memes can provide different types of information like consequences, historical data, comparisons, water usage and they can explain when to use what button. A case with a screen that could display the memes was placed first in the men's and then in the woman's toilet. When inactive, a message with the text "wait for it" was displayed to encourage people to keep looking at the screen. Two sensors were placed behind the button panel of the toilet and would generate a voltage when one of the buttons was pressed. When a button was pressed the sensor would send a radio signal telling the screen which button was pressed which then displayed a random meme to the user.

The majority of the users who evaluated the prototype were positive about the installation and most believe that they will be more aware of their flushing behaviour in the future. Additionally, the users think memes are a suitable, fun and accessible way to provide feedback. While the installation did get the attention when entering the toilet, a few users did not feel comfortable with this due to privacy concerns. Some people also indicated that they plan on sharing either the meme or talk about the installation which can make the reach of the solution even bigger. Last, 31.6% of the users indicated that they plan on using the small button more often from now on. These users have been moved to the preparation phase which was the

ultimate goal of this project. Most users (52.6%) indicated that they already use the buttons correctly. All these results seem to indicate that the installation is a suitable solution to make people more aware of their flushing behaviour.

To conclude, raising awareness on flushing behaviour can save a lot of water and showing memes seem to show a lot of promise in making people more aware. Both the client (CFM) and the UT, were enthusiastic regarding the prototype and they see potential to continue the project and doing additional research. They are interested in the possibilities of scaling up and implementing the prototype on more toilets at the UT and to see if the product manages to change the behaviour of people flushing the toilet.

8.2 Future recommendations

Memes seem to raise the awareness and moves roughly one third of the people to the preparation phase it would be interesting to see if people actually change their toilet flushing behaviour. However, before this is tested some additional improvements and research are recommended.

While the button panel sensor works fine most of the time the sensitivity could be higher. The sensor should be activated even when the button is pushed softer than usual. Additionally, while the battery can be easily replaced it should last for at least three months and also notify the UT staff if it is almost empty. First, the exact power consumption should be tested. As an alternative, the piezo sensor creates a small voltage that could be enough to send a short radio signal. If implemented well this could mean no microcontroller would be needed and it would even be able to run without a battery.

A different power supply for the screen and Raspberry Pi is also needed since it now turns off whenever electricity is gone. An option might be a power supply that charges whenever there is electricity and can be used in the off-time when no power is used.

The Raspberry Pi should also be able to connect to the UT internet in able to set the time correctly and allow for additional features. Additional features to make testing easier could be the online uploading of data and memes and checking the status of the installation.

Last, modification to the case should be made. First, a different attachment mechanism might be needed since the tape got loose from the wall after some time. Second, the case could be designed differently to allow for easier access to the raspberry pi. Third, the case could allow

for better airflow by adding places for small fans in places where water is less likely to come like the bottom.

To summarize, the following improvements are recommended to improve the solution and make testing easier.

- Higher reliability of button panel sensors
- Measure power consumption button panel sensor unit
- Implement new button panel sensor system without need of battery
- Implement back-up power supply for Raspberry Pi + Screen
- Connect automatically to UT internet to:
    - Upload memes online
    - Collect data online
    - See status of installation
- New casing:
    - Alternative waterproof ventilation
    - Different attachment system

8.2.1 Future research

As said earlier it would be interesting to see if the installation actually changes the behaviour of users. This would need to be researched over a longer period of time to see if the behaviour of users also remains the same and to see what the influence of the installation is after multiple visits.

Additionally, it should also be research if the rebound-effect is not taking place and people do not use the button more often. Second, the effect of different memes should be studied to see what works most effectively in both raising awareness and educating about the proper usage of the dual-flush toilet. Third, the installation has quite some potential inside the UT-community but further research would be needed to see if it can also applied outside of the UT and if people still like or understand the memes shown.

Appendix A: Decision matrix

		Water physicalization		Water visualization LEDs		Screen: fishualization		Screen: Agriculure		Screen: Grolsch		Screen: tree		Plant getting water		Flowers opening up		Ambient lightening		Memes	
	Importance	Score	Result	Score	Result	Score	Result	Score	Result	Score	Result	Score	Result	Score	Result	Score	Result	Score	Result	Score	Result
Energy spend while operating is low	**162**	2	324	1	162	1	162	1	162	1	162	1	162	3	486	2	324	3	486	2	324
Can run independently	**108**	3	324	3	324	3	324	3	324	3	324	3	324	1	108	3	324	3	324	2	216
Can be installed fast	**54**	1	54	2	108	3	162	3	162	3	162	3	162	2	108	3	162	3	162	2	108
It can be fitted to most toilets	**90**	3	270	3	270	3	270	3	270	3	270	3	270	2	180	3	270	3	270	2	180
Communicates water usage of big and small flush	**135**	3	405	3	405	3	405	1	135	1	135	1	135	1	135	3	405	2	270	3	405
Shows consequences of water usage	**63**	1	63	1	63	2	126	3	189	2	126	2	126	3	189	2	126	1	63	2	126
Sparks discussion	**63**	2	126	2	126	2	126	2	126	2	126	1	63	3	189	2	126	1	63	3	189
Information is easily accessed	**189**	3	567	3	567	3	567	3	567	3	567	3	567	2	378	3	567	3	567	3	567
Feedback is given immediately	**135**	3	405	3	405	3	405	3	405	3	405	3	405	2	270	3	405	3	405	3	405
Combines artistic with pragmetic approach	**63**	1	63	1	63	1	63	1	63	1	63	1	63	1	63	3	189	2	126	1	63
Does not provide judgemental feedback	**189**	3	567	3	567	1	189	1	189	1	189	2	378	2	378	2	378	2	378	2	378
It should catch the attention/be surprising	**189**	2	378	1	189	2	378	1	189	1	189	1	189	1	189	2	378	3	567	3	567
Provides compariitive data	**81**	1	81	1	81	1	81	1	81	1	81	1	81	1	81	2	162	2	162	2	162
It should fit the target audience (students)	**243**	1	243	2	486	2	486	1	243	1	243	1	243	1	243	1	243	2	486	3	729
It should be aesteticly pleasing	**136**	2	272	2	272	1	136	1	136	1	136	1	136	2	272	3	408	2	272	1	136
Clearly shows what button should be used	**135**	1	135	1	135	2	270	1	135	1	135	1	135	1	135	2	270	1	135	2	270
It should remain interesting (not be repetitive)	**243**	1	243	1	243	1	243	1	243	1	243	1	243	1	243	2	486	1	243	3	729
Information is provided in a fun way	**243**	1	243	1	243	2	486	1	243	3	729	1	243	2	486	2	486	1	243	3	729
Final score:			**4763**		**4709**		**4879**		**3862**		**4285**		**3925**		**4133**		**5709**		**5222**		**6283**

Appendix B: ESP32 code

```
/*
  Deep Sleep with External Wake Up
  =====================================
  This code displays how to use deep sleep with
  an external trigger as a wake up source and how
  to store data in RTC memory to use it over reboots

  This code is under Public Domain License.

  Hardware Connections
  ======================
  Push Button to GPIO 33 pulled down with a 10K Ohm
  resistor

  NOTE:
  ======
  Only RTC IO can be used as a source for external wake
  source. They are pins: 0,2,4,12-15,25-27,32-39.

  Author:
  Pranav Cherukupalli <cherukupallip@gmail.com>
*/

#define BUTTON_PIN_BITMASK 0x8004 // GPIOs 2 and 15
#include <RH_ASK.h>
#include <SPI.h> // Not actually used but needed to compile

RTC_DATA_ATTR int bootCount = 0;
RH_ASK driver;
bool messageSend = false;
int count = 0;
int wake_gpio;
/*
  Method to print the reason by which ESP32
  has been awaken from sleep
*/

void print_wakeup_reason() {
  esp_sleep_wakeup_cause_t wakeup_reason;

  wakeup_reason = esp_sleep_get_wakeup_cause();

  switch (wakeup_reason)
  {
    case ESP_SLEEP_WAKEUP_EXT1 : Serial.println("Wakeup caused by external
signal using RTC_CNTL"); break;
    default : Serial.printf("Wakeup was not caused by deep sleep: %d\n",
wakeup_reason); break;
  }
}
```

```
/*
  Method to print the GPIO that triggered the wakeup
*/
void print_GPIO_wake_up() {
  int GPIO_reason = esp_sleep_get_ext1_wakeup_status();
  messageSend = false;
  Serial.print("GPIO that triggered the wake up: GPIO ");
  //calculated the gpio pin that caused wakeuup
  wake_gpio = (log(GPIO_reason)) / log(2), 0;
  //Serial.println(wake_gpio);
}

void setup() {
  Serial.begin(9600);
  delay(1000); //Take some time to open up the Serial Monitor
  if (!driver.init())
    Serial.println("init failed");
  //Increment boot number and print it every reboot
  ++bootCount;
  Serial.println("Boot number: " + String(bootCount));

  //Print the wakeup reason for ESP32
  print_wakeup_reason();

  //Print the GPIO used to wake up
  print_GPIO_wake_up();

  while (messageSend == false) {

    if (wake_gpio == 2) {
      const char *msg = "Small";
      driver.send((uint8_t *)msg, strlen(msg));
      driver.waitPacketSent();
      //Serial.println("this is also happening");
    }
    if (wake_gpio == 15) {
      const char *msg = "Big";
      driver.send((uint8_t *)msg, strlen(msg));
      driver.waitPacketSent();
      //Serial.println("this is happening");
    }

    count ++;
    if (count == 2) {
      messageSend = true;
      count = 0;
    }
  }
  /*
    First we configure the wake up source
    We set our ESP32 to wake up for an external trigger.
    There are two types for ESP32, ext0 and ext1 .
    ext0 uses RTC_IO to wakeup thus requires RTC peripherals
    to be on while ext1 uses RTC Controller so doesnt need
    peripherals to be powered on.
```

```
    Note that using internal pullups/pulldowns also requires
    RTC peripherals to be turned on.
  */
  //esp_deep_sleep_enable_ext0_wakeup(GPIO_NUM_15,1); //1 = High, 0 = Low

  //If you were to use ext1, you would use it like
  esp_sleep_enable_ext1_wakeup(BUTTON_PIN_BITMASK, ESP_EXT1_WAKEUP_ANY_HIGH);


  //Go to sleep now
  Serial.println("Going to sleep now");
  delay(1000);
  esp_deep_sleep_start();
  Serial.println("This will never be printed");
  //This is not going to be called
}

void loop() {


}
```

Appendix C: Python code

```
import pygame, os, random, time, pigpio, vw
from pygame.locals import *
from datetime import datetime
pygame.init()
condition = False
pressed_small = False
pressed_big = False

MAX_MESSAGE_BYTES=77

MIN_BPS=50
MAX_BPS=20000
_BPS = 2000
_HEADER=[0x2a, 0x2a, 0x2a, 0x2a, 0x2a, 0x2a, 0x38, 0x2c]

_CTL=3

_SYMBOL=[
   0x0d, 0x0e, 0x13, 0x15, 0x16, 0x19, 0x1a, 0x1c,
   0x23, 0x25, 0x26, 0x29, 0x2a, 0x2c, 0x32, 0x34]

"""
                                                                    8    3    B
preamble 48-bit   010101 010101 010101 010101 010101 010101 0001 1100 1101
length   12-bit   S1 S2
message  12*n bit S1 S2 ... S(2n-1) S(2n)
CRC      24-bit   S1 S2 S3 S4

S are the 6-bit symbols for each nibble.
"""

def _sym2nibble(symbol):
   for nibble in range(16):
      if symbol == _SYMBOL[nibble]:
         return nibble
   return 0

def _crc_ccitt_update(crc, data):

   data = data ^ (crc & 0xFF);

   data = (data ^ (data << 4)) & 0xFF;

   return (
            (((data << 8) & 0xFFFF) | (crc >> 8)) ^
             ((data >> 4) & 0x00FF) ^ ((data << 3) & 0xFFFF)
          )


class rx():

   def __init__(self, pi, rxgpio, bps=2000):
      """
      Instantiate a receiver with the Pi, the receive gpio, and
      the bits per second (bps).  The bps defaults to 2000.
```

```
      The bps is constrained to be within MIN_BPS to MAX_BPS.
      """
      self.pi = pi
      self.rxgpio = rxgpio

      self.messages = []
      self.bad_CRC = 0

      if bps < MIN_BPS:
         bps = MIN_BPS
      elif bps > MAX_BPS:
         bps = MAX_BPS

      slack = 0.20
      self.mics = int(1000000 / bps)
      slack_mics = int(slack * self.mics)
      self.min_mics = self.mics - slack_mics       # Shortest legal edge.
      self.max_mics = (self.mics + slack_mics) * 4 # Longest legal edge.

      self.timeout =  8 * self.mics / 1000 # 8 bits time in ms.
      if self.timeout < 8:
         self.timeout = 8

      self.last_tick = None
      self.good = 0
      self.bits = 0
      self.token = 0
      self.in_message = False
      self.message = [0]*(MAX_MESSAGE_BYTES+_CTL)
      self.message_len = 0
      self.byte = 0

      pi.set_mode(rxgpio, pigpio.INPUT)

      pi.set_glitch_filter(rxgpio, int(self.mics/4))

      self.cb = pi.callback(rxgpio, pigpio.EITHER_EDGE, self._cb)

   def _calc_crc(self):

      crc = 0xFFFF
      for i in range(self.message_length):
         crc = _crc_ccitt_update(crc, self.message[i])
      return crc

   def _insert(self, bits, level):

      for i in range(bits):

         self.token >>= 1

         if level == 0:
            self.token |= 0x800

         if self.in_message:
```

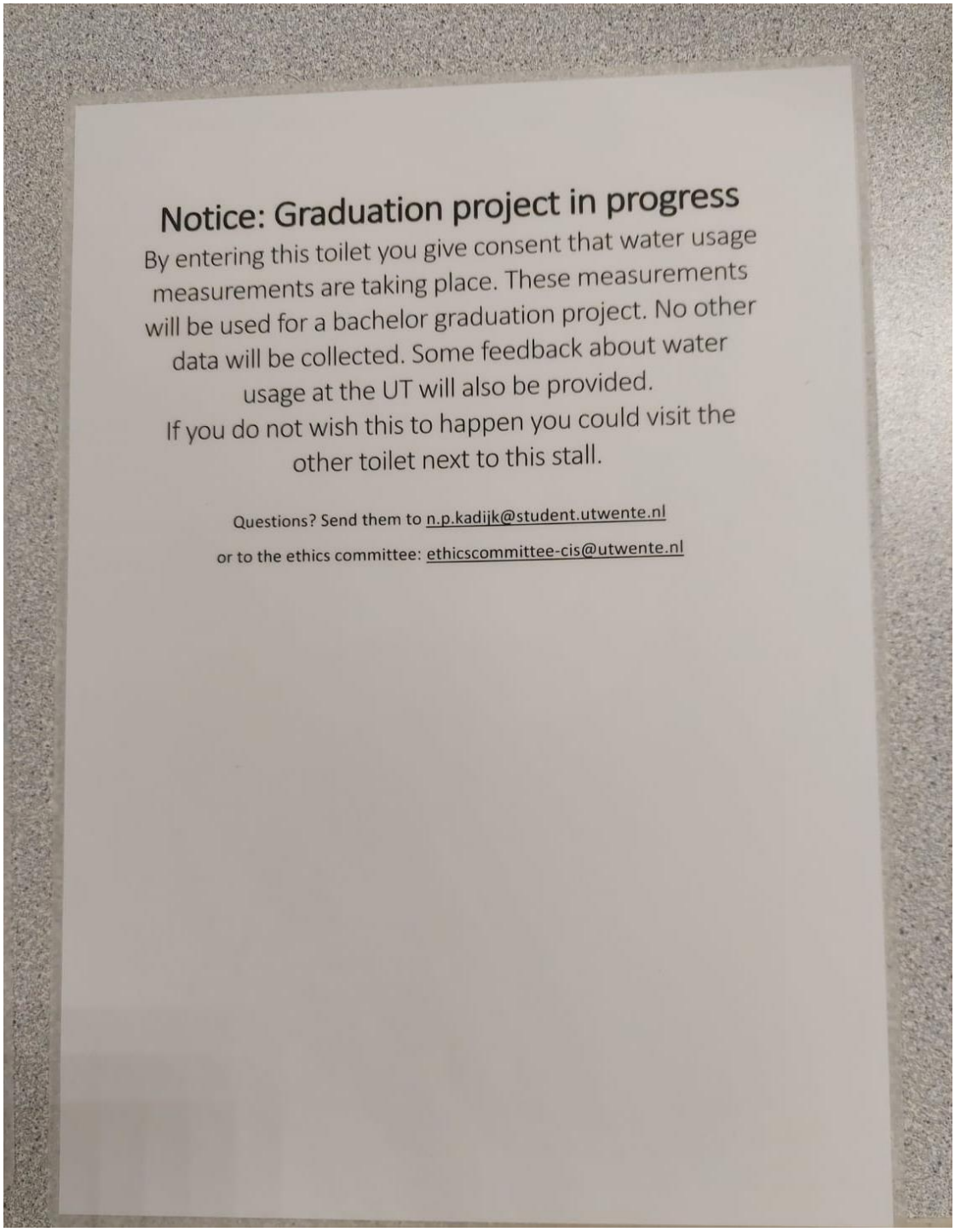
```
            self.bits += 1

            if self.bits >= 12: # Complete token.

               byte = (
                  _sym2nibble(self.token & 0x3f) << 4 |
                  _sym2nibble(self.token >> 6))

               if self.byte == 0:
                  self.message_length = byte

                  if byte > (MAX_MESSAGE_BYTES+_CTL):
                     self.in_message = False # Abort message.
                     return

               self.message[self.byte] = byte

               self.byte += 1
               self.bits = 0

               if self.byte >= self.message_length:
                  self.in_message = False
                  self.pi.set_watchdog(self.rxgpio, 0)

                  crc = self._calc_crc()

                  if crc == 0xF0B8: # Valid CRC.
                     self.messages.append(
                        self.message[1:self.message_length-2])
                  else:
                     self.bad_CRC += 1

         else:
            if self.token == 0xB38: # Start message token.
               self.in_message = True
               self.pi.set_watchdog(self.rxgpio, self.timeout)
               self.bits = 0
               self.byte = 0

   def _cb(self, gpio, level, tick):

      if self.last_tick is not None:

         if level == pigpio.TIMEOUT:

            self.pi.set_watchdog(self.rxgpio, 0) # Switch watchdog off.

            if self.in_message:
               self._insert(4, not self.last_level)

            self.good = 0
            self.in_message = False

         else:

            edge = pigpio.tickDiff(self.last_tick, tick)
```

```
            if edge < self.min_mics:

               self.good = 0
               self.in_message = False

            elif edge > self.max_mics:

               if self.in_message:
                  self._insert(4, level)

               self.good = 0
               self.in_message = False

            else:

               self.good += 1

               if self.good > 8:

                  bitlen = (100 * edge) / self.mics

                  if   bitlen < 140:
                     bits = 1
                  elif bitlen < 240:
                     bits = 2
                  elif bitlen < 340:
                     bits = 3
                  else:
                     bits = 4

                  self._insert(bits, level)

      self.last_tick = tick
      self.last_level = level

   def get(self):
      """
      Returns the next unread message, or None if none is avaiable.
      """
      if len(self.messages):
         return self.messages.pop(0)
      else:
         return None

   def ready(self):
      """
      Returns True if there is a message available to be read.
      """
      return len(self.messages)

   def pause(self):
      """
      Pauses the wireless receiver.
      """
      if self.cb is not None:
```

```
            self.cb.cancel()
            self.pi.set_watchdog(self.rxgpio, 0)
        self.cb = None

    def resume(self):
        """
        Resumes the wireless receiver.
        """
        if self.cb is None:
            self.cb = self.pi.callback(self.rxgpio, pigpio.EITHER_EDGE,
self._cb)

    def cancel(self):
        """
        Cancels the wireless receiver.
        """
        if self.cb is not None:
            self.cb.cancel()
            self.pi.set_glitch_filter(self.rxgpio, 0)
            self.pi.set_watchdog(self.rxgpio, 0)
        self.cb = None

while True:
    WIDTH = 800
    HEIGHT = 480
    windowSurface = pygame.display.set_mode((WIDTH, HEIGHT),pygame.NOFRAME)
    img = pygame.image.load('/media/pi/7E95-E1D1/Memes/curious.jpg')
    x, y = img.get_size()
    rxw = WIDTH / x
    ry = HEIGHT / y
    ratio = rxw if rxw < ry else ry
    img = pygame.transform.scale(img, (int(x*rxw), int(y*ry)))
    events = pygame.event.get()
    start = time.time()
    windowSurface.blit(img, (0, 0)) #Replace (0, 0) with desired coordinates
    pygame.display.flip()
    while condition == False:
        if __name__ == "__main__":
            RX=27
            BPS=_BPS #edited

            pi = pigpio.pi() # Connect to local Pi.
            #print(pi.connected)

            rx = vw.rx(pi, RX, BPS) # Specify Pi, rx GPIO, and baud.


            msg = 0

            start = time.time()

            while condition == False:

                msg += 1

                while rx.ready():
```

```
                print("Ready")
                message = "".join(chr (c) for c in rx.get())
                print(message)
                small = "small"
                for i in range(0,len(message)):
                    if(message[i] == 'B' and message [i+1] == 'i'):
                       print('big button')
                       condition = True
                       pressed_big = True
                       file = open("/media/pi/7E95-E1D1/Raspberry
pi/flushData.csv","a+")
                       file.write(datetime.today().strftime('%Y-%m-%d
%H:%M:%S') + ",big")
                       file.write('\n')
                       file.close()
                    if(message[i] == 'S' and message[i+1] == 'm'):
                        print('small button')
                        condition = True
                        pressed_small = True
                        file = open("/media/pi/7E95-E1D1/Raspberry
pi/flushData.csv","a+")
                        file.write(datetime.today().strftime('%Y-%m-%d
%H:%M:%S') + ",small")
                        file.write('\n')
                        file.close()

    if  condition == True:
        if(pressed_small == True):
            folder = r"//media/pi/7E95-E1D1/Memes/smallMemes"
            a=random.choice(os.listdir(folder))
            img = pygame.image.load('/media/pi/7E95-
E1D1/Memes/smallMemes'+'/'+a)
            pressed_small = False
        if(pressed_big == True):
            folder = r"//media/pi/7E95-E1D1/Memes/bigMemes"
            a=random.choice(os.listdir(folder))
            img = pygame.image.load('/media/pi/7E95-
E1D1/Memes/bigMemes'+'/'+a)
            pressed_big = False
        WIDTH = 800
        HEIGHT = 480
        windowSurface = pygame.display.set_mode((WIDTH,
HEIGHT),pygame.NOFRAME)

        x, y = img.get_size()
        rx = WIDTH / x
        ry = HEIGHT / y
        ratio = rx if rx < ry else ry
        img = pygame.transform.scale(img, (int(x*rx), int(y*ry)))
        start = time.time()
        events = pygame.event.get()
        windowSurface.blit(img, (0, 0)) #Replace (0, 0) with desired
coordinates
        pygame.display.flip()
        time.sleep(10)
        condition = False
```

Appendix D: Debriefings toilet

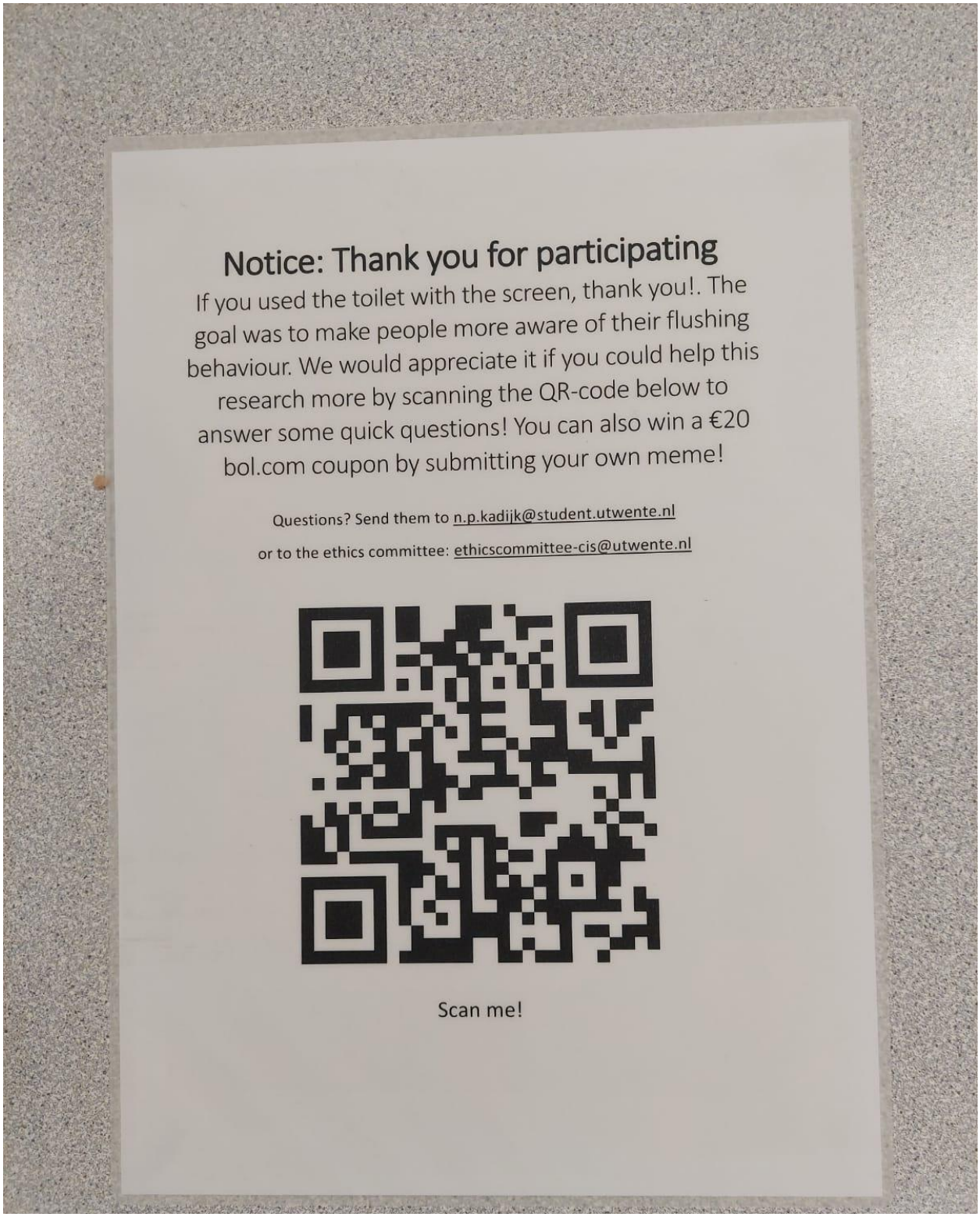


Notice: Graduation project in progress

By entering this toilet you give consent that water usage measurements are taking place. These measurements will be used for a bachelor graduation project. No other data will be collected. Some feedback about water usage at the UT will also be provided.
If you do not wish this to happen you could visit the other toilet next to this stall.

Questions? Send them to n.p.kadijk@student.utwente.nl

or to the ethics committee: ethicscommittee-cis@utwente.nl

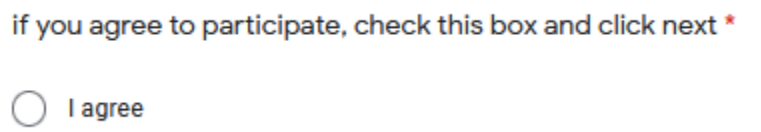

Notice: Thank you for participating
If you used the toilet with the screen, thank you!. The goal was to make people more aware of their flushing behaviour. We would appreciate it if you could help this research more by scanning the QR-code below to answer some quick questions! You can also win a €20 bol.com coupon by submitting your own meme!
Questions? Send them to n.p.kadijk@student.utwente.nl
or to the ethics committee: ethicscommittee-cis@utwente.nl
Scan me!

Appendix E: Survey questions

Dear reader,
We would like to inform you about the research you have applied to participate in.
This research focuses on raising awareness and potentially changing the behaviour of people not using the dual flush toilet system correctly. This goal is important since research has indicated that the dual flush toilet is not always used correctly which can result in unnecessary water waste. To attain this goal, this research focuses on how to give information about the right use of the dual flush toilet and give feedback to the user about their flushing behaviour. The ultimate goal is to raise awareness of how to properly use the dual flush toilet. Thank you for helping by filling in this survey.

Participating in the research means you are asked to fill in this survey consisting of a few multiple-choice questions and a few open-ended question and should take no longer than 10 minutes to fill in.
'I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research as described in the aforementioned information. I agree that the result of this survey will be used for the research. No personal data will be used or mentioned for the report. Your name is asked in case you want your results removed in which case you can send an email to n.p.kadijk@student.utwente.nl with the name you used to fill in the survey. Additionally, you can provide your email account to get a chance to win a €20 euro bol.com gift card which will be given to the best meme submitted which will be judged by the researcher. Your email address will only be used for sending one email if you have won the price or not. Both your name and email address will not be shared with anyone except the researcher and will be removed within 2 months after finishing the thesis which is finished on the 4th of July.

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente, P.O. Box 217,
7500 AE Enschede (NL), email: ethicscommittee-cis@utwente.nl).



In the future I will be more aware/conscious about the choices I make when flushing the toilet. *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

The screen got my attention when entering the toilet *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

I was surprised about the meme appearing on the screen *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

The information about flushing was presented in a fun way *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

The information provided (through the meme) was easy to understand *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

If more memes are provided (every day) the installation will remain interesting *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

Memes are the right way to communicate with the UT community *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

I will discuss/share the meme with friends *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

I did not feel that the installation intruded on my privacy *

	1	2	3	4	5	
Fully disagree	○	○	○	○	○	Fully agree

From now on, do you plan on using the small button more often? *

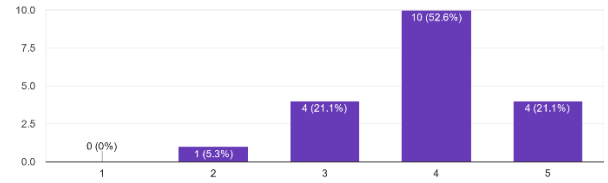
- ○ Yes
- ○ No
- ○ Maybe
- ○ I already use it all the time when I urinate

Do you have any tips or other remarks about your experience with the installation?

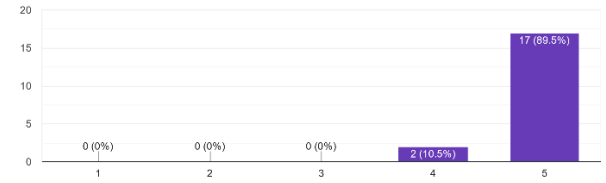
Your answer

Appendix F: Survey results

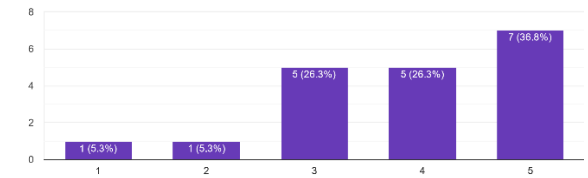
In the future I will be more aware/conscious about the choices I make when flushing the toilet.
19 responses



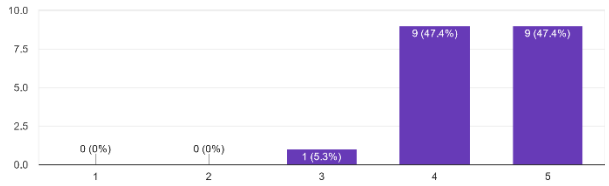
The screen got my attention when entering the toilet
19 responses



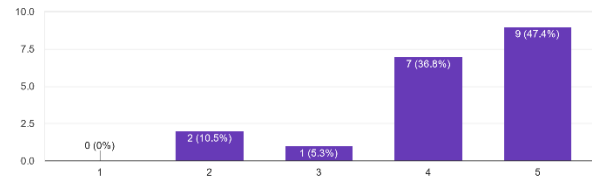
I was surprised about the meme appearing on the screen
19 responses



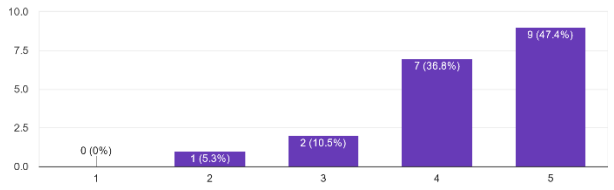
The information about flushing was presented in a fun way
19 responses



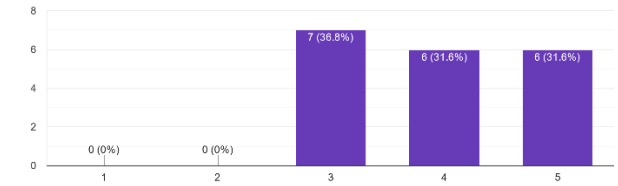
The information provided (through the meme) was easy to understand
19 responses



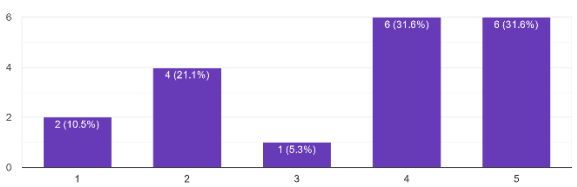
If more memes are provided (every day) the installation will remain interesting
19 responses



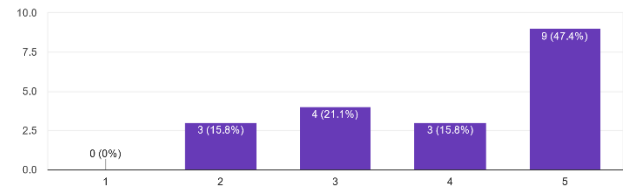
Memes are the right way to communicate with the UT community
19 responses



I will discuss/share the meme with friends
19 responses



I did not feel that the installation intruded on my privacy
19 responses



From now on, do you plan on using the small button more often?

19 responses

Do you have any tips or other remarks about your experience with the installation?

- Show it a bit longer, I want to make pictures to share with friends
- The letters at the bottom were a little hard to read because of the edge.
- Wanted to flush more often to see more memes
- Rather than letting it up to the flusher to decide with how much water to flushuldn't it be better to let the toilet do that? Like, by using a scale on the flat bit where turds drop?
- Make more memes
- As male i always go to the toilet to do the big business.
- Memes voor het doortrekken is beter want nu weet je eerst totaal niet aat het is. Het maakt misschien nu wel meer impact als je op de grote knop drukt want dan voel je je echt een newbie
- Its on only one toilet :(make it uni wide!
- Memes might be fun for students, but staff also use the toilet snd they might not understand or like it as much.
- I may not share the meme with friends, but the fact that there was an installation randomly in the toilet was shared with friends
- The meme was fun, but I think the fact that the installation was there to remind me of the impact of flushing did more for me than the meme itself
- Make the text better readable, ask more attention. Maybe put it above the screen instead of below

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