Changing the Environment for Sustainable Living: Reflect or Change?

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Abstract

Water scarcity is becoming more and more evident and thus becoming a more pressing issue. However, water is not being treated as such a scarce resource with its conservation lacking. It was discovered that people consume water the most during showers thus systems have been developed aimed at reducing the consumption in the shower. The paper investigates persuasive technology strategies and how to use them to create a nudge which aims at changing attitudes and behaviours in the shower and use less water. It was discovered from different systems that different people have different motivations to perform conservation behaviour and thus a system aimed at being able to motivate all users to conserve water was designed and built. The paper yielded the shower games system which uses social comparisons, goal setting, feedback, and ambient displays to enable participants to see their water consumption in the shower and compare it to other participants in the household in form of a game where each participant sets a target water consumption (goal) and gains points if they are able to keep their daily water expenditure bellow their set goal. The implementation of the shower games as all participants were able to consume below their goals and achieving maximum amount of points even though each participant had different motivations to partake in the shower games.

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1. Introduction

1.1 Motivation

Water scarcity has become one of the world's most pressing concerns. According to the United Nations (UN), over 2 billion people live in countries experiencing high water stress (UN, 2018). It is estimated that by 2040, one in four children under the age of 18 will be living under similar circumstances (Dooley, 2017). This is mainly because, whilst 70% of the planet consists of water; freshwater, the water used for drinking and other activities, is incredibly rare. Only 3% of the planet's water is freshwater and in addition, only a third of the 3% freshwater is readily available for human consumption; the rest is frozen in glaciers. This makes water the rarest mineral on the planet.

Despite the acute shortages of water described above, freshwater resources, if managed sustainably and effectively can meet the growing demand for water. However, the minimal conservation of these resources has created major challenges in securing enough water to meet the demand. For example, whilst the Netherlands is a generally wet country that receives rain all year there are not enough points where water infiltrates the soil. Additionally, there is no policy that regulates who can dig borehole and how much underground water can be sourced. This therefore has put the Dutch ground water sources at risk.

Countries such as South Africa (Cape Town) did the imaginable and could set an example for other nations as they were able to implement water saving restrictions to citizens, such as water tariffs and water cuts. This could show that we consume way more than we actually need and through conservation of water, the amount of water we have available can be prolonged to give life to future generations. In the case of the Netherlands, the challenge is convincing people that drought is a reality. The problem doesn't immediately affect all people of The Netherlands; (Kappel & Grechenig, 2009) describe individuals as showing more self-interest than collective interest, meaning that if problems don't affect them directly then the conservation of water for the greater good is not much of motivation for individuals that are not directly affected.

This paper serves to address the challenge of designing systems aimed at water conservation which fail in successfully motivating different types of people to conserve water. Therefore, from the research done throughout the paper, an attempt to build such a system will be made and tested to see if it successfully persuades different users to conserve water.

The following research questions are posed for further investigation of this topic:

Main Research Question: How can we create a nudge by using persuasive technology strategies for water conservation efforts to effectively change behaviour and reduce consumption?

Sub Research Question 1: What are the characteristics of a nudge and how can they be applied to persuasive technology strategies?

Sub Research Question 2: What is the best placement of the system to maximise water conservation in a household?

Sub Research Question 3: Which processes of decision making are needed to be considered to design an optimal system for achieving behavioural change.

1.2 Challenges

Problems that could arise during the thesis are categorised as follows.

The first challenge is determining if the system has impacted behaviour, meaning how will conservation efforts be insured for long term. The second is the effectiveness of the system, meaning is the placement sufficient for a thorough reflection of one's behaviour. The third challenge is Research practicality issues meaning during the global pandemic (Covid-19) to what extent is it a possibility to build and place a physical system.

Behavioural change is normally measured over longer periods of time. The duration of the thesis does not allow for a long testing period therefore it may be difficult to continuously monitor participants after the removal of the device. Only when the device has been removed it can be an indication that participants behaviour has change in the regard of conserving water.

Ideally for the system to work at the most efficiency it should be placed in an area which is highly accessible by the participants and enables them to reflect on their consumption. If the system is places in an irrelevant position, then the research would therefore yield insufficient result.

The last challenge will be the unfortunate corona virus global pandemic that the world is fighting. The campus has been shut down which therefore means there is no access to workshops. This makes the building of a physical prototype close to impossible. Furthermore, the implementation of the system will be limited as the country is in lockdown and the act of social distancing has been strongly advised.

2. Literature Review

In this chapter, nudges will be investigated to determine how they can be characterized and classified into persuasive technology strategies. With this classification, the first sub research question can be answered. The best suitable placement option will also be discussed to successfully achieve the most water consumption to fulfill sub research question 2.

2.1 Introduction

There is an apparent problem of a possibility of severe water shortage in the Netherlands. This therefore calls for measures of conservation before it is too late. The objective of the literature review is to find ways of incorporating persuasive technology strategies in our daily activities revolving around water consumption to enable us to reflect upon consumption behaviour during a moment of decision making. The research investigates systems that have already been implemented which use persuasive technology. The paper therefore discusses how persuasive technologies have been implemented this far. With many systems aiming to be unobtrusive, there comes a lot of disadvantages to such systems in term of the intended effect of behavioural change. The literature review makes a clear distinction between forceful strategies for persuasion from unobtrusive systems and select a methodology to use for the design of a system. All the aspects will be used to fulfill the research question: “How can we create a nudge with the use persuasive technology for water conservation efforts to effectively change behaviour and reduce consumption?”.

2.2 The Art of Persuasion

Persuasion has been studied throughout history for at least 2000 years but not everyone has agreed on what the term really means. Fogg describes persuasion as an attempt to change attitudes or behaviours or both. Although broad, this definition best describes how the word is used in everyday life thus this will be taken as the definition for the paper. (Fogg, 2011) however, suggests that persuasion as an act must act exclusively without coercion or deception. Coercion implies the use of force for change whereby persuasion is voluntary change. Powers argues that the difference in meaning of persuasion and coercion are not precise nor self-evident but only differs with regard to time, place, language, participants and culture. Although keeping Fogg's definition of persuasion, the use of somewhat coercive methodology of persuasion will also be considered as a form of persuasion within persuasive technology.

Most persuasive systems reviewed aim to be unobtrusive of which, in some cases, this may come at a cost. During the study of similar systems, it was observed that strategies that had the aim of unobtrusiveness, were not successful across all participants (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011). The shower calendar is a prime example of this, the system was tested on 2 different household of which only 1 household was able to achieve the intended behavioural change. Change is not achieved by the product alone but by people involved (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011). This effect then questions if indeed the system is persuasive or not and if the term persuasive technology is suitable. One might argue that unobtrusive systems do not aim to directly change one's behaviour but offer a platform to enable behavioural change. (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011) goes on to suggest the term transformational products rather than persuasive technology.

Water scarcity being of great importance, must be handled with some form of urgency to effectively conserve this life source. It is observed in places such as Australia and South Africa where drought was eminent, how the government stepped in with strict policies to govern water usage (White & Karssies, 1999). As a result of this, these places are known for their water conservation efforts. According to the Australian bureau of statistics, the government introduced strict water restrictions. These limited the use of water and encouraged the use of grey (recycled) water to be used with tasks such as washing cars and watering lawn. Similarly, (Dolnicar et al. 2012) reported that due to the government's restrictions, water consumption in Australia dropped by 19% between 2001 and 2004.

2.3 Nudging

Water restrictions around the world have successfully changed behaviour for conservation. This has helped nations secure water better. These restrictions can be seen as forceful. These forceful means of persuasion have also been observed in the field of energy. Forceful measure like this are prime examples of nudging. Nudging is described as "any aspect of the choice architecture that alters people's behaviours in a predictable way without forbidding any option or significantly changing their economic incentive" (Caraban, Karapanos, Gonçalves, & Campos, 2019).

2.3.1 Characteristics of the Nudges

Nudges can be used in different ways. Caraban, Karapanos, Gonçalves, & Campos, 2019, highlights 3 different ways nudges can be used; as facilitators, sparks or signals. The paper describes facilitators as a nudge that is used when motivation to perform task in there but no ability to do so. Spark nudges are used when users have the ability but not enough motivation to carry out a certain behaviour. Finally, signal nudges are suitable when both motivation and ability are present but there is no action performed for users' intensions.

To further understand these, the characteristics of each type of nudge must be defined and the studied techniques must be categorised under each type of nudge. After this process, this process, the implementation of the types of nudges can be discussed.

Facilitator	Spark	Signal
- Aims to simplify the behaviour and make the task easier to perform - Reduces cognitive & physical effort - Battle impulses by putting additional effort into choosing or prompting reflective choice	- Aims to increase motivation and self-efficacy - Designed to include one or more motivational elements. - Uses support planning, increasing accountability and personal control, inserts competing attractive alternatives and exploits social acceptance mechanisms.	- Aims to reinforce behaviours - Designed to trigger doubt, triggering discomfort with current behaviour, increasing preference to stimuli.

Table 1:Characteristics of nudges suggested by Caraban, Karapanos, Gonçalves, & Campos, 2019.

2.4 Creating Nudges with Persuasive Technology Strategies

2.4.1 Information

The most widely applied source of promoting conservation is through awareness. It is believed that through the awareness of problems leads to more people acting in a pro-environmental way. The channels include newspapers, media campaigns and websites. However, (Froehlich, Findlater, & Landay, 2010) observes that various studies of informational programs have shown that simply presenting people with information on the benefits of conservation behaviour only results in marginal effects. This could be due to many different reasons. An important issue to raise is that people tend to do things out of self-interest rather than collective interest meaning that conservation in itself is not a great motivation to persuade people to conserve especially when they can’t feel the problem yet (Kappel & Grechenig , 2009). This is evident in times of crisis when a clear behavioural change is observed in short periods of time. This may be because at the point of a crisis, everyone is feeling the stresses.

In general information by itself is not enough. Often mass forms of information are not personalised enough to motivate many people. Information is however the foundation of what is needed for behavioural change. When comparing all the techniques it is evident that the first step to changing behaviour is supplying them with the information about their behavioural patterns. (Caraban, Karapanos, Gonçalves, & Campos, 2019) emphasises that the lack of knowledge is the main reason people do not successfully implement changes in their behaviour.

2.4.2 Feedback

Feedback, a basic ingredient to all persuasive techniques. Feedback serves at the backbone for all behavioural change in general. Appropriate feedback on conservation allows for reflection during decision making thus can provide the needed nudge for a change in behaviour. (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011) Feedback comes in different forms and shapes. There are two kinds of feedback: Low-level and high-level. With high level feedback, a user can use the feedback to improve results as compared to low level where this is not possible. An example would be if you switch of a tap, a chime sound goes off. This feedback is useful to alert users if the tap is not closed however it does not give any more information regarding whether the tap has been open for too long resulting in water waste. This therefore means this is low level feedback.

The show calendar developed by (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011) used a display in the shower to shower inhabitants of a household how much water they consume whilst taking a shower. This was done by displaying a large dot on the screen in the beginning of the shower. This dot represented 60 litres of water. As a user showered this dot reduced in size, every participant was assigned a colour. This showed all participants results and through this there was an automatic social comparison being made and motivated users to set reduction goals for themselves.

2.4.3 Ambient Displays

Ambient displays have been used as a form of feedback in various systems. They use attractive features such as colours to persuade people to act in a different way. As observed from (Kuznetsov & Paulos, 2010), elements from our day to day lives are essential for ambient displays. The Upstream system uses the traffic light analogy on their faucets to encourage less use of water. When the faucet is first turned on, the colour displayed is green, as time goes on the colour becomes yellow then red to signal the overuse of water. The traffic system is again observed in the Waterbot system where the colours green and red are used to signal when the tap must be switched off (Bonanni, Arroyo, Lee, & Selker, 2005). Using ambient displays in this way acts as a visual cue. This is evident in the system designed by Rogers which aimed at using lights to guide users to use the stairs instead of the elevator (Rogers, Hazlewood2, Marshall, Dalton, & Hertrich, 2010). All the above systems force users to reflect on their usage.

It is evident that unobtrusiveness is the goal when it comes to ambient displays. ShowMe did this by implementing blue coloured bars into the shower. Each bar represented 5 litres of water and as a user showers, more bars are added. This system informed users on the exact amount of water they used for each shower. It was observed that when installed in a household setting, it sparked conversations regarding how to reduce consumption and users started to set personal goals to reduce their consumption.

When analysing the use of ambient displays, one can categorise them as forceful or not. When studying the traffic light system, the system may be perceived as judgemental. It is clear that good behaviour is categorised by the colour green whereas bas behaviour is categorised as red (Kappel & Grechenig , 2009). This behaviour does not consider a legitimate use for high water consumption. This may then come off as pushy and unfair which would therefore cause for reactance rather than the intended effect of change (Torrance & Brehm, 1968). Although the traffic light analogy may be judgemental, this factor could be the reason for ensuring behavioural change. (Caraban, Karapanos, Gonçalves, & Campos, 2019) emphasises that the use of confrontation as one of the effective ways to create a nudge. He says by using ambient feedbacks and creating friction, designers can minimise intrusiveness whilst maximising behavioural change.

2.4.4 Goal Setting

Goal setting is another well studied source of motivation. Goal setting operates through the comparison of present and a desirable future scenario. Goal setting is the action of "setting or agreeing on a goal defined in terms of a behaviour to be achieved" (Michie, et al., 2013). From above mentioned system, this has naturally occurred from users who received feedback on their consumption (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011). Goal setting itself can be considered as somewhat forceful depending on consequences. If you set a goal such as passing an exam with a certain percentage and if the condition is that if you don't get that percentage you are not eligible for a scholarship then one can perceive goal setting as forceful.

Combining goal setting with feedback from the get-go is more effective as users are working towards a target already instead of developing their own goals which may not be the case for all users. This has been through experiment of Becker where the combination of goal setting and feedback given to a user group yielded in more conservation effort and in an experiment by Howelingen saw the combination of the two techniques reduce natural gas consumption by 12.3% (Froehlich, Findlater, & Landay,James, 2010). The key to effective goal setting is self-efficacy, it has been research that the major finding of goal setting is that individuals who are provided with specific, difficult but attainable goals perform better than those given easy, nonspecific, or no goals at all. At the same time, however, the individuals must have sufficient ability, accept the goals, and receive feedback related to performance (Latham, 2003).

2.4.5 Social Comparisons

A comparison between people can serve as motivation through competition. By using social comparison, it is possible to add a gamification aspect to conservation. The effectiveness of social comparisons in psychology has been mixed. As stated in Froehlich's paper where 2 experiments are cited; one experiment saw a change in behaviour and the other saw users interests in knowing another's group performance but did not really change behaviour (Froehlich, Findlater, & Landay, 2010).

It is evident that comparisons of usage amongst users of another group have been a beneficial to more conservation behaviour as stated by (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011). In General, it is observed that system users indeed have a greater motivation to perform the target behaviour if they can compare their performance to the performance of others (EU & GreenSoul, 2017).

2.5 Classification of Strategies

The studied strategies each fall under one type of nudge. By mapping out where each strategy fits, the process of selecting a dominant strategy can be chosen. For this research different types of nudges may be combined depending on classification and possibility of implementation.

2.5.1 Information

Information aims at educating people on the problem. It is believed that the more information one has the better they comprehend the situation therefore the more increased chance at conservation behaviour. Information can therefore be categorised as a signal nudge. This choice is made as by providing more information, behaviours are enforced.

2.5.2 Feedback & Ambient displays

Ambient displays and feedback are used in various ways by different systems. They mostly act as a 'guard' to make sure the right behaviour is being carried out. When looking at displays which use the traffic light metaphors for enforcing behaviour or lights which motivate a certain behaviour, their goal is to reinforce behaviour. This therefore categorises ambient displays as signal nudges.

2.5.3 Goal setting & Social Comparisons

Commitment bias is our commitment to be true to your word. This therefore suggest humans have more motivation to do something if they have set it as a goal and making promises to someone. This therefore increases motivation to carry out a task. In addition, people tend to look at each other when they do not know how to proceed (herd instinct). By using social comparisons, users can compare their actions to others and therefore be motivated to do better. Goal setting and social comparisons therefore fall under spark nudges.

2.6 Placement of System

The goal of the placement is to implement the system where users in households: 1. Consume the most water and 2. In an area that is constantly used. These two factors serve as the determining factors for the effectiveness of a system. It is evident from the literature studied that there are 2 main favourable places, the shower and the sink. These seem to be popular amongst water conservation systems designers. Bathing and showering have been reported to consume 36% of total household water consumption (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011)

The main question then lies in which type of setting is most preferred. The choice lies between Public or private showers or taps. It is more convenient to install systems in private spaces as it is easier to monitor users' overtime and follow up with any questions that may arise.

2.7 Conclusion

In the world of persuasive technology, there has been a great misunderstanding of the term persuasion. Some researchers argue the term refers to changing attitudes or behaviours without the use of force and make clear distinctions between persuasion and coercion. On the other hand, some researchers believe they differ only according to certain given circumstances. For this paper, I have decided to use nudges and applying them to persuasive technology strategies, reason being when it comes to mater such as water conservation where people are put in a do or die state, slightly forceful measures such as nudges have been known to be` successful at behavioural change. These forceful measures are referred to as nudges. This has been witnessed in areas like Cape Town and Australia where the water crisis led the governments impose stricter restrictions on water, nudging inhabitants to conserve. Although these places may have water now, citizens behaviour towards water stays highly conservative due to the initial nudges from the governments.

In conclusion, as observed in this chapter from systems and strategies analysed above, the most convincing implementation of persuasive technology is through nudging. Characteristics of nudges have been studied and then coupled persuasive techniques. In addition, the most optimal placement option has been identified as the shower. This therefore concludes the literature review by answering sub research question 1 and 2 with the next phase of the paper being creating a system which can create a nudge towards changing water consumption patterns.

2.8 Related Work

2.8.1 Introduction

In this section, relevant work in the field of persuasive technology is represented. The purpose of the related work section is to get a broad scope of how the market is using persuasive tech as a nudge for behavioural change.

Waterpebble (Waterpebble 2009)

The "Waterpebble" monitors water going down the plug hole and inform a user when to stop. It uses your first shower with it and gradually uses that time to reduce time spent in the shower. This way it aims to reduce water consumption whilst showering. The system uses ambient displays with green representing "go" meaning continue the shower and red representing "stop" meaning stop showering.

Figure 1: The Waterpebble monitor (Waterpebble, 2009)

Efergy Shower timer (efficientOZ 2012)

The timer allows you to monitor how much water you consume whilst in the shower. Upon calibration, a user fills a bag using the shower pressure for 10 seconds and after the 10 seconds the bag indicates the amount of water in the bag. The user then enters this amount into the timer and the timer can show how much water is consumed per time in the shower. The device uses informative feedback as a persuasive strategy to reduce consumption.

*Figure 2: The Efergy Shower Timer (**fficientOZ, 2012)***

Ecologic Timer (EconologicSystems 2011)

The ecological timer aims at reducing water consumption by using ground-breaking shower head technology in combination with persuasive technology. The shower head uses ambient displays for feedback. The traffic light analogy is present here as when a user is in the shower for 4 minutes the shower head will be green, then as the shower continues it becomes blue and when the shower has been going on for more than 6 minutes then the shower head becomes red which indicates that the user must stop showering.

*Figure 3: The Ecologic Timer (**EconologicSystems 2011**)*

Shower Calendar (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011)

The shower calendar aims at showing using their consumption by using a display in the shower. Each participant is assigned a circle which represents 60 litres. As a participant showers the circle gets smaller and smaller. If the user consumes more than 60 litres the circle reaches its smallest and stops reducing in size.

Figure 4: The Shower Calendar (Laschke, Hassenzahl, Diefenbach, & Tippkämper, 2011)

Show Me (Kappel & Grechenig , 2009)

This system uses ambient displays to display the amount of water being used. There are led bars which each represent 5 litres of water used. As the user showers, the bars increase. The user can then see how much water they are using up by adding the total number of bars and multiplying by 5.

Figure 5: The Ecologic Timer (Kappel & Grechenig , 2009)

3. Methodology

3.1 The Creative Technology Design Process

A Design Process for Creative Technology is a paper written by Mader and Eggink aimed at guiding students working on their Creative Technology graduation project. This methodology has been adapted in other disciplines such as interaction technology and industrial design. The methodology comprises of 4 phases namely, Ideation, specification, realization, and evaluation (Madder & Eggink, 2014).

In the ideation phase, concepts and ideas are generated and collected. The phase is split into 2 parts, divergent and convergent. In the convergent part, activities such as brainstorming, and tinkering are done to come up with multiple ideas. These ideas are then further specified in the convergent part to finally pick one or more concepts to take into the specialization phase.

The specialisation phase aims at taking the idea from the ideation phase, designing prototypes, and exploring the design space. In this phase, researchers evaluate prototypes and feedback loop is applied to ensure an optimal system design. Knowledge gained in this phase shape the final design of the system/product.

When the system specification is given, then it can be realised. This phase includes taking a concept and bringing it to life. This may be referred to as the engineering section where concepts meet the technology used to realise them.

Lastly the evaluation phase addresses the system effects and if it met pre required standards. Here the system may be compared to similar systems or analysed on its functionality. Through user testing, researchers analyse user interaction and reflect upon design decisions.

3.2 Design Method (Co-Design)

Given that there is a lot of interaction between the system and user, a co design methodology of design will be followed. By getting useful insights from end users, designers are then able to design the right product for the user and see exactly how users go through the system which helps in establishing whether the right design choices have been made and if the intended effect is being achieved.

3.2.1 Interviews

Structured interviews with the end users will be conducted, testing the overall user perception of the interface, and exploring the design space. Users will be asked to go through lo-fi prototypes created and explore the interface through a performance of multiple tasks. Interviewees will then go through various designs and choose their desired design.

3.3 User Tests

Upon completion of the specification phase, comes the realisation of which the designed system will be built into a hi-fi prototype and put into practical use in the user testing phase. This will determine if the prototype will do what it is intended to do. Due to Covid-19, user tests will be done amongst inhabitants of my household and thus they will be testing the system. The system is to be tested in a space of 5 days.

4. Ideation Phase

In this chapter, we aim to successfully analyse the process of decision making to successfully answer the third sub-research question “Which processes of decision making are needed to be considered to design an optimal system for achieving behavioural change?”. This will therefore be used to help select the right system from many ideas.

4.1 Divergence

The literature review focused on 5 persuasive technology strategies. For each strategy, it was implied how a nudge was created. Furthermore, the literature review identified characteristics of nudges and classified each persuasive technique strategy with a type of nudge. From these ways of implementing nudges, this section intends on using the above-mentioned information to ideate on possible systems.

4.1.1 Concept Brainstorm

In order to refrain from limitation to specific ideas, it was decided to follow divergent methodology for the initial ideation phase as suggested by Mader & Eggink. This way everything that was trying to be accomplished could be included which is essential in the initial phase of the ideation. First a word association activity was conducted followed by a tinkering session which highlights the technology associated with nudges and finally a brainstorm of general ideas.

The ideation phase is Kicked off by a word association activity whereby the 3 different types of nudges: facilitator, spark, and signal were put into a table. Below the titles, characteristics were listed for each type of nudge. The aim is to use these characteristics is to use them in coming up with system concept characteristics.

Since for the system, it is highly beneficial to include all the strategies reviewed in chapter 2, and all the persuasive strategies fit into different categories of nudges. The brainstorm will be generated from nudge characteristics with the aim of coming up with a system that encompasses all strategies.

Facilitator	Spark	Signal
- Simple - Quick - Right choice - Automatic - Low cognitive load - Easy access	- Motivate - High performance - Greater good - Social - Comparative - Self-efficacy	- Reinforce - Restrict - Trigger - Consequence - Conditioning

Table 2: Word association activity.

The next stage was identification of technologies used by similar systems and application, referred to as tinkering (Madder & Eggink, 2014). Six technologies were identified which were used as seen in the literature and similar systems. This triggered the ideation for the next phase as by putting words from the word association activity together with the technologies, concept ideas can emerge. In addition, a list of concept techniques was added which helps the system concept idea generation.

Technologies	Techniques
- Ambient displays - Sensors - Timers - Displays (info, water flow etc) - Meters - Sounds	- Bonus - Incentives - Money - Placebo - Deception - Shock - Gamification

Table 3: Tinkering and additional techniques.

The final stage of ideation was the system concept ideas. These were formulated by choosing a random characteristic from the word association activity and coupling it with a technology. With these 2, a concept was formulated. If it was hard to do so, the additional techniques played a role in further specifying and helping with the formulation of concepts. For efficiency, codes were created for each system concept to show how the concept had been formulated. This technique led to 10 system concepts. Codes include which type of nudge a system is and are in the format: Word association_Technology_Technique (if applicable) _Nudge type.

1. Auto Shower
   Programable shower which automatically shuts when a user has elapsed a certain time in the shower.
   Code: Simple _ Timer _ Facilitator
2. Alarm Shower
   Loud noise (alarm/buzzer) goes off when user has been in the shower for a certain period.
   Code: Motivate _ Sounds _ Spark
3. Daily Cap
   Informs users on their daily limit of water consumption as a whole for all users in the shower and all user must adhere to the limit. If limit is exceeded, then no water.
   Code: Reinforce _ Display _ Signal
4. Rationing system
   System aims at personalising daily water usage depending on daily activity. System calculates the amount of water which should be used depending on certain parameters such as age, work, gender, etc.
   Code: Simple _ Information Displays _ Facilitator
5. Prompt Out
   Displays facts on how stopping the shower at that exact time benefits them in other ways such as saving money on their water bill, or environmental factors depending on what motivates the users the most.
   Code: Self-efficacy _ Information Displays _ Incentives _ Spark
6. Cold flashes
   Temperature declines as time in the shower increases. Drastic changes in the temperature act as warning signals/flashes for users to indicate they are taking long.
   Code: Trigger _ Sensors _ Shock _ Signal
7. Soaping stop
   Shower connected to a soaping dispenser. Whenever soap is being dispensed, water stops for a certain time of which allows the user to adequately apply soap to their bodies and after this time has elapsed water will start again.
   Code: Low Cognitive Load _ Sensors _ Facilitator
8. Shower Games
   Uses social comparisons to compare user consumption. Aims to make users set goals and compete against each other to achieve the goals of the lowest water consumer. Deception as a tool to motivate for more conservation is used whereby users are shown fake results which should make them want to do better in the game.
   Code: Reinforce _ Displays _Deception & Gamification _ Signal
9. The Punisher

If a user is in the shower for too long a certain punishment is implemented towards that user. Different punishments may differ from water cuts to being sprinkled by glitter.
Code: Consequence_ Sensors _ Incentives _ Signal

10. Deceptive Clock
Shower timer that initially will time the first few showers normally but start to run faster than normally to decrease the time spent in the shower with user thinking they are spending the same amount of time.
Code: Easy _ Timer _ Deception _Facilitator

The ten system concepts mark the completion of the divergent phase. Next will be the convergence phase whereby from the ten ideas, one or a few will be chosen as a final concept to be tested in the specialisation phase.

4.2 Convergence

In this phase, a final concept will be chosen. By looking at what the system hopes to achieve and analysing the possible user group needs a final choice of system(s) can be chosen which will be further analysed in the following sections of the paper.

4.2.1 Decision Making

Decision making process has been an ongoing argument in psychology. There have been multiple theories of how humans perceive different things and how they react. A dual process model has been suggested whereby they classify 2 areas of your mind which influence decision made in day to day life: the reflective mind and automatic mind (Rothman et al., 2009). The automatic mind is described as the principal mode of thinking. This mode is responsible for decisions made for repeated actions and skilled actions such as driving or catching a ball. These are generally actions that require minimal cognitive efforts and are permanently active state of mind (Rothman et al., 2009). Caraban, Karapanos, Gonçalves, & Campos, 2019 state that the automatic mind accounts for 95% of decisions made daily. For this paper and the system, the dual process model will be used as to date the dual process of decision making provides the most compelling evidence on decision making and influencing behaviour (Djulbegovic, Hozo, Beckstead, Tsalatsanis, & Pauker, 2012).

The reflective on the other hand, makes decisions based on rationality. This part is conscious of decisions it is making and is a relatively slow process, which demands a high cognitive load and goal oriented. When cognitive capacity is available, the reflective system runs parallel and sometimes interacts with the automatic system (Rothman et al., 2009).

It has been seen that 96% of persuasive systems has been aimed at the reflective mind which therefore contributes to the failure of some systems (Caraban, Karapanos, Gonçalves, & Campos, 2019). This therefore suggests for more successful systems, one must aim to design a system that works with the automatic mind more than reflective as the automatic mind is in

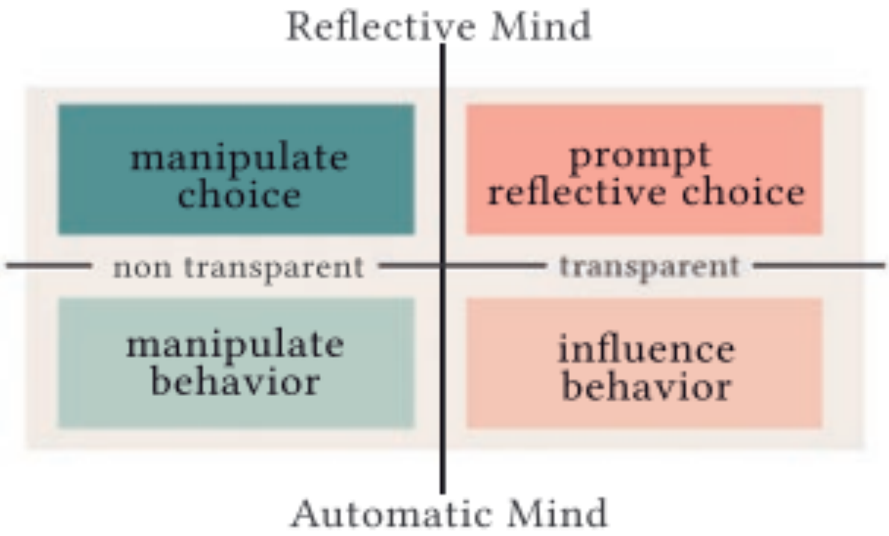

Figure 4: The four categories of nudges (Source: Caraban, Karapanos, Gonçalves, & Campos, 2019)

charge of 95% of daily decisions. There is a quadrant of four categories of nudges suggested by Hansen and Jespersen. The categories depict what type of behaviour fits with which part of the mind which leads you to the type of design.

This therefore prompted for the ten ideas from the brainstorm to be further specified based on their characteristics and placed in a part of which they belonged in the quadrant. To help clarify this better, Caraban, Karapanos, Gonçalves, and Campos have positioned the different types of nudges and persuasive technology strategies in the quadrant along the axis (see figure 5). This aids in identifying technology and or strategies used for each system and thus put each idea where it belongs.

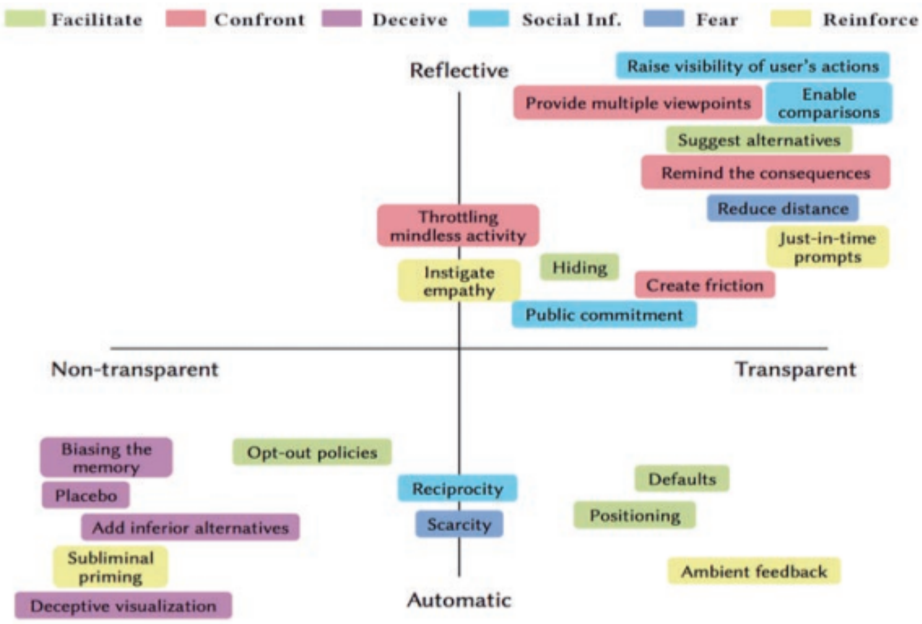

Figure 5: Nudge positioning (Caraban, Karapanos, Gonçalves, & Campos, 2019)

In the divergence section, similarly to Caraban, Karapanos, Gonçalves, and Campos the ten systems were put into which nudge they belong to thus in this sector to further clarify the systems, they will each be classified per quadrant based on characteristics of the ten system:

1. The auto shower system uses default setting this therefore categorises it in the bottom right quadrant; Automatic Transparent.
2. The Alarm shower aims to raise visibility of user's actions therefore fits into the top right quadrant; Reflective Transparent.
3. The Daily cap system aims at reminding users' consequences of showering for too long, therefore it fits into the top right quadrant; Reflective Transparent.
4. The rationalising system raises visibility of user's actions in terms of how much water they actually need to spend therefore fits into top right quadrant; Reflective Transparent.
5. The prompt out system reminds users of the consequences of wasting water therefore fits into the top right quadrant; Reflective Transparent
6. The Cold flashes system aims to create fiction by disturbing their time in the shower by using cold water against them this therefore fits into the top right quad; Reflective Transparent.
7. The soaping stop system reduces effort by automating the whole process of stopping the water whilst soaping and making it a default setting. Therefore, fits into the bottom right quad; Automatic Transparent
8. The shower games system uses water usage limits as defaults for conservation. Therefore, fits into bottom right quad; Automatic transparent.

9. The Punisher system aims to remind users consequences, therefore, fits into the top right quad; Reflective Transparent.
10. The deceptive clock system uses deception to make users think they are spending more time than they actually are in the shower therefore fits into bottom left quad; Automatic Non-transparent.

As stated above, most systems have been aimed towards the reflective mind. For this research, the automatic mind will be explored, this therefore narrows down the selection of the system to 4 systems (1,7,8, and 10) aimed at the automatic mind.

To further decide on which system will be the final system, some pre-set requirements must be met by one of the four systems. For this, the MoSCoW method of prioritisation will be used. The method aims to distinguish the most important needs of the system from the least needed using its section criteria of:

Mo – Must Have: Non-negotiable characteristics that the system should have.

S – Should Have: Important initiatives that are not vital but add significant value.

Co – Could Have: Nice to have initiatives that make a small impact if left out

W – Would Not Have: Initiatives that are not a priority for this time frame.

The Must Have condition is that the system must incorporate all of the 5 persuasive technology strategies reviewed in the literature review and the inclusion of persuasive technology as the principal technology.

The Should Have condition is if they could possibly invoke a change in behaviour. This is the intended effect however can truly be known after evaluation thus it is a should have.

The Could Have condition is the addition of other persuasive strategies not in the literature review.

The Would Not Have condition is no long study duration.

In order to use the above the MoSCoW method as a filter, the first criterion has to be assessed, the must condition, and it has to be determined which system fulfils the condition. From the 4 remaining systems:

System 1: Only includes possible information displays as a persuasive strategy which already removes it from the list.

System 7: Although aims at the automatic mind, unfortunately it does not include any of the strategies thus does not fulfil the must condition and can be neglected.

System 8: Includes all of the 5 persuasive strategies and thus fulfils the must condition. Furthermore, from analysis of the literature review the combination of the different strategies can possibly invoke a change in behaviour thus fulfils the should condition thus fulfils all conditions

System 10: Fulfils all the should, could and won't conditions however it only includes feedback, ambient displays but does not include social comparisons or goal setting which means it cannot be the chosen system.

This therefore deduces that the chosen system will be system 8.

4.2.2 Final System Design

The final chosen system is the shower games system. This system uses social comparisons and goal setting as main strategies. The system also includes feedback and ambient displays in a game of water conservation in the shower. The system intends on rewarding points to users if the achieve set goals per day which will investigate the conservation success rate of the combination of different persuasive strategies meant to create a nudge.

5. System Design

5.1 Design Features

To further answer the main research question, the specialization phase aims at successful implementation of nudges into the system. Here, users will have the first look at the system and have input on design decisions which will be put into the hi-fi prototype to be tested.

5.1.1 Goal Setting

Goal setting provides motivation to perform a task by setting personal targets a user wishes to obtain. It is important that these targets are attainable therefore reasonable targets must be set. The shower games system will encompass goal setting from the beginning. The users of the system must set a goal of shower water expenditure per day of which they should try to keep their shower consumption under this goal to attain the most amount of points. This goal will have negative consequences when it comes to points if not reached as negative feedback has more persuasive effects and in addition, negative feedback yields more persuasive effects (Midden & Ham, 2009).

5.1.2 Social comparisons

Through social comparisons, users can keep an eye on their consumption and see how much each other participant is consuming. The aim is to achieve the highest amount of conserved water amongst participants thus by observing how others are doing, serves as motivation to maximise efforts. This aspect will be depicted through leader boards that show who is in the lead and where exactly a user is and how much they need to beat the opponent. The leader board also includes the number of points a user has gained and how much water they have used.

5.1.3 Feedback & Information Displays

Information displays are used in displaying the amount of water a user has used. This enables user’s to keep track of how much water they are using and stay on track with the goal set by themselves. Users can use feedback to assess themselves. The other participant’s performance will also be accessible thus they can make the needed comparisons.

5.2 Lo-fi Prototype

The system would need to log in different users to record their water data, show how others in the competition are doing and be able to show live data of how much water is being used during a shower. To clearly understand the user journey a flow map has been created which shows the interactions users have with the system:

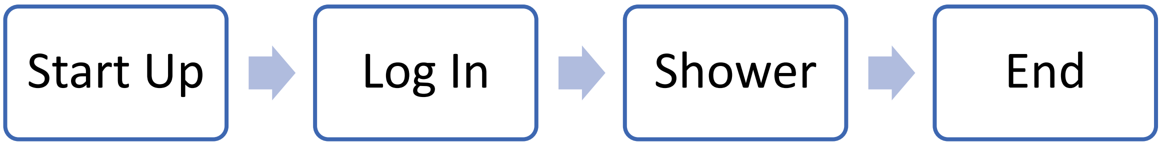

Figure 6: Flow chart of the user interaction with the system.

The start-up screen is the first interaction with a user, this screen aims at updating users on the game how it is going. There will be leader boards in place here in which users can see their progress as compared to others in the game. The user then goes on to the log in screen where the users alert the system as to who is about to take a shower to log the right data for the right person. The following interaction is during the shower itself. Here the consumption of water will be shown as the user is taking a shower, which gives users the ability to see how much water is being used up and can clearly see their goal to successfully not cross the amount of water they intend on using per shower. The final interaction will be the end which is like the start just shows the refreshed leader board. These interactions are visible in figure 7.

These interactions are the basis of the lo-fi prototype which is to be tested during interviews to explore design space.

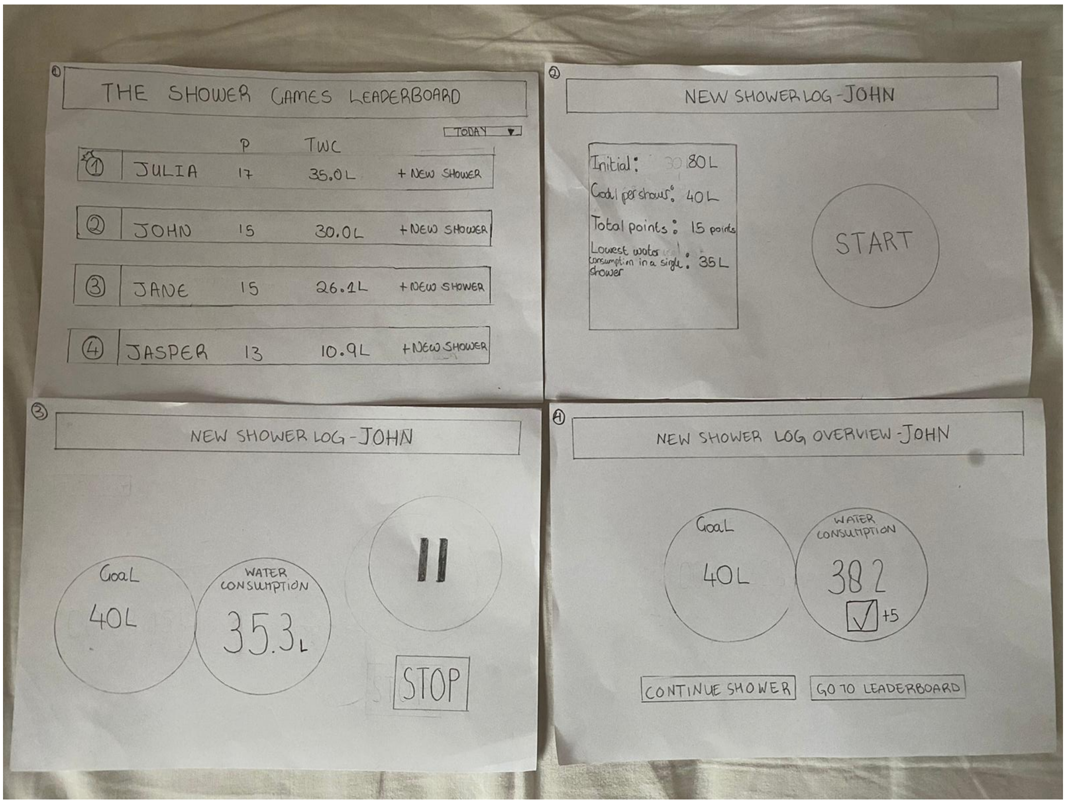

Figure 8: The shower games lo-fi prototype system screen design

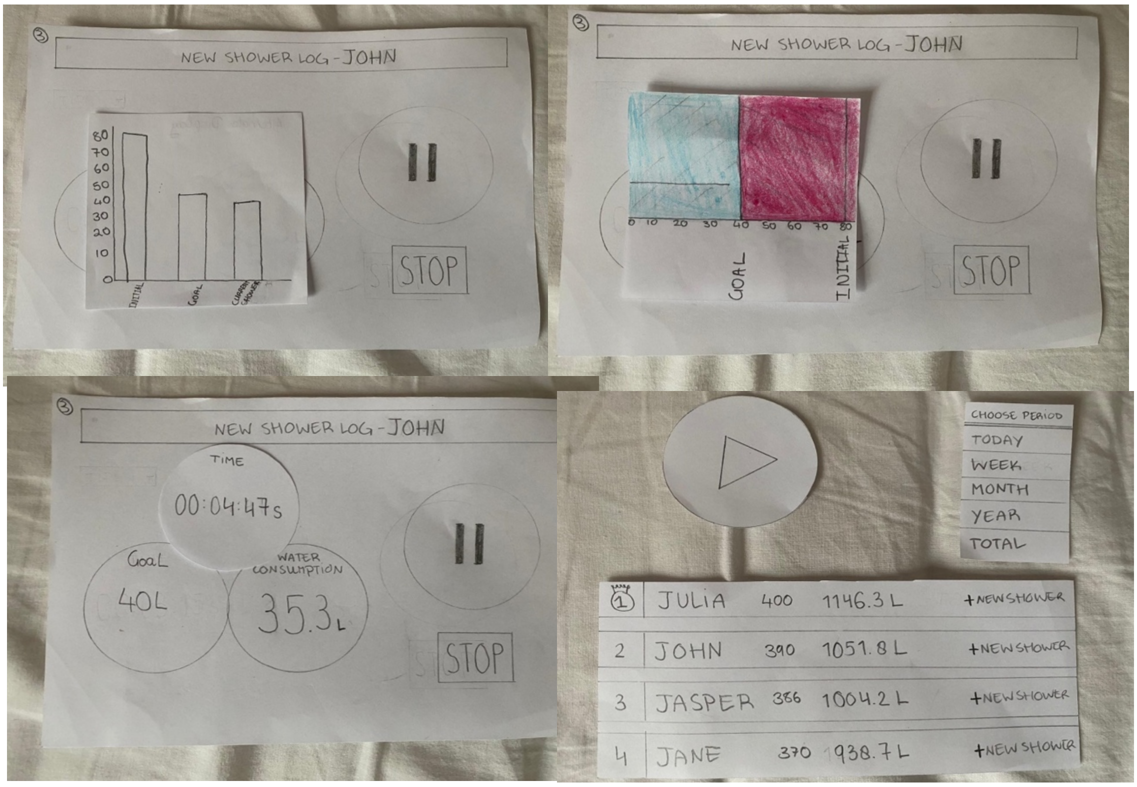

Figure 7: Shower games system designs and extra functions

5.3 Hi-fi System Design

From the lo-fi prototype design, the overall interaction flow was easily comprehended by all interviewees. They however brought up the same problems of cheating the system, thorough explanation of terms and clarification of the start buttons functionality. Though the problem were brought up they each had similar ways of solving them. A common goal was the first solution that was common. Users felt the need for a common goal which means that everyone is responsible for everyone and that way people refrain from cheating as the common goal acts like a daily limit. With a common goal system, users cannot simply take multiple showers to accumulate points as this could possibly negatively impact their score. The terms are an easy fix, it has been decided that further descriptions will be added to the interface and lastly the design choice will be the time integrated system as users tend to prefer that one the most. With all of these taken into consideration, the system will be built for the users with their personal contributions added. With all this being put into consideration, the final system was built.

5.4 Final Shower Games System Design

The system uses social comparisons and goal setting to enable users to see their consumption, set reduction goals and thus conserve water. Users decide their individual goal and must try and consume less per day. In addition, the sum of the individual goals will be the common goal for all participants which means the total amount of water used per day cannot exceed the total goal. Each participant therefore will be tasked with trying to stay under this goal to achieve maximum points available. A user is free to take multiple showers in a day however their water consumption is cumulative which means regardless of the number of showers taken, the sum of all the water used will be as if it was used in 1 shower. If the user stays under the allocated amount of water, they will be awarded 5 points and if exactly on the allocated amount they will be awarded 3 points and 0 points for going over the allocated amount as this impact's other users. In addition, the user with the highest amount of water saved in comparison with all users will be awarded 2 bonus points at the end of the competition (end of the week). At the end of the competition, the participant with the highest amount of points will win the shower games tournament. Other bonus points will be awarded mentioned below.

Point System:

- 5 Points when keeping daily water expenditure bellow one's goal
- 3 Points when keeping daily water expenditure exactly as one's goal

- 0 Point when daily water expenditure is above one's goal
- 0 Points for everyone if the total daily limit is exceeded

The game includes a couple of bonus points a participant can get:

- 1 Point for Least amount of water used in one the shower (Household record of the participant who recorded the least amount of water expenditure in a single shower)
- 1 Point for Inhabitants choice of most innovative shower saving technique (which will be discussed at the end of the testing phase with inhabitants)
- 2 Point for Most amount of water saved overall (participant with the least amount of water used throughout the whole competition)

Components:

- Arduino Uno (see appendix A for the programming code)
- Water flow rate Sensor
- LCD screen 128x64

5.4.1Ambient Displays & Feedback

The water flow rate sensor was connected between the shower head and the thermostatic mixture valve (tap) which enabled us to measure the flow rate in litres per minute and from this flow rate we can then determine the volume. The flow meter is then connected to an LCD display which shows the participant their water consumption whilst in the shower which is all ultimately powered by a laptop see figure 10. Users were able to see their water consumption and their flowrate which did not have a user interface but manage to display consumption.

Figure 9: Shower setup with screen and flowrate sensor

5.4.2 Social Comparisons

After getting the consumption per shower per day of all participants, a leader board is sent out which showed the points gained today(P) and total water consumed (TWC).

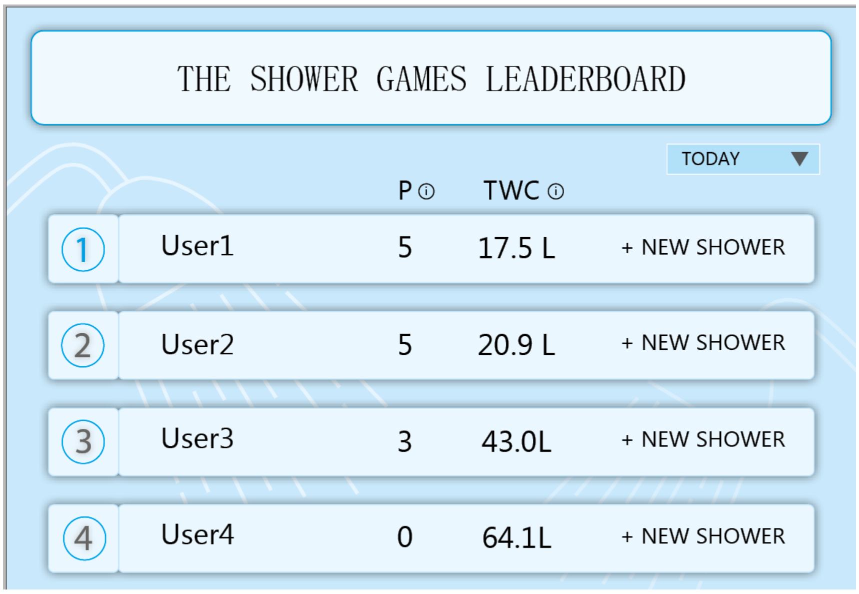

Figure 10: The leader board interface

5.4.3 Goal Setting

Users had on display their baseline measurements and their goals which will aid them in the shower in case a user forgets the goal they had set for themselves. This was displayed similarly to the leader board.

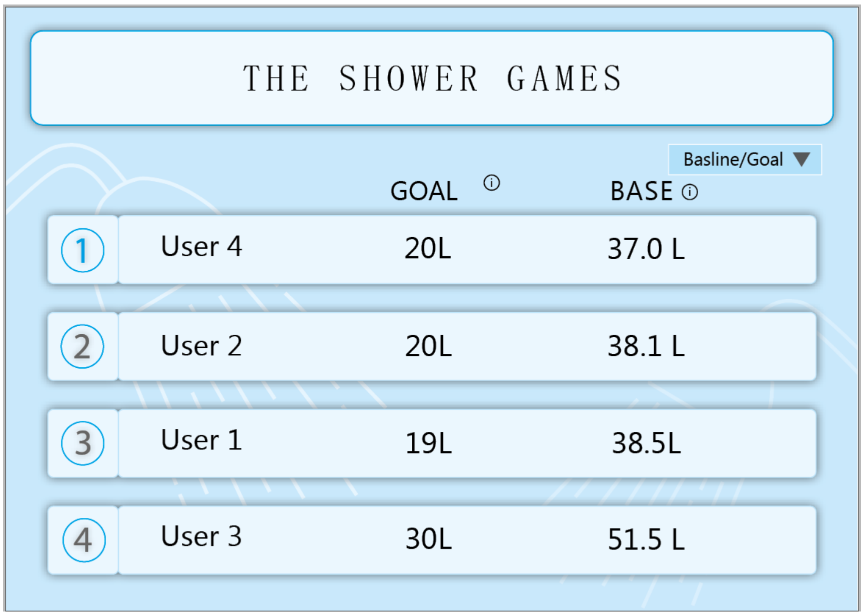

Figure 11: The goals and baseline measures overview interface.

6. Method

6.1 Lo-fi prototype Method

The prototype aims at providing the necessary insights on the design of the system and makes sure the system is designed for the users to achieve the best interaction possible. For each stage describes in the flow map, a screen has been designed. Participants will be asked to rank different types of interfaces and the interfaces which participants prefer the most will be implemented onto the system design. Therefore, the research question for the lo-fi testing is:

How can the target group help design the shower games system given and design the interaction that satisfy their needs?

In order to successfully answer this question, it was split into sub questions of which will be addressed in segment during the interview. The sub questions are as follows:

1. What design options must be taken in terms of providing feedback, showing the leader boards and showing if a user is successfully on track?
2. What expectations do users have about the system and what would they like to see in the system?
3. How should users interact with the system and vice versa

To prepare for the interview a paper prototype was prepared which had the whole system layout. For different sections there were different designs intended to invoke participants opinions on the preferred design.

First, the shower games system will be introduced to the participants. The instructions of the game will be given, and participants will be asked to go through the whole prototype. Techniques such as thinking aloud will be encouraged to determine how participants interact with the system and to gain an understanding of their decision-making process.

Participants will be given the following questions and tasks:

- Who is in the lead?
- Check scores of different days
- Log a new shower
- Go through the whole system

After participants have done the above tasks, they will be asked to log another shower this time the interface used will be different. Three different interface designs have been made; one which displays the goal, initial shower consumption and current consumption as a histogram and the other as a slider of some sort which has a green zone (below goal) and a red zone (above goal set). The last iteration is the same as the standard design except it has a timer as well attached to it. For the different kinds see figure 7.

6.2 High-Fi Prototype Research Plan

As most systems aim to be as unobtrusive as they can, the shower games system does the opposite. It is therefore important to identify if this slightly more aggressive way of persuasion works. Therefore, upon completion of testing, an interview with the participants will be conducted to determine how they felt about the system. The interview will be a way for the participants to reflect on their personal usage of the system. The main things I will be looking for is:

- *Does the system motivate the user to conserve water?*

  This will be based on the performance whilst using the full prototype. The baseline measurements will be compared to the water consumption during the use of the prototype. The participant will then be asked a set of questions in the interview which will determine why they performed the way they did:

  1. What was your motivation to conserve water?
  2. To what extent was it easy to stay under your set goal?
  3. How did you manage your water consumption?
  4. How is your perspective on the amount of water you used in the shower before and after the use of the prototype?
  5. Do you think the shower games system is fair? If yes or no, explain why.

- *Did the system invoke conversations about water consumption?*

  This will be assessed during the interview with the following questions:

  1. How often do you think about your water consumption?
  2. How often did find yourself talking about your water consumption?
  3. To what extent were water saving techniques discussed with other participants or the system engineer?

4. Did you often think about your shower habits before the system?
5. What was your biggest realisation about how to save water in the shower during the shower games?

- *What improvements could be made to the system?*

  This will also be discussed in an interview with the following questions:

  1. What did you dislike the most about the system?
  2. What did you like the most about the system?
  3. IF you could add features to the system, what would they be?
  4. Which application do you think is best for the system?

6.2.1 Testing

As the system is designed to inform participants on their usage and hopefully encourage conservation, this is the main objective of the test; to see if the system can change users' perspective on shower methods and the amount of water one should consume in the shower.

6.2.1.1 Testing Setting.

The test will be conducted in a household of 4. All four residents will partake in the testing of the system. The testing will take place for 5 days. The household is a family with the father (male 58 years old), Mother (female, 48 years old), son (29 years old) and daughter (19 years old). Before the start of the procedure, all participants are put into a WhatsApp group chat of which the whole procedure is described, from there on meetings are scheduled for setting up the shower games tournament.

6.2.1.2 Procedure

1. **Baseline Measurements:**

   The study will start with a baseline measurement of participants' shower water consumption levels. Over the course of one day, participants will be asked to shower as they normally shower. The measurements of their water consumption will be stored. Next, participants will be asked to fill in a questionnaire that will assess their pro-environmental behaviour. This metric is important as the questionnaire will be given again after the end of the study to determine if the system changed attitudes toward pro-environmental behaviour:

1. The balance of nature is very delicate and easily upset.
2. Plants and animals have as much right as humans to exist.
3. Humans will eventually learn enough about how nature works to be able to control it.
4. The so-called ‘‘ecological crisis’’ facing humankind has been greatly exaggerated.
5. If things continue their present course, we will soon experience a major ecological catastrophe.
6. Humans were meant to rule over the rest of nature.
7. The earth is like a spaceship with very limited room and resources.
8. Human ingenuity will ensure that we do not make the earth unliveable.
9. We are approaching the limit of the number of people the earth can support.
10. The balance of nature is strong enough to cope with the impacts of modern industrial nations

The Participants will answer these on a scale from Strongly agree to somewhat agree to unsure to somewhat disagree and to strongly disagree. From the research agreement with items 1, 2, 5, 7, and 9, and disagreement with items 3, 4, 6, 8, and 10 indicate pro-environmental attitudes. A show of pro-environmental behaviour could signify a willingness to change behaviour towards more sustainable behaviour which serves as a precursor to behavioural change (Clark, Kotchen, & Moore, 2003).

The final step is determining individual goals of which each participant will adhere to throughout the course of the testing. These individual goals are set by the participant themselves. The only condition is that the goal should be significantly below their ‘normal shower water expenditure’. All the individual goals combined sets the common goal.

All baseline measurements will be measured individually. A group meeting will be conducted where the common goal will be discussed and the rules of the game.

2. Prototype Use

Social Comparisons - The Hi-Fi prototype does not save data thus does not show performance of others therefore the leader board is updated after every shower manually. After each shower, I therefore must upload the results of the participant. To ensure that all participants see the updated performances at the end of the day, the leader board will be sent to them via WhatsApp group.

Feedback - After every day, results will be analysed to see if participants stayed under their common goal, and under their own personal goal. Points will therefore be awarded at this point. These goals will always be present for users to see in the bathroom. By having these present at all times, the element of the complete system is included

Information & Displays – The System will be installed in the shower with a screen that shows time, current water being consumed/used and flowrate.

3. End of the game

The system testing will take 5 days, at the end of this time, participants will be invited for an interview each where they each take the pro-environmental behaviour questionnaire and aspects of the system are discussed.

7.Results

7.1 Lo-fi Results

Interview 1

The interviewee understood the system and how it worked the first immediate question was the benchmark and how users could use it to cheat as higher benchmarks make the goal higher thus easier to achieve and collect more points. The interviewee had good understanding of the flow of the system. All terms were understood. There was a question raised about if the water starts when you push start, which raised the question of the necessity of the pause button. The point system and multiple showers was a concern as people may cheat the system by taking multiple showers a day to accumulate points. Out of all the different types of interfaces, the time integration was most favourable followed by the normal interface, then the bar and the zones interface ranked as least favourable. Note added that the water consumed is real time or is it per shower or is it current, just a clear indication is needed. The emphasis of time being a universal indicator of water consumption in the shower it is highly beneficial that time as a factor is included. The interviewee made a comparison to fuel consumption and a vu meter as more natural for them thus that could be implemented.

Interview 2

The second interviewee had a great understanding of the system and its terms. There was no difficulty in understanding and straight away explored the system. There were similar concerns to the first interview about the cheating aspect of multiple showers a day and an additional code for logging new showers. There were also concerns about the pause button being unnecessary and confusing. Similarly, to the first interviewee, the integration of a time function was seen as most favourable.

Interview 3

The third interviewee had a generally good perception of the interface and the terminology, a bit of clarification was needed to explain TWC (total water consumption). It was suggested that setting individual goals may not be challenging enough for individuals as people can set high goals to make it easier for themselves. A common goal was suggested as a way to motivate all and keep each other motivated. As the other interviewees suggested, there must be further elaboration for the display whilst showering i.e. where the real-time water is being displayed it should say something like real-time or current. Regarding the interfaces, like the other interviewees, the preferred interface was the one with the time function included.

7.3 Hi-Fi Results

7.3.1 Pro-Environmental Behaviour

Participants were asked to fill in the pro-environmental behaviour questionnaire which assessed the scale of how committed each participant is when it comes to minimizing one's impact on their natural surroundings. This served as a preliminary test to see if there is a correlation between performance during the shower games and pro-environmental behaviour. Concluding from the questionnaire, participants 2 and 4 showed pro-environmental behaviour, whereas participants 1 and 3 did not. This would suggest that participants 2 and 4 will perform the best as they are already aware of their natural environment.

7.3.2 Shower games Results

Remarkably, all participants were able to gain the maximum amount of points every day. This came as a surprise as ultimately the winner of the whole competition did not show pro-environmental behaviour. The first day was the baseline measurements and goal setting. As seen on figure 10, the measurements went accordingly. Each day participants would shower and after all showers are done a scoreboard was sent to them. The results were as follows:

	Participant 1	Participant 2	Participant 3	Participant 4
Baseline & Goal	Base: 38.5 L Goal: 19 L	Base: 38.1 L Goal: 20 L	Base: 51.5 L Goal: 30 L	Base: 37.0 L Goal: 20 L
Day 1	9.61 L	8.5 L	3.22 L	16.3 L
Day 2	2.76 L	8.2 L	29.6 L	7.63 L
Day 3	5.11 L	11.0 L	23.63 L	6.53 L
Day 4	3.18 L	10.2 L	7.63 L	12.68 L
Day 5	2.75 L	9.2 L	16.21 L	3.55 L
TOTAL	**25.4 L**	**47.1 L**	**80.4 L**	**41.4 L**

Table 4: Participants water consumption results

	Participant 1	Participant 2	Participant 3	Participant 4
Day 1	5	5	5	5
Day 2	5	5	5	5
Day 3	5	5	5	5
Day 4	5	5	5	5
Day 5	5	5	5	5
Bonus Points	4	1	1	1
Total	**29**	**26**	**26**	**26**

Table 5: Participants points results

As seen on the tables above, all participants were able to keep under their goals per day which meant that each participant gained 5 points each day thus it was up to the bonus points and the amount of water used to decide the winner. Participant 1 received 3 bonus points as he had the least amount of water usage throughout the game (2 points bonus) and holds the record of the least amount of water used in a shower which is 2.75L (1 bonus point). All the participants go to water saving technique was the soaping stop technique which means that when soaping, they would close the tap. This therefore resulted in awarding 1 bonus point to all of them. The clear winner after 5 days of testing was therefore participant 1 followed by Participant 4, then Participant 2, and finally participant 3.

8. Discussion

As stated in the introduction, water is increasingly becoming a pressing issue of which we must solve. The solution to water consumption can only come in a form of behavioral change which in my opinion is the hardest thing to achieve. The difficulty in achieving behavioral change in many people through one system goes down to personal motivation. Often solutions geared towards behavioral change are somewhat targeted to a certain user hence why I believe systems before were not fully able to persuade all users of the system to effectively change their behaviors or attitudes. The reason for my research was to try and come up with a solution that can be applied to different kinds of people and motivate all types of users to conserve water.

My research question was "How can we create a nudge by using persuasive technology strategies for water conservation efforts to effectively change behaviour and reduce consumption?" I decided to tackle this question by studying systems that had used persuasive strategies and put all the strategies together in one system. I, therefore, answer this question with my shower games system which was able to motivate different users into conservation for different reasons, thus the realisation that different persuasive strategies work for different people, and by combining these strategies, a system designer can personalise their system for all through one system. This evident as the participants who did not show pro-environmental behaviour managed to conserve water and managed to outperform the pro-environmentalists in the case of participant 1.

The table below shows pro-environmental behaviour vs game results vs their personal motivation, which provides an overview of the diversity of participants that were able to adhere to the shower games.

	Pro-Environmental	Goal Success Rate (days)	Personal Motivation
Participant 1	No	5/5	Feedback (Saving Money)
Participant 2	Yes	5/5	Goal Setting
Participant 3	No	5/5	Social Comparisons
Participant 4	Yes	5/5	Social Comparisons

Table 6: Overview of evaluation metrics

During the interviews, all participants testified to think more about their water consumption because of the game. Participant 2 mentioned that even in the bed they would discuss their consumption with participant 1, which also serves as a precursor to behavioral change. Participant 3 went to never care nor thinking about their consumption to getting annoyed at the amount they consumed and constantly thinking about how they will stay under his goal in his next shower.

Social Comparisons

Throughout the shower games system testing, all participants were able to stay under their goal which means everyone gained 5 points daily. This was astonishing as even the participants which did not show pro-environmental behaviour were eager to gain the maximum amount of points. When asked what their motivation was to conserve water, participant 3 said "simply because everyone is doing it, so why not? And, it's a competition and I wanted to win!" similarly, participant one was driven to use the system due to the competition and in addition, he wanted to see how much each person in the house conserved as they have a high water bill. Participant 1 and 2 were the parents thus they both had concerns about the water bill thus using this system makes people use less water. Participant 2 remarked that the first reason she used the water was "one the finances because the water in this country is really expensive."

Goal Setting

The goal-setting was quite interesting as participants could choose their goals themselves. It was encouraged that they choose challenging goals, but the choice was theirs. The baseline measurements served to be very important as it allowed for reflection of past shower behavior as compared to whilst using the system. Participant 1 remarked that "because of the baseline, you can remember your behavior as how it used to be and for some reason you are very driven to reduce". All participants were able to stay under their goals which was evidence of the power of goal setting as once a user had a goal to reach, they did everything possible to stay under that goal.

Feedback and Information Displays

The full system should be a fully integrated application that will have a system interface however due to the time frame this could not be done and as a result, the users saw consumption on a small LCD screen. This was a bit of a problem especially to the older users as their eyesight was not too good. Participant 2 thought said the only thing she did not like was that without glasses she could not see her consumption. Similarly, participant 1 could not see his consumption well which meant it became a feeling, he added that he would even go to the extent of counting just to keep track of how long he has been in the shower. All participants additionally pleaded for a time function which should be considered for further development of the system.

System Feedback

Some participants thought the system was not fair especially Participant 3 who was the only participant working during the testing. He mentioned that everyone else had a vacation and because it is the summer he has to be "fresh before work and after work, he is sweaty and must take another shower so I won in my own category as I had to take 2 showers and still remained under my goal!" Participant 4, however, complained about the coldness and water consumption making it a point that when she showers first she losses a lot of water in making the shower warm which is not fair as the next person to shower already has warm water thus can jump right into the shower.

Limitations

Due to the time limit, it was not possible to build a fully functional app therefore the system was not as seamless as I would have wanted it to be. However, the system encompassed all strategies as closely as it could. The system was not able to save all the consumption data by itself and update leaderboards and thus as the system designer, I had to be on-site to record and update scores after every shower, which meant that I was on site for the duration of the testing. This could lead to different side effects as participants may just perform because I was present at all times. I tried to stay clear and interfere as little as possible but that could be the case. In addition, due to the coronavirus, testing had to be done in the household you lived in or that belonged to your family which meant that participants may have been influenced by the personal relationship they have with me (system designer).

9. Conclusion

From the get-go, the paper set out to investigate persuasive technology strategies and how to create a nudge using these strategies as an attempt to create a system that will successfully change people's water consumption in showers. At first, an analysis of persuasive technology strategies was made where 5 strategies were identified and further analysed as they were the most common strategies used for behavioural change. This however was not enough for designing a system, nudges were to be researched to merge the concept of a nudge with persuasive strategies. This identified characteristics of nudges which became the base of the ideation phase.

During the ideation phase, it was identified that to further design the right system, an understanding of how people make decisions was necessary to identify which considerations regarding decision making were to be made when designing the system. It was identified that 95% of decisions made daily are from the automatic mind which enticed the system to be built for the automatic mind as the system thrives to change behaviour thus making it automatic to conserve water as much as possible.

This ultimately led to the final system design of the shower games system which encompassed all persuasive strategies reviewed in the paper. The implementation of the strategies leads to a high success rate in conserving water. From the results, we see that the participant with the highest consumption from the 5 days consumed a total of 80.4L which seems like a lot when compared to other participants but in fact, the average consumption in the shower in the US is 60L per shower which is remarkable. In addition, participant 3 who was taking 2 showers a day managed to stay under 30L which is half the average daily consumption per shower in the US.

In conclusion, It is uncertain whether the shower games system is an effective behavioural change agent as behavioural change can only be determined after long studies. However, the system has shown pre-cursers to behavioural change as all users were able to successfully keep under their goals, and participants started actively thinking more about their water consumption of which I can say the shower games system was a success.

For future studies, I would recommend the completion of the system with a seamless interface and wider testing populations to determine if the same effects will be yielded.

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Appendices

Appendix A

Programming code

```
#include <U8glib.h>

U8GLIB_ST7920_128X64 u8g(13, 11, 10, U8G_PIN_NONE);

int X;
int Y;
float TIME = 0;
float FREQUENCY = 0;
float WATER = 0;
float TOTAL = 0;
float LS = 0;
const int input = A0;

void setup()
{
  Serial.begin(9600);
  u8g.begin();
  u8g.setFont(u8g_font_unifont);
  u8g.setColorIndex(1);
  delay(1000);
  pinMode(input, INPUT);
  pinMode(8, OUTPUT);
}
```

```
void loop() {
  u8g.firstPage();
  do {
    draw();
  } while ( u8g.nextPage() );
}


void draw() {
  X = pulseIn(input, HIGH);
  Y = pulseIn(input, LOW);
  TIME = X + Y;
  FREQUENCY = 1000000 / TIME;
  WATER = FREQUENCY / 7.5;
  char tmp_Water[6];
  itoa(WATER, tmp_Water, 10);
  char tmp_Total[6];
  itoa(WATER, tmp_Total, 10);
  LS = WATER / 60;
  if (FREQUENCY >= 0)
  {
    if (isinf(FREQUENCY))
    {
      u8g.drawStr( 0, 15, "FLOW(L/M):" );
      u8g.drawStr(80, 15, tmp_Water );
      u8g.drawStr (0, 40, "VOL (L):");
      u8g.drawStr (80, 40, tmp_Total );

      //u8g.print( TOTAL);
      //u8g.print(" L");
```

```
    }
    else
    {
      TOTAL = TOTAL + LS;
      Serial.println(FREQUENCY);
      u8g.drawStr(0, 15, "FLOW(L/M):");
      u8g.drawStr(80, 15, tmp_Water );
      //u8g.print(WATER);
      //u8g.print(" L/M");
      //u8g.setCursor(0,1);
      u8g.drawStr(0, 40, "VOL (L):");
      u8g.drawStr(80, 40, tmp_Total );

      //u8g.print( TOTAL);
      //u8g.print(" L");
      Serial.println("VOL:");
      Serial.println(TOTAL);

      //Serial.println("TIME:");
      //Serial.println(TIME * 0.001);
      //
      //Serial.println("FLOW:");
      //Serial.println(WATER);

    }
  }
  delay(1000);
}
```

Appendix B

Individual flow results

Participant 1

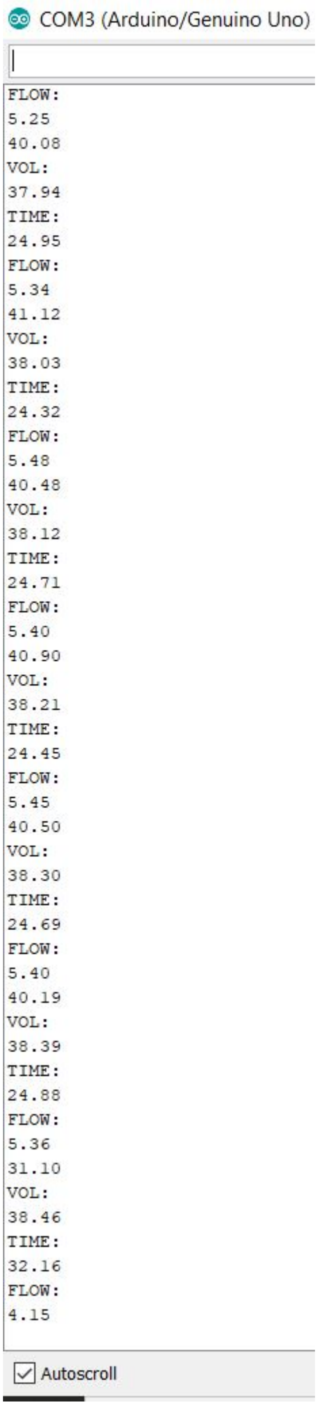

Figure 12: Baseline

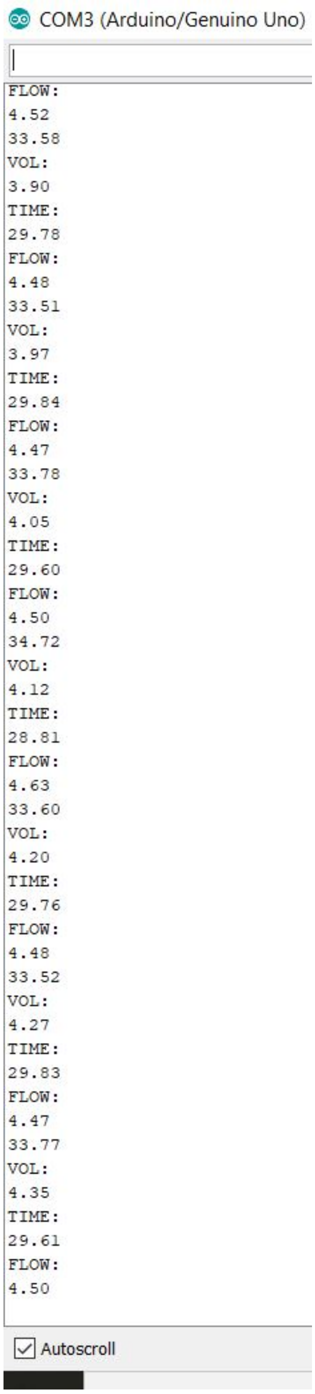

Figure 13: Day 1

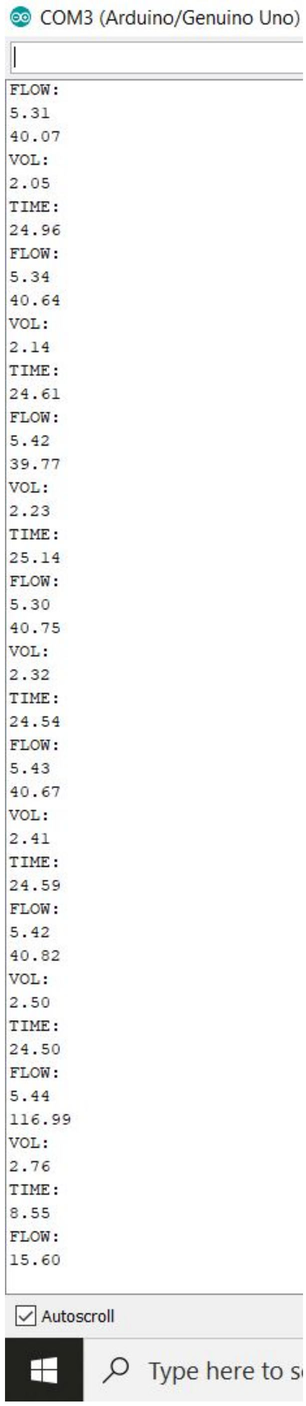

Figure 14 Day 2

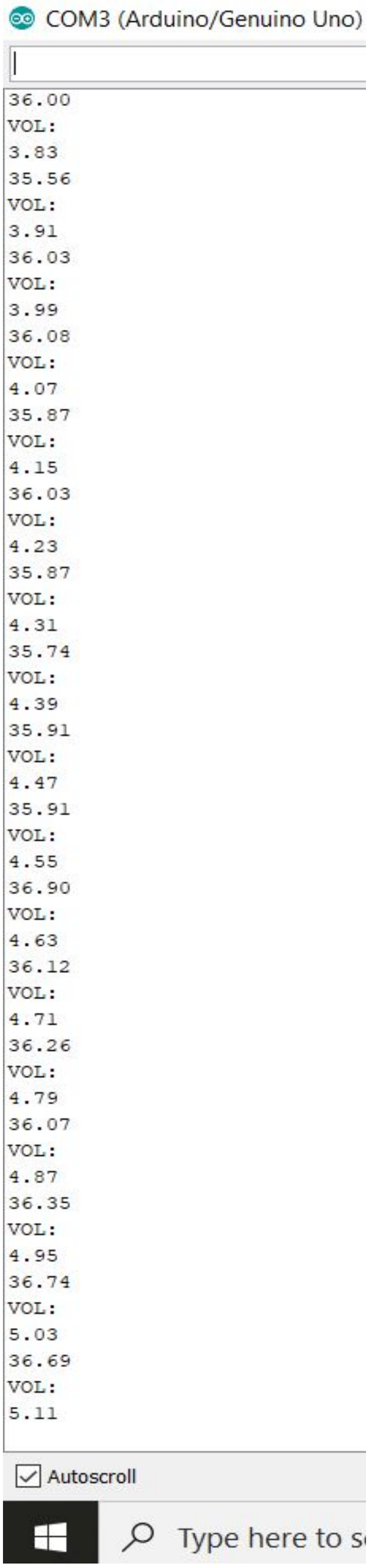

Figure 15: Day 3

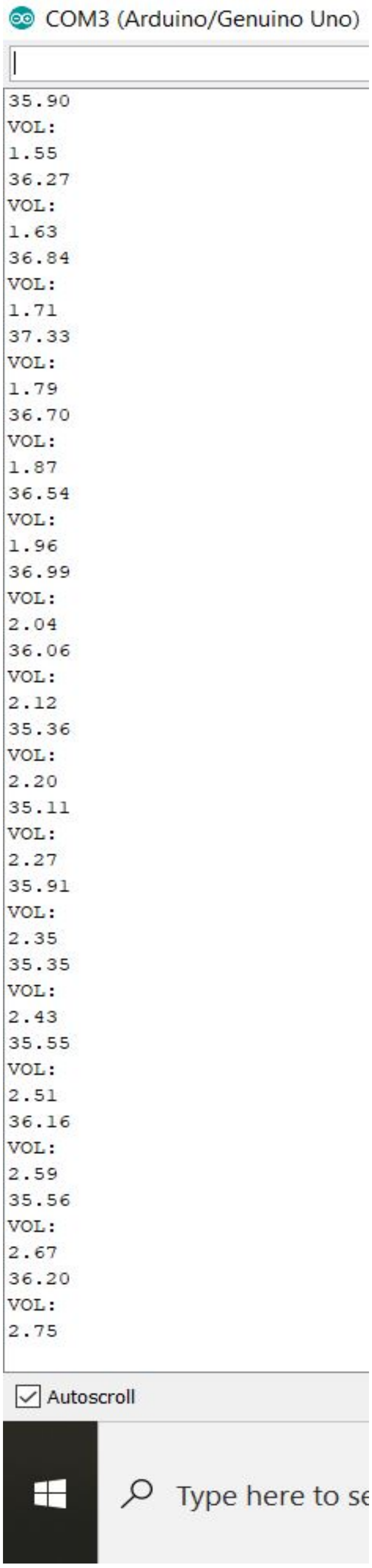

Figure 17: Day 4

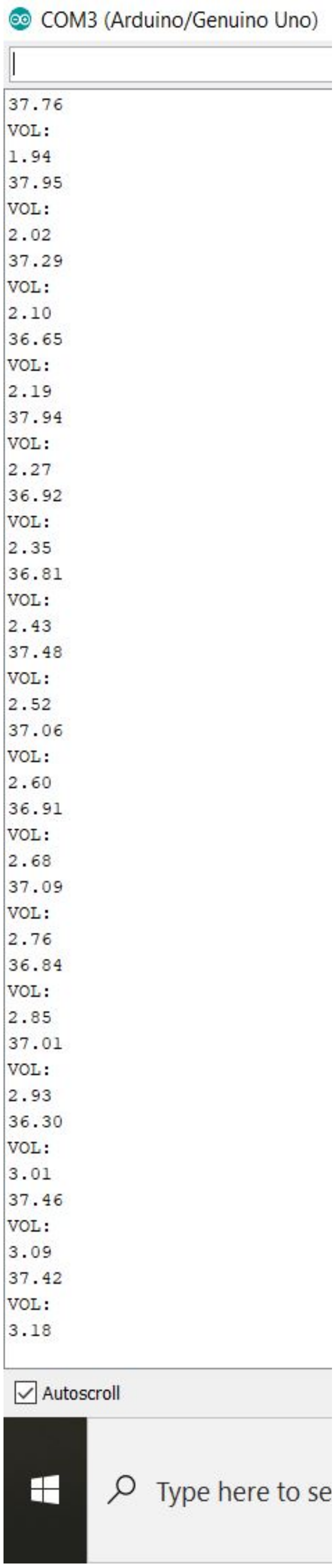

Figure 16: Day 5

Participant 2

COM3 (Arduino/Genuino Uno)

```
FLOW:
5.61
41.41
VOL:
21.50
TIME:
24.15
FLOW:
5.52
40.83
VOL:
21.59
TIME:
24.49
FLOW:
5.44
41.31
VOL:
21.68
TIME:
24.21
FLOW:
5.51
41.11
VOL:
21.77
TIME:
24.32
FLOW:
5.48
41.24
VOL:
21.86
TIME:
24.25
FLOW:
5.50
32.47
VOL:
21.94
TIME:
30.79
FLOW:
4.33
64.88
VOL:
22.08
TIME:
15.41
FLOW:
8.65
```

Autoscroll

Figure 20: Baseline

COM3 (Arduino/Genuino Uno)

```
31.71
VOL:
0.07
TIME:
31.53
FLOW:
4.23
106.29
VOL:
0.31
TIME:
9.41
FLOW:
14.17
```

Figure 19: Day 1

COM3 (Arduino/Genuino Uno)

```
34.54
VOL:
0.08
TIME:
28.95
FLOW:
4.61
31.85
VOL:
0.15
TIME:
31.40
FLOW:
4.25
35.50
VOL:
0.23
TIME:
28.17
FLOW:
4.73
```

Autoscroll

Figure 18: Day 2

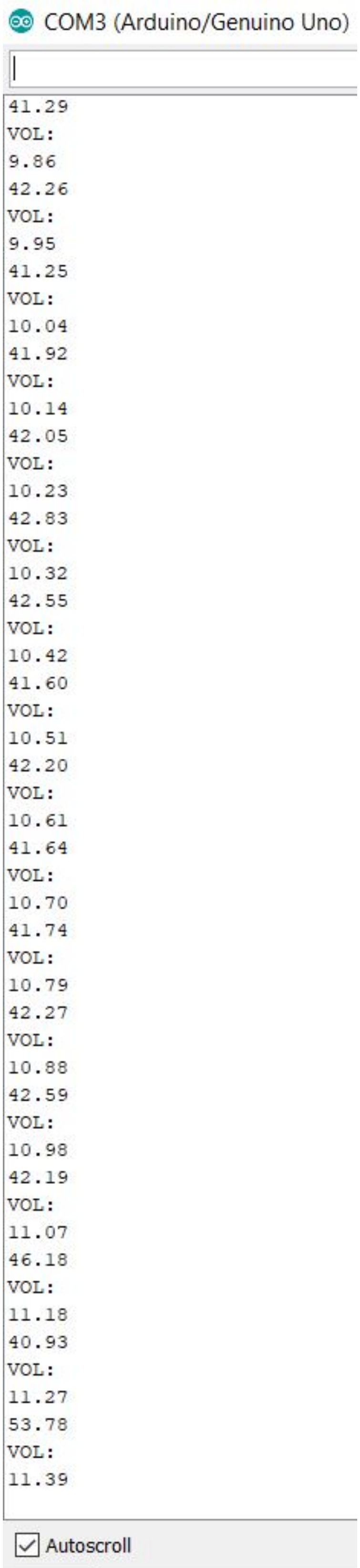

Figure 21: Day 3

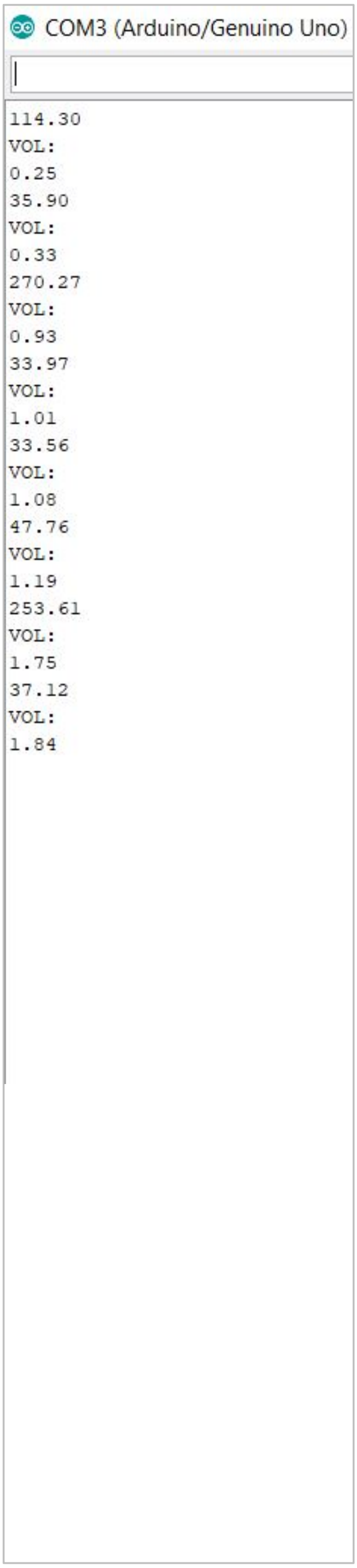

Figure 23: Day 4

Figure 22: Day 5

Participant 3

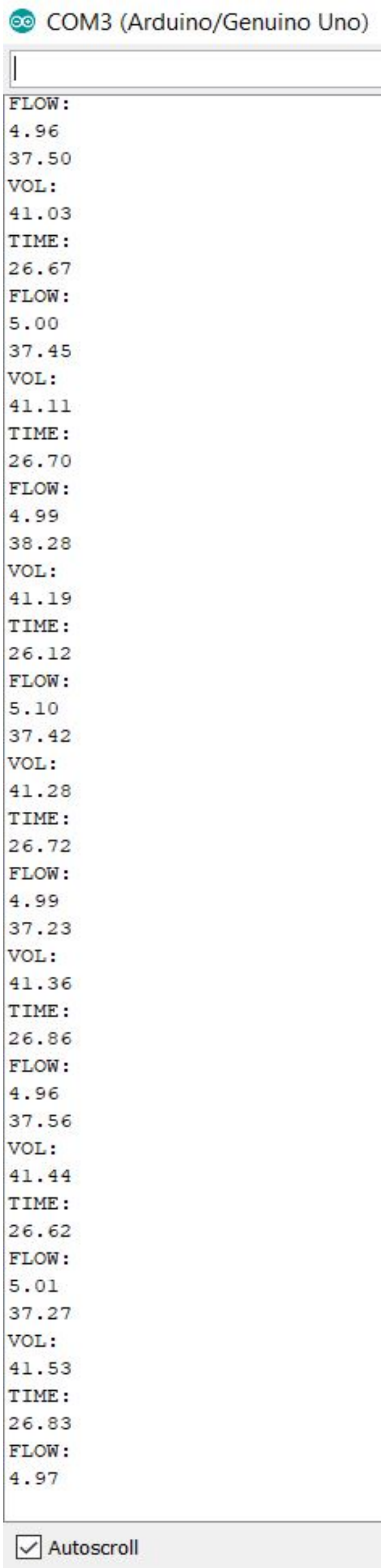

Figure 26: Baseline

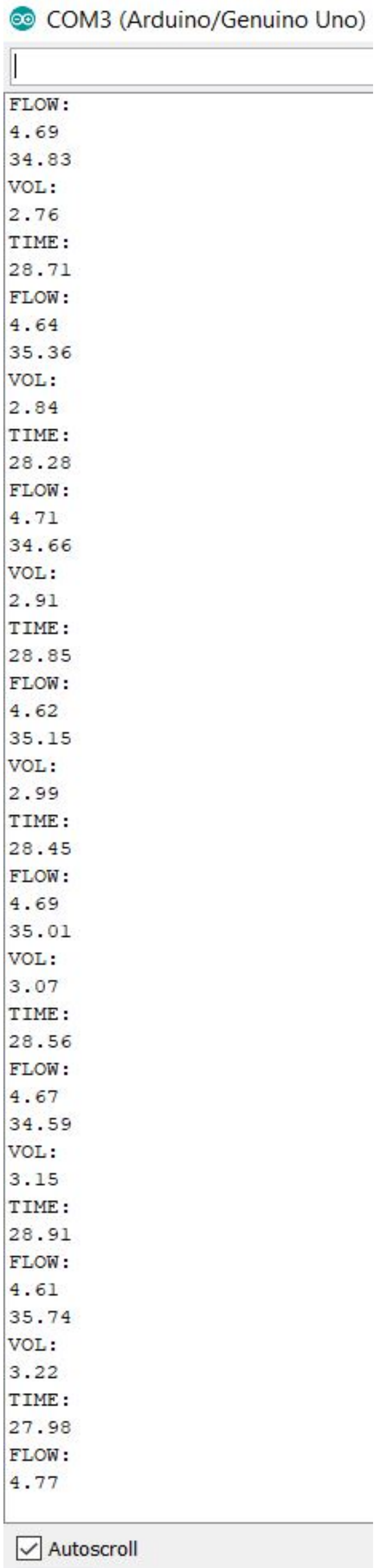

Figure 25: Day 1

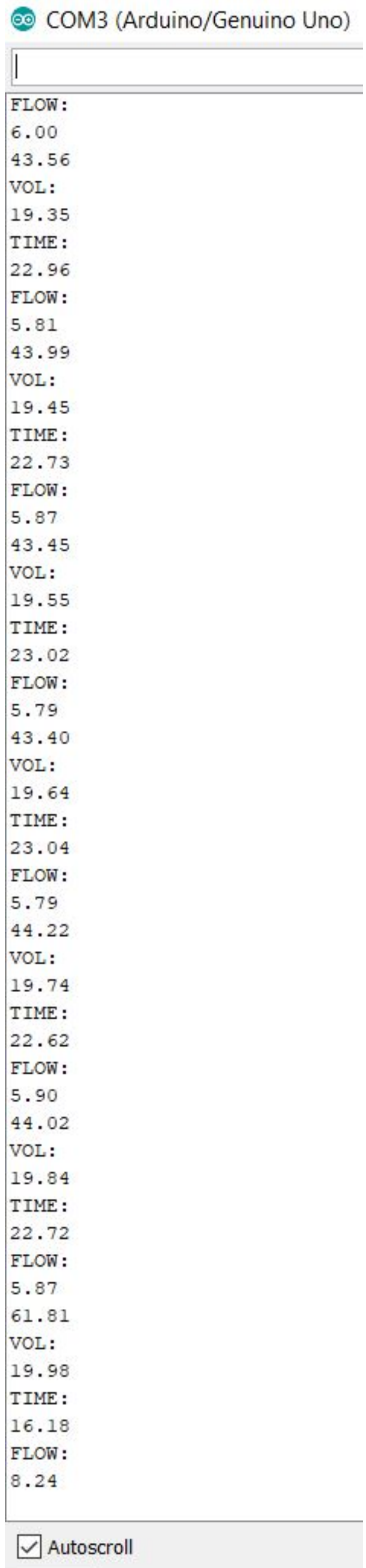

Figure 24: Day 2

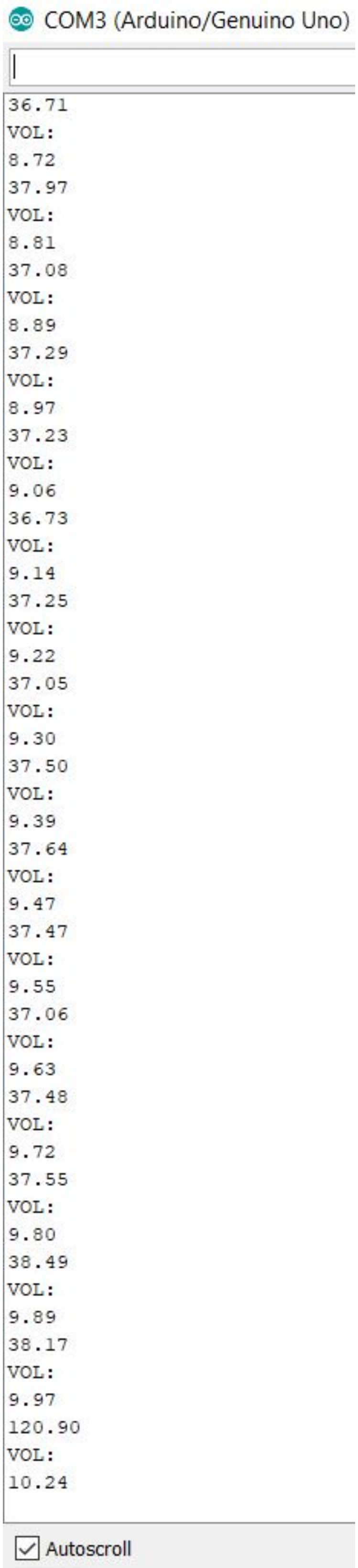

Figure 29: Day 2 - Shower 2

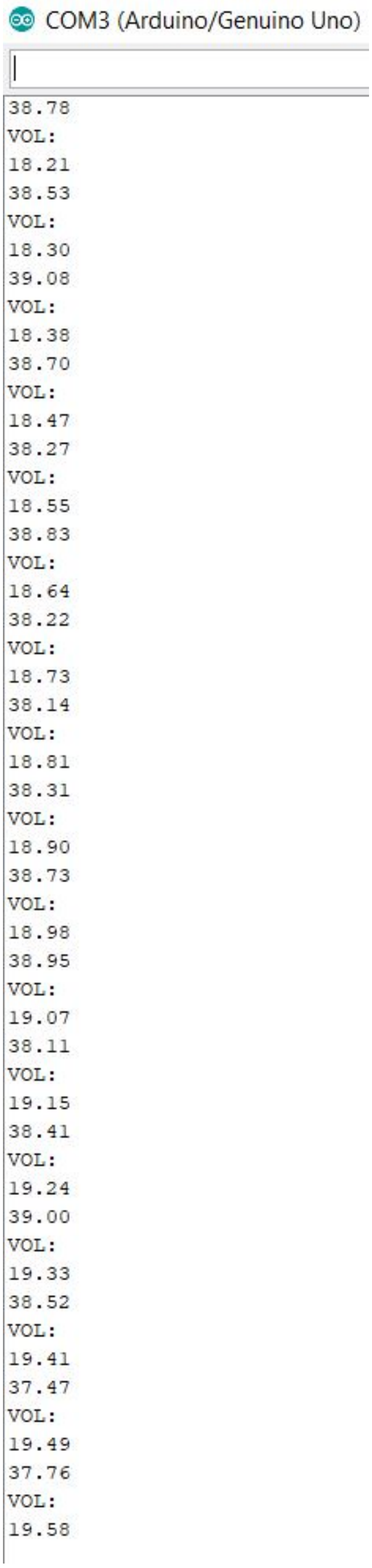

Figure 27: Day 3 - Shower 1

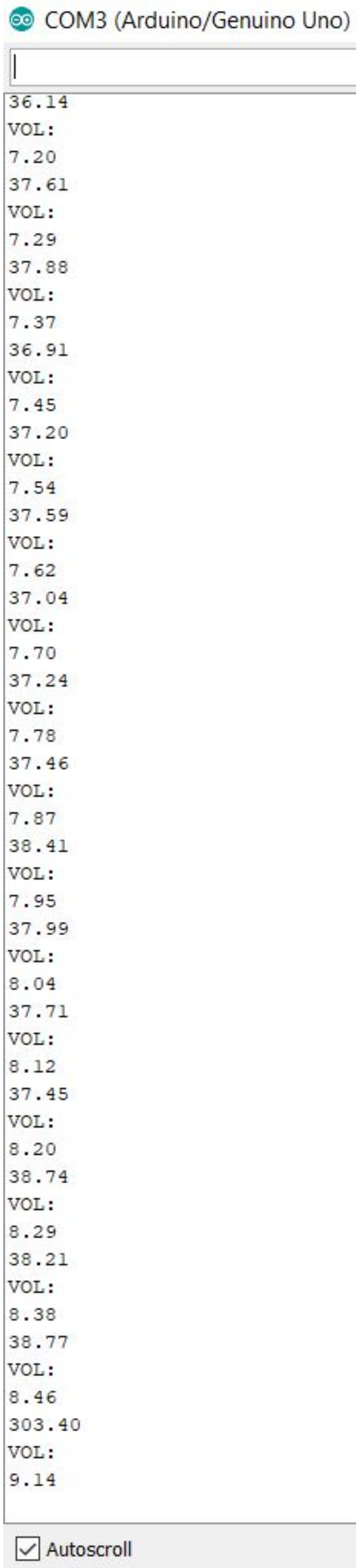

Figure 28: Day 3 - Shower 2

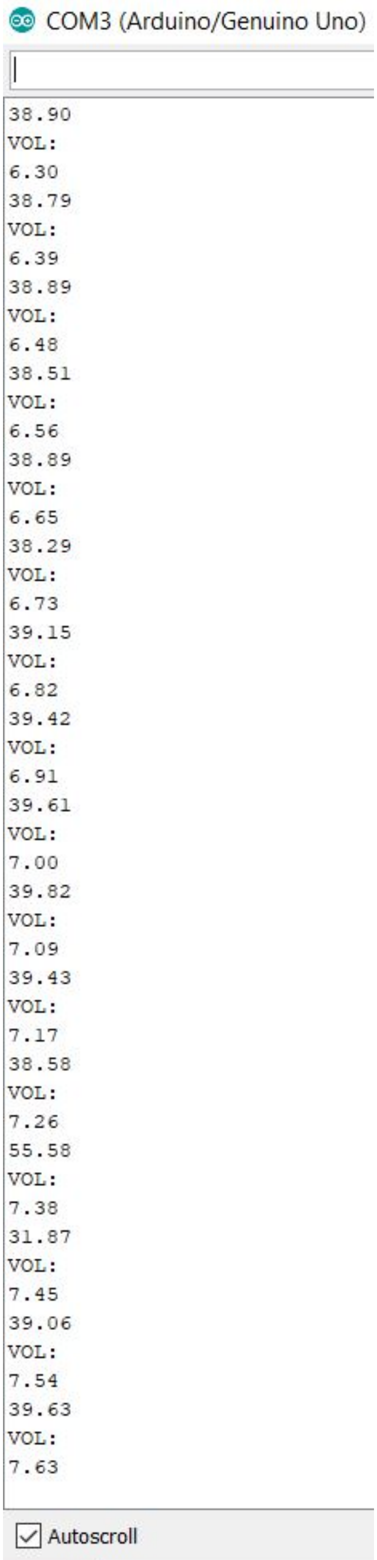

Figure 32: Day 4

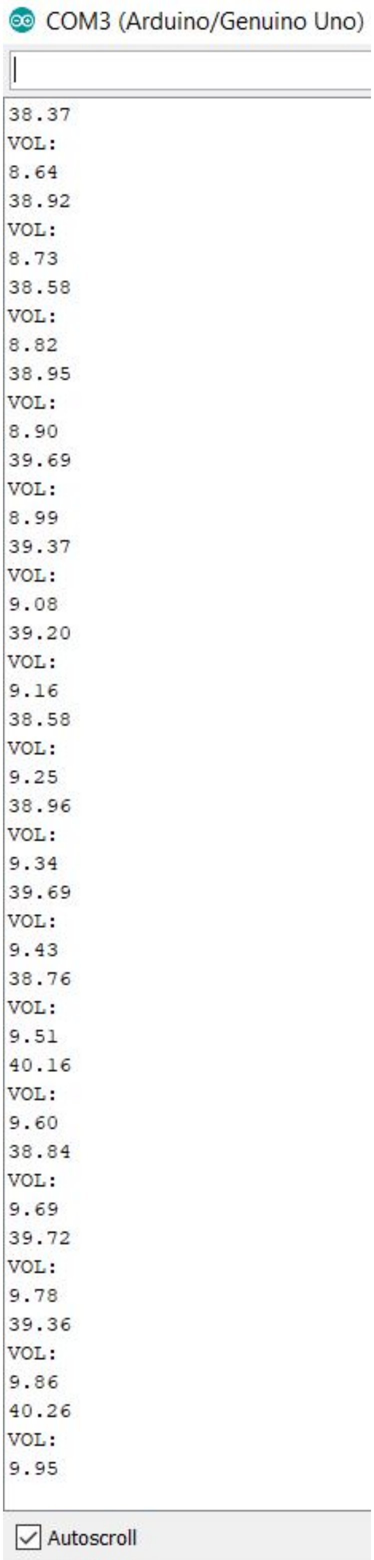

Figure 31: Day 5 - Shower 1

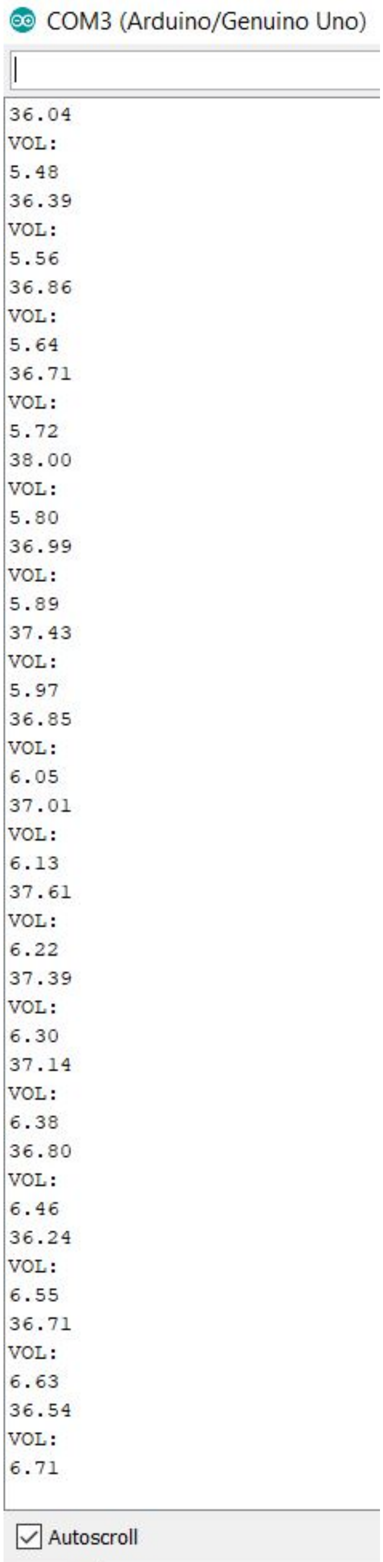

Figure 30: Day 5 - Shower 2

Participant 4

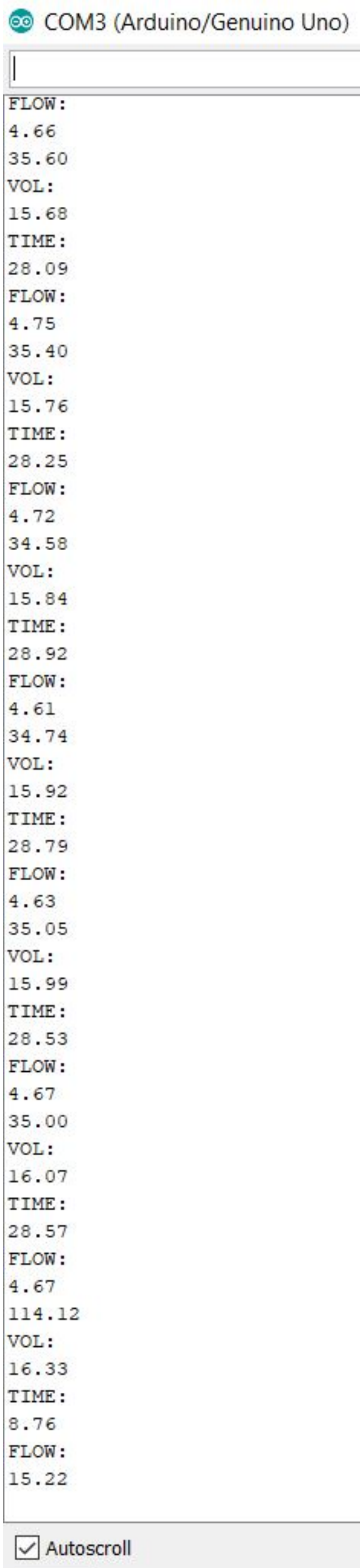

Figure 35: Day 1

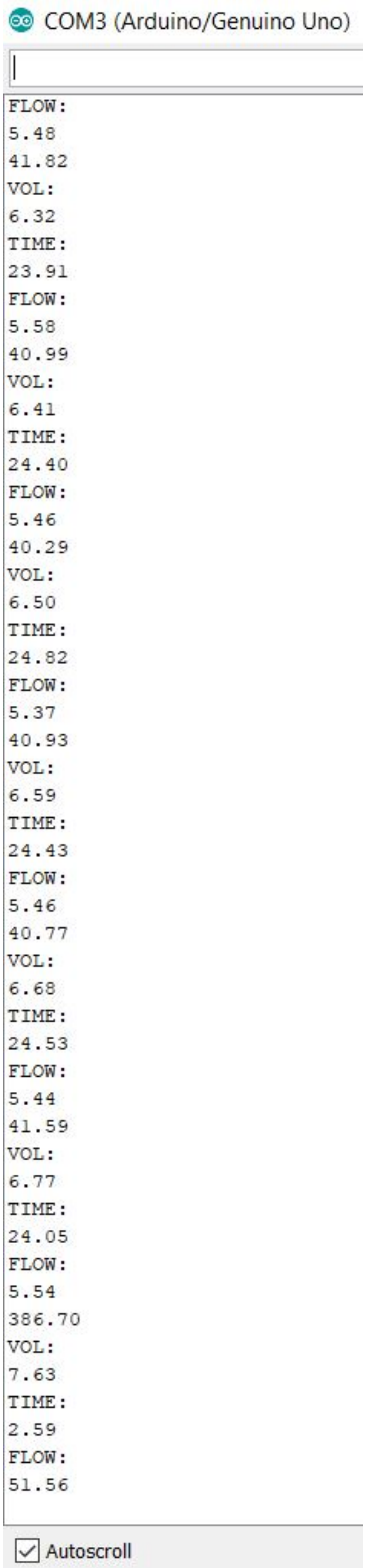

Figure 34: Day 2

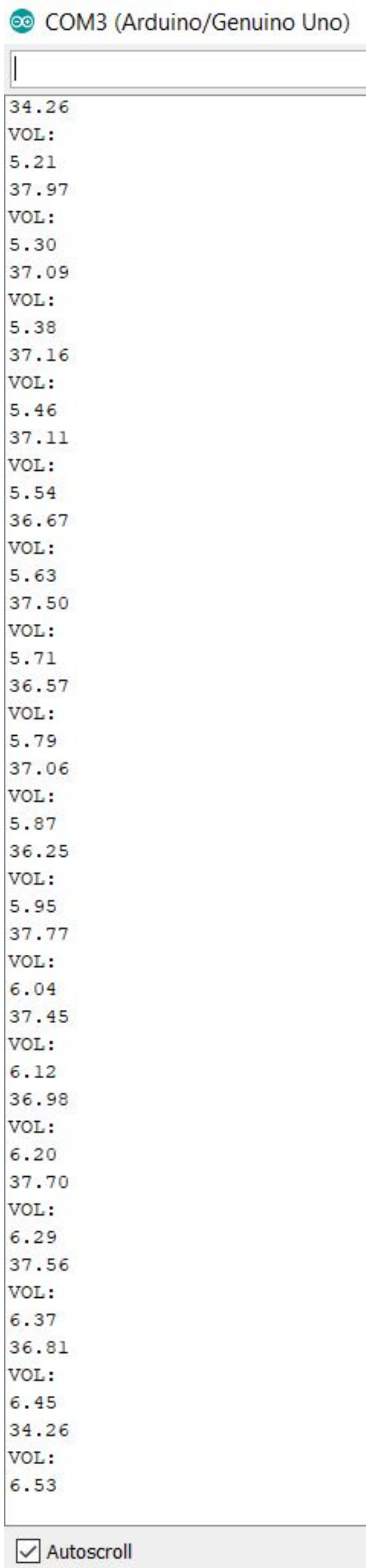

Figure 33: Day 3

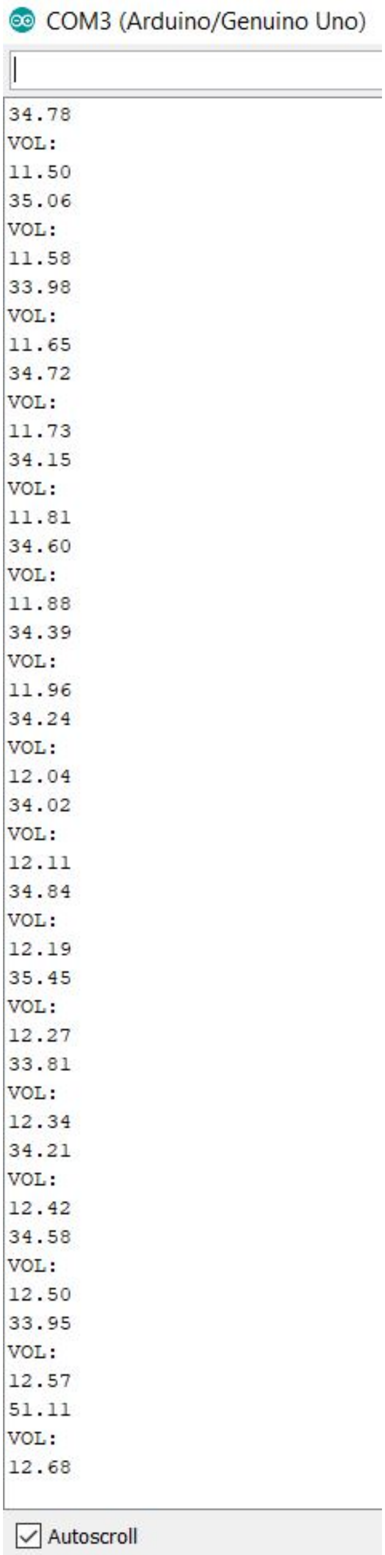

Figure 37: Day 4

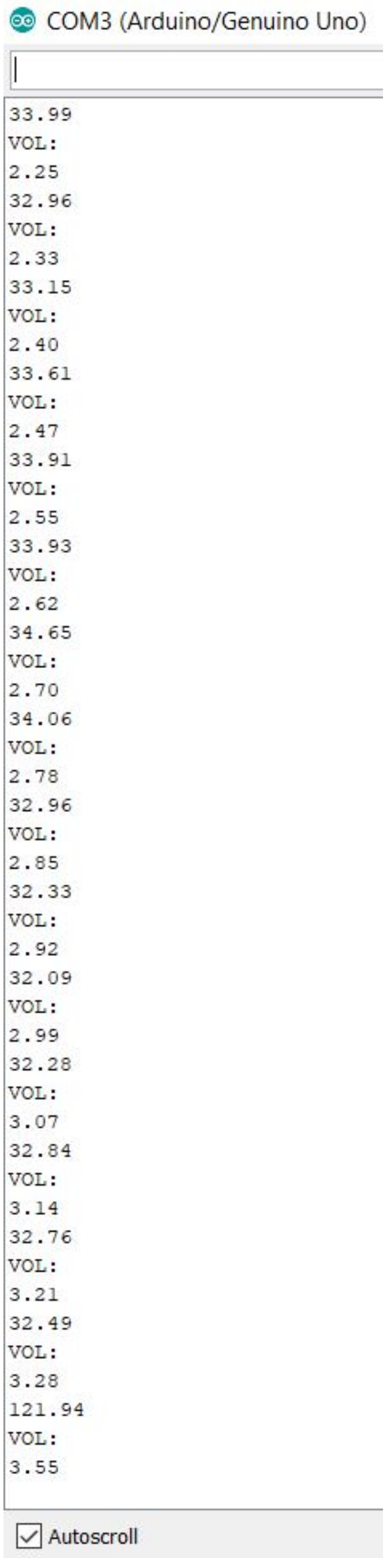

Figure 36: Day 5