MSc Thesis

Water-saving at the household level using gamification features: A design-oriented study in the Netherlands

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Abstract

With the ever-increasing water demand and the pressures caused by climate change, a need has risen to save water. In recent years, the Netherlands has experienced dry summers causing the water supply to fall short. With the expectations of water use only going up, the problem is expected to worsen in the coming years. A place where water users are the most in control of their water consumption is their households. The determinants of water consumption behavior in households include attitudes, norms, and habits. One way to change or influence this behavior is using gamification, which applies game design elements to real-life applications to persuade users to undertake specific actions. However, such gamification design has not yet taken shape or form that can be used in Dutch households. Therefore, this research aims to identify the features of gamification for a water-saving system applicable in the Netherlands. The research starts with identifying the features of existing water-saving platforms, allocating them into understandable categories, and identifying existing behavioral change models to see if these features will alter behavior. The identified features were tested on Dutch households in the village of Grou in the north of the Netherlands using surveys, which were analyzed using frequency distribution and central tendency. The research results show that visualization features, push notifications, and action tips are the most preferred features. If these features are combined in a water-saving platform, actual water-saving behavior is expected to occur based on the findings.

Keywords: gamification, water-saving, water consumption, behavior, domestic water use

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1. Introduction

1.1. Research background

Nowadays, pressing issues such as overconsumption, climate change, and unsustainable behaviors are some of the main challenges faced by humankind. One of such issues is the sustainable use of water. Sustainable water resources are essential to human health, environmental sustainability, and economic prosperity (United Nations, n.d.). For this reason, assurance of sustainable water resources and mitigation of water risks has become one of the United Nations Sustainable Development Goals (SDGs), which were established in 2015 in the form of SDG6, "Ensure availability and sustainable management of water and sanitation for all" (United Nations, 2021), especially indicator 6.4, "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity" (Cai et al., 2021 page 2) is a challenge to be tackled.

Due to climate change, the Netherlands will have to deal with multiple water-related challenges, such as sea-level rise, longer periods of extended droughts, lower levels of water in the rivers, more salinization from seawater intrusion, and more frequent and intensive flooding due to heavy rainfall. Due to these phenomena, enough freshwater is not always available (*Deltaprogramma Zoetwater*, n.d.), which causes problems with the (drinking) water used in households. To assure the availability of water, the delta program of freshwater from the Dutch government has called for all water users to be more sustainable with their water use as the goal is to reduce the demand for water. Moreover, citizens get called upon to implement smarter solutions for their water usage (*Deltaprogramma Zoetwater*, n.d.). One such goal of the Dutch government's drinking water policy is to make users, including households, more aware of their water use to reduce the waste of drinking water and the energy needed to produce and use drinking water. Instruments implemented by the government include behavioral measures, such as communications and campaigns, as well as smart metering (Ministerie van Infrastructuur en Waterstaat, 2021). Furthermore, the government attempts to improve communications about the (un)sustainable water use in households and is exploring approaches to get households to be more aware and sustainable with their water use (Ministerie van Infrastructuur en Waterstaat, 2021).

Adding to this, Dutch water companies such as Vitens have been proposing that households should lower their water consumption, especially due to the projected increase of 30% more drinking water in 2040 (Vitens, n.d.). This increase is expected due to population growth, social-economic developments, and an increase in overall water use per person (Ministerie van Infrastructuur en Waterstaat, 2021). In recent years, Vitens has already had to lower the pressure in the pipeline in some cases to be able to keep up with the demand. Moreover, the problem of drought is expected to happen more often due to climate change and to affect the availability of drinking water (Willems et al., 2012). This phenomenon has already occurred in the past few years, specifically in 2018, 2019, and 2020 due to very dry summers (Bierkens, 2022) (CBS, 2021a). Additionally, with the current high energy prices of 1.74 euro per m^3, and unsustainable water heating with fossil fuel gas emitting greenhouse gasses (GHGs) (In January 2020), reducing the behavior of using heated water would save both money and GHG emissions (Millieucentraal, n.d.).

1.2. Research problem

Water users can change their behavior the best in their households where they are in control (Danielsson, n.d.). Besides, water users change their consumption behavior when environmental or economic incentives are in play (Tijs et al., 2017). Research on psychosocial and behavioral determinants of household water conservation and intention shows that "attitudes, norms, and habits play an important role in determining intention to conserve water" (Russell & Knoeri, 2020, page 1). Changing these norms and habits is where gamification can play a role. In the 2010s, there have been developments in using a social-centered gamification design, with e.g. the objective to save water at a household level, to deal with issues related to the overconsumption of natural resources (Wang & Capiluppi, 2015). However, this kind of design has not yet taken the shape or form that it can be applied in Dutch households. Therefore, research is needed to identify the appropriate features of such a gamified water-saving platform for Dutch households.

1.3. Research objective

The main objective of this thesis is to identify the features of a gamification platform for a water-saving system at the household level, focusing on the empirical case of Dutch households to contribute to promoting pro-environmental behavior.

The literature review explores existing features of gamification designs to identify which features have been used to motivate users to change their water use behavior. These features were tested through a survey at a household level in the Netherlands to identify which features are responded well to by Dutch households and, therefore, might help achieve the objective of contributing to pro-environmental behavior.

1.4. Research questions

This research follows a design-oriented approach, through which features will be recognized that should or could be implemented in a water-saving application to be used by a Dutch household. Therefore, the following main research question was created:

How to save water at the Dutch household level using gamification features?

To be able to answer the main research question, the following sub-questions are formulated:

1. *Which features are preferred by specific characteristics (e.g., age, educational level) of Dutch households?*
2. *What are the desired features of a gamification platform for water-saving in Dutch households?*

1.5 Thesis outline

This thesis follows an IMRaD-inspired outline: the first chapter is the introduction which includes some empirical background, research problem, research objectives, and research questions. The second chapter is the theoretical background, which starts with some empirical background, then goes into some behavioral models, and the last part goes into the identification of features related to gamification and, more specifically, water use reduction. The third chapter, methodology, goes into the research design, ethical considerations, and the overall data gathering. In the fourth chapter, an analysis of the gathered results is conducted. In chapter five, a discussion on the performed research is conducted, and the results get discussed. In the last chapter, conclusions, the research questions get answered, and practical recommendations and further research recommendations based on the findings of this thesis are given.

2. Empirical and Theoretical Background

This chapter consists of four subsections. The first section provides an overview of the reasons and motivations to save water in the Netherlands. It consists primarily of the review of empirical documents, such as statistics, policy reports, and documents from water companies and institutions. The second section reviews selected theoretical approaches to behavioral change to create a basis for the application and use of behavior-changing gamification features. In the third subsection, features applied in existing water-saving platforms, which can potentially be applied by Dutch households as well, are identified. In the last section, the applicable features are summarized and linked to the aforementioned behavioral approaches. The identified features are then tested using a survey, as explained in chapter 3 Methodology.

2.1. Reasons and motivations to save water in the Netherlands

Even though Europe has an abundant supply of renewable water, climate and hydrological reports indicate that there is already a 24% decrease per capita in renewable water sources. (*European Environment Agency*, 2020). Currently, the water supply for households is around 102 liters per person, which would not count as water stress. However, with the increase in population, urbanization, and expected change in climate, this could change in the future. With the (over)extraction of groundwater for freshwater in the European Union (EU), groundwater depletion, loss of habitats, and deteriorating water quality will occur if no action is taken (Kristensen et al., 2004).

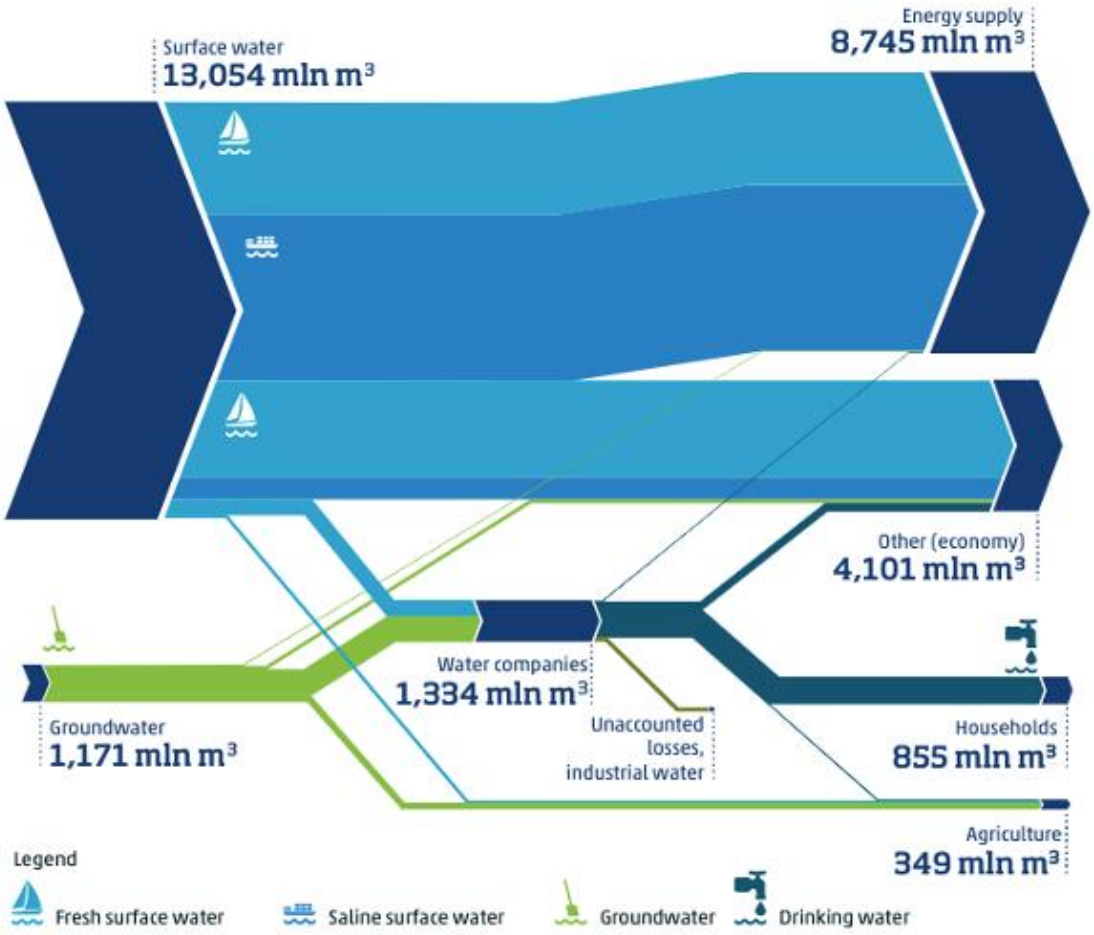

Figure 1 Water supply and consumption in the Netherlands

Source: CBS (2022)

In the Netherlands, the main challenge to the sustainable use of groundwater is that the freshwater use of its major cities is already 61% of the yearly national groundwater supply (UNESCO World Water Assessment Programme, 2022), a number that currently puts pressure on the groundwater aquifers. If the demand increases even more with climate change, this pressure might only increase. As it currently stands, the highest share of groundwater in the Netherlands is the consumption of drinking water, as shown in Figure 1. Due to the consequences of climate change, more extreme weather situations and water problems such as scarcity in the Netherlands will arise (Willems et al., 2012). The Netherlands had to deal with three consecutive dry summers (2018 to 2020), which affected the availability of freshwater even further since households use more drinking water in dry summers, for instance, to fill swimming pools or water their gardens (CBS, 2021a).

Therefore, changes need to be made to solve the issue of the increase in water demand as the current predictions are that in 2040 people will be using 30% more drinking water. This translates to roughly 100 billion liters more than currently used in the Netherlands (Vitens, n.d.). One of such changes is using less drinking water as called for by water companies such as the north-Netherlands water provider Vitens (Vitens, n.d.).

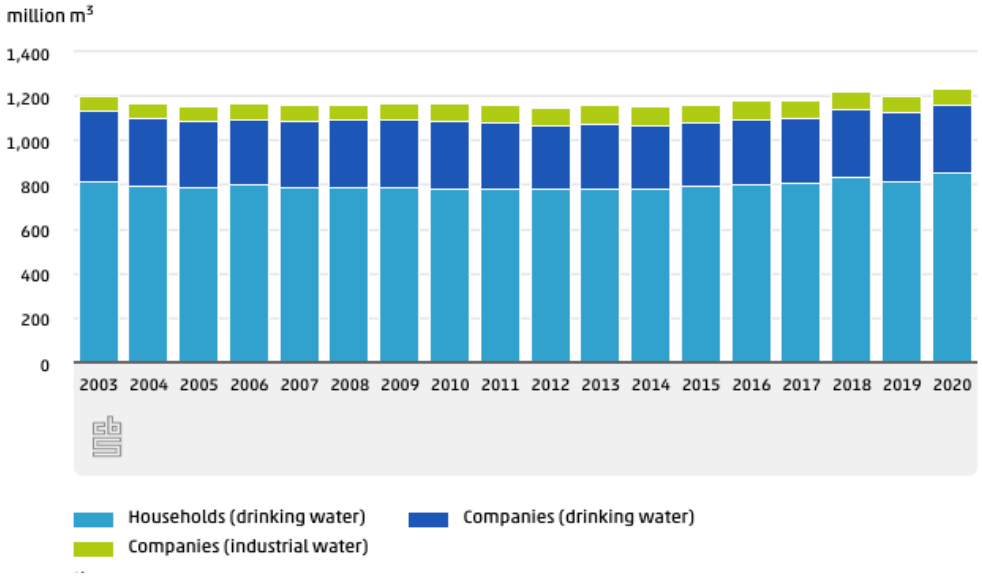

Figure 2 Mains water consumption consisting of drink and industrial water

Source: (CBS, 2022)

Currently, 10% of total water consumption globally is on the household level (Danielsson, n.d.). In the case of the Netherlands, this is around 6%, as can be seen in Figure 1. Moreover, EU citizens underestimate their personal water use, which is only rising (Seelen et al., 2019). As shown in Figure 2, a similar pattern can be observed in the Netherlands. Between 2003 and 2014, drinking water use decreased, but after 2014 consumption increased again (CBS, 2021a). From 2018 on, a further slight increase in water use was observed, particularly due to drought, which could be an early sign of climate change showing its impact on water availability (CBS, 2022). Moreover, since the weather in the past years has been irregular with dry summers and households using more freshwater, the pressure on the supply increases, too (CBS, 2021a).

Households can have a significant impact on water consumption if tackled, as people underestimate how much water they use, not only in the perspective of liters but also in the energy required to heat the water for their daily shower (Steg, 2008). The potential for saving energy required for heating a shower is significant in the Netherlands. On average, reducing the shower time from 9 minutes to 5 minutes would save 120 cubic meters of water and 450 million cubic meters of natural gas, or, in monetary terms, 700 million euros (Millieucentraal, n.d.). As the energy prices are increasing in the Netherlands, saving on heating costs for water would be beneficial for Dutch households in monetary terms and, therefore, an incentive to save on water use. Tijs and colleagues (2017) conducted an experiment testing if monetary appeals such as "conserving energy will save you money" (Tijs et al., 2017, page 1) or environmental appeals such as "conserving energy will save the environment" (Tijs et al., 2017, page 1) influenced the water consumption while showering, based on data from 100 Dutch households. The results showed that environmental appeals were more effective than monetary appeals, although the monetary appeal was initially seen as more motivating. Moreover, as policymakers struggle with implementing policies to save water, other measures need to be taken to manage urban water demand (Russell & Knoeri, 2020).

Therefore, there is a need to expand scientific and environmental literacy regarding water use amongst EU and hence Dutch citizens, as well as emphasize their important role in saving water (Seelen et al., 2019). The goal of Dutch households should be to lower their water use now to prevent possible supply and demand problems, as a lower demand means a lower need for supply (Vitens, n.d.). As it currently stands, there are few possibilities to save water in a proactive manner on a daily basis (United Nations Environment Programme, 2019).

2.2. Theoretical approaches to behavioral change

Fogg's behavioral model studies the factors of ability, motivation, and triggers that can generate a certain behavior and has high applicability to human-computer interaction (Muntean, 2011), which is useful for a gamified platform. This model is included in the research as it can help identify which kind of features or combination of features can help change the target behavior of saving water.

The other model introduced in this section is the theory of planned behavior. The theory of planned behavior delves into the contextual factors of behavior which Fogg's model does not. It is therefore included in the research to identify which kind of background factor each feature influences and helps change the intention and, therefore, the action.

2.2.1. Fogg's behavioral model

One way to understand human behavior is using Fogg's behavioral model. This model states that behavior results from three factors: motivation, ability, and triggers. These factors need to be fulfilled to perform a certain behavior, meaning that a person must be sufficiently motivated, have the ability to perform the behavior and has a trigger to perform this behavior (Fogg, 2009). Each of these three factors has subcomponents. Firstly, *motivation* is described by pleasure and pain, hope and fear, and acceptance and rejection. Secondly, *ability* has factors such as time, money, physical effort, brain cycles, social deviance, and nonroutine. Thirdly, *triggers* consist of the spark, facilitator, and signal. These categories and their interlinkages help users perform a certain target behavior, as shown in Figure 3 (Fogg, 2009).

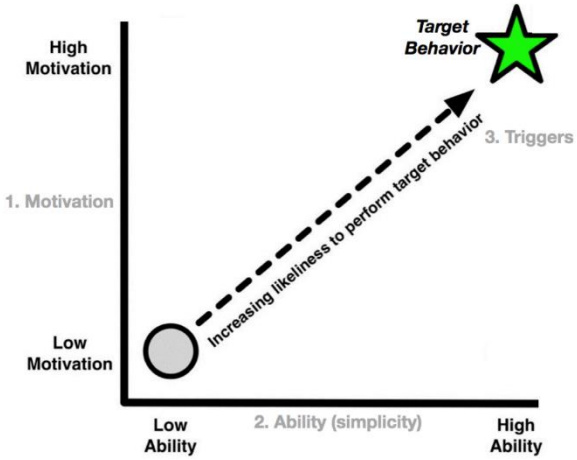

Figure 3 Fogg's behavioral model

Source: (Fogg, 2009, page 2)

Fogg's behavioral model is used to analyze and design persuasive technologies, such as gamification (Fogg, 2009). Therefore, it can also be applied in identifying the features of a water-saving gamification platform. The model of Fogg was applied in a previous study by Kouroupetroglou er al. (2015) to help users with engaging in and providing insightful information regarding their water usage behavior. The study notes that Fogg's model can be used as starting guideline for designing solutions for water-saving features and mentions motivations for saving features such as an orb visualization which gives the users incentive to reduce consumption out of fear of overconsumption. For ability, the study states that the designer should ask questions about whether the feature is feasible for changing behavior. For this the features need to be easy and accessible. Lastly, for triggers, the study describes doing something now, for example, a trigger such as a reminder notification.

The problem with Fogg's model is that it does not address underlying attitudes, beliefs, and personal and social norms (Albertarelli et al., 2018). Therefore, the theory of planned behavior is also incorporated into the current study to address such facets of behavioral change.

2.2.2. Theory of planned behavior

Another theoretical approach related to changing behavior that addresses underlying attitudes, beliefs, and personal and social norms is the theory of planned behavior (Ajzen, 1991). This theory proposes that a person's decision to do a certain behavior can be traced back to their intention. The overall idea behind the theory of planned behavior is that humans are more likely to perform a behavior when they have a favorable attitude to the behavior (Chen, 2018).

The theory of planned behavior consists of four variables. The first variable is the attitude toward behavior which can predict the intention of a person to act on the behavior. The second variable is the subjective norms which are about the perceived social pressure to act in or on behavior. The third variable is perceived behavioral control, which is the person's perception of the ease of use of a certain behavior. The final variable of the theory of planned behavior is the intention or the readiness to conduct the wanted behavior. This variable is directly influenced by the other three background variables, as seen in Figure 4.

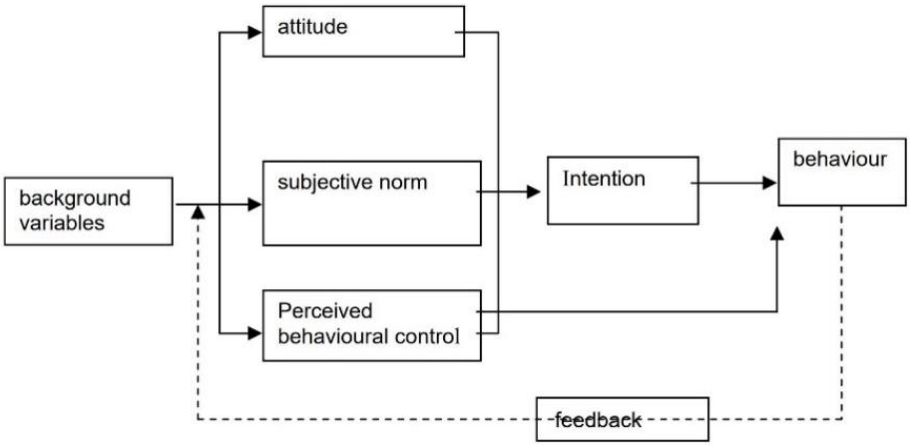

Figure 4 The theory of planned behavior

Source: (Brookes, 2021)

As seen in Figure 4, the actual behavior can again influence these background variables and, subsequently, the wanted behavior. This is where the gamification features can play a role, as these can impact the background variables (Krath et al., 2021). An example of how to apply this model to a water-saving system is presented in Figure 5 (Russell & Fielding, 2010).

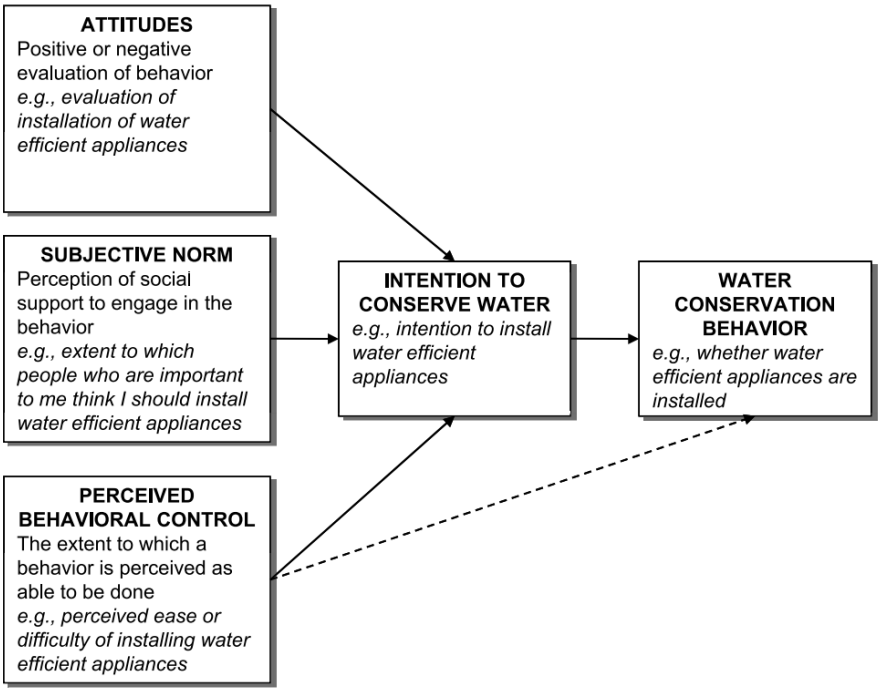

Figure 5 The theory of planned behavior applied to a water-saving system

Source: (Russell & Fielding, 2010)

Moreover, the theory of planned behavior has been previously applied in research on the gamification of education (Chen, 2018). This study concluded that gamification designs could impact users to change their behavior by influencing their attitudes, social norms, and perceived behavioral control. In section 2.4, features will be identified that are based on the variables included in this theory.

2.3. Gamification platforms to stimulate water-saving

In this section, the literature on existing platforms that stimulate water-saving is reviewed and investigated in order to identify their respective features.

2.3.1. SmartH2O

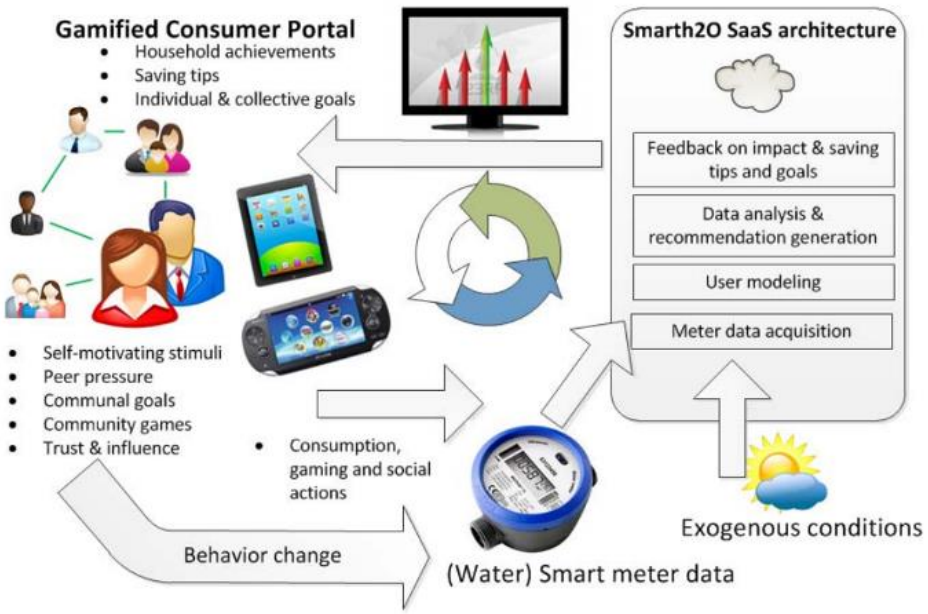

Figure 6 SmartH2O

Source: (Fraternali et al., 2015, Page 1)

The SmartH2O platform collects the consumption data of users using an "automatic meter infrastructure", which gives users insight into their actual water use and its forecasted use. Moreover, this platform engages users with gamification techniques such as educational games and, as an extension, real-life board games. This stimulates a change in behavior on water use and rewards when appropriately done (Fraternali et al., 2015). Such a system nudges users by providing features that stimulate reducing water consumption at a household level.

As depicted in Figure 6, SmartH2O uses smart metering to measure a household's actual use and uploads this to a Software as a service (SaaS) architecture, known as a cloud. It translates the data into a gamified consumer portal. The platform also collects the data and clusters customers based on their household types and how they use water. Based on this, the platform comes to personalized educational content and water-saving tips and creates four types of badges: consumption, education, profiling, and social participation. The social participation aspects get put into global leader boards, and high scores can redeem physical goodies. However, it should be noted that this smart H2O application is not accessible in the Dutch app store market, causing Dutch households to miss out on these features which can be seen in Table 1 .

Table 1 Features of the SmartH2O water-saving platform and their aims adapted from:(Fraternali et al., 2015)

Feature of water-saving platform	What does the feature do/aim for?
Self-motivating stimuli	Give insights that would motivate the users
Peer pressure	Send out notifications and comparisons to put pressure
Communal goals	Set goals that you as a community have to achieve
Community games	Set up games that promote saving water on a household level

2.3.2. WaterGoWhere

The WaterGoWhere platform for conserving water has been implemented in Singapore. The application was implemented with the help of water company SUEZ and the PUB, the agency in charge of water management in the city-state. The objective was to give insights into households' water use patterns, habits and the motivations behind water-saving. This, in turn, would help and reward users for improving their water usage (Wong et al., 2019), following the "vision for a Smart Nation where people are empowered by technology to improve living" (Wong et al., 2019, page 1). The WaterGoWhere platform uses smart metering to measure the amount of water consumed or, as called in the platform, "advanced metering infrastructure" (Wong et al., 2019, page 3). As shown in Figure 7, this infrastructure analyzing the data provides personalized challenges and tries to change the user's behavior to help preserve the water resources of the region.

Figure 7 WaterGoWhere

Source: (Wong et al., 2019, page 3)

The WaterGoWhere platform uses a variety of water-saving features to influence household water use, and the underlying values behind it these features can be found in **Error! Not a valid bookmark self-reference.**.

Table 2 Features of the WaterGoWhere water-saving platform and what they aim for adapted from: (Wong et al., 2019)

Feature of water-saving platform	**What does the feature do/aim for?**
Neighbor and block comparisons	Customers like to compare their usage with those around them
Positive messages, rewards, and encouragement	Customers are motivated by positive reinforcement
Daily usage trend information	With hourly and weekly information
Monthly face-to-face meetings	To help customers with challenges in using the app and saving water
Monthly reports are sent out to offline customers	Show insights when not using applications.

2.3.3. Other gamification platforms

A previous study by Albertarelli and colleagues (2018), on the design of gamified systems for energy and water sustainability, identified three games focused on water-saving sustainability, as shown in Table 3. All the gamified platforms shown in Table 3**Error! Reference source not found.** have a different focus but have similar issues and backgrounds. However, they do not track specific data about the water use of households but rather play a more one-sided information-providing role.

Table 3 Features of water sustainability games (Albertarelli et al., 2018, page 16)

	Water Mansion	**Water Flavors**	**Water Saving Calculator**
Technology	Unity	Java	Java
Roles	Family	Family	Family
Feedback	N/A	N/A	No feedback
Mechanics	Simulation	Trivia	Trivia
Issues	Consumption awareness and money saving	Raise awareness of water consumption and education	Consumption awareness and money saving
Players	Single player	Single player	Single player
Focus	Efficient water consumption and its relationship with economic savings	Educate about water importance and usage	Educate about water efficient consumption and its relationship with economic savings
Target	Family	Domestic consumers	Domestic consumers
Platform	Web	Web	Web
Data collection	N/A	N/A	N/A

2.4. Features of gamification platforms for water-saving

Previous studies identified different sets of features that nudge the user to save water. This section summarizes these features and the reasoning behind them.

Albertarelli et al. (2018) identified that systems that focus on water sustainability should include the design elements or features, as presented in Table 4, to influence users. The features shown in Table 4 **Error! Reference source not found.**are the most commonly used incentive mechanisms for inducing behavioral change. Such mechanisms are designed in a way that they should trigger the engagement of human users by influencing the underlying psychological factors of behavior.

Table 4 Overview of features of a water-saving platform and their corresponding aim adapted from (Albertarelli et al., 2018)

Feature of water-saving platform	**What does the feature do/aim for?**
Visualization of behavior	Allows to self-monitor saving and (over)use
Comparison of behavior against historical, normative, or social Reference Values	Showing what the water consumption means in understandable ways and showing how the user is doing, comparing to friends and or similar users
Action Tips and Personalized Recommendations	Providing tips on how to improve on
Gamification and games with a purpose (GWAP) elements	Users can earn points for their behavior and get incentivized to do certain actions.
Social interaction	Users can interact with other users to either compete or cooperate with them to incentivize their use behavior.

As presented in Table 5, the features of water-saving platforms can be grouped into four main categories, derived from Albertarelli and colleagues (2018), but grouped differently to incorporate the factors of the identified behavioral models of Fogg (2009) and the theory of planned behavior (Ajzen, 1991).

First, insights and visualization provide a graphical and understandable representation of water usage. They link to the feedback construct of the theory of planned behavior as it shows the effect of behavior. Second, social aspects provide social interactions between users to incentivize better water use. Third, notifications and reminders are pop notifications to keep users using the water-saving system and pushing them to do certain actions. Lastly, tips provide information on how to improve the user's behavior in the right way. In the last column, we see how these features relate to the two behavioral models proposed by Fogg (2009) and Ajzen (1991) and which variable or factor is applicable to these categories of features.

The features identified through this literature review have been tested on Dutch households via a survey, which consists of the four categories and their respective features.

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Feature category	Definition	Features	References
Insight and visualization	Features that provide a graphical and understandable representation of water usage	Visualization of behavior Daily usage trend information Monthly reports are sent out to offline customers	Feedback (Ajzen, 1991), (Chen, 2018), (Krath et al., 2021) Trigger (Fogg, 2009), (Kouroupetroglou et al., 2015) Motivation (Fogg, 2009), (Kouroupetroglou et al., 2015)
Social aspects	Features that provide social interactions between users to incentivize better water use	Comparison of Behavior against Historical, Normative, or Social Reference Values Social Interaction Peer pressure Communal goals Community games Neighbor and block comparisons	Subjective norms (Ajzen, 1991),(Chen, 2018), (Krath et al., 2021) Attitudes (Ajzen, 1991),(Chen, 2018), (Krath et al., 2021)
Notifications and reminders	Pop notifications to keep users using the system and push them to do certain actions	Notifications and Reminders	Trigger (Fogg, 2009), (Kouroupetroglou et al., 2015)
Tips	Providing information on how to improve users' behavior in the right way	Action Tips and Personalized Recommendations Positive messages, rewards, and encouragement Monthly face-to-face meetings	Motivation (Fogg, 2009), (Kouroupetroglou et al., 2015) Ability (Fogg, 2009), (Kouroupetroglou et al., 2015) Perceived control (Ajzen, 1991),(Chen, 2018), (Krath et al., 2021) Feedback (Ajzen, 1991), (Chen, 2018), (Krath et al., 2021)

3. Methodology

3.1. Overall methodology: Design-oriented research

A design-oriented research approach, meaning an approach where knowledge is derived from studying a designed artifact that is in use or must be established, is selected for this thesis. The reasoning for selecting this approach is that it would allow for a starting point to put the intervention of gamifying water-saving on a household level in action (*Design-Based Research*, n.d.). Adding to this, another reason for opting for this research approach is that it provides not only theoretical input but also empirical insights, concepts, and inputs, as well as reflection (*Design-Based Research*, n.d.). This way of research will provide a starting point for a practical solution that can potentially be applied in real life to benefit society, especially households, on a more concrete level and therefore is expected to be more suited than classic predictive research (Amiel & Reeves, 2008).

3.2. Research strategy

This section delves into the different components and elements of the research strategy and how these will answer the research questions and fulfill the research objectives. The unit of analysis in the current study is Dutch households sampled in the village of Grou, with around 5500 inhabitants (CBS, 2021b), in the province of Friesland, as this is a representable sample of an average village in the Netherlands. Due to time constraints, a small-scale survey approach was selected as it would be the best use of time to get a broader overview of a household situation. Data saturation was reached when at least 40 survey respondents provided information. Moreover, goals for the number of participants were set to allow for certain stratification of age, homeowner, and gender.

The research contains the following boundaries, and it will focus solely on the features that a water-saving platform should have for a Dutch household. In this research, water use on a household level is understood as all the water which goes through the water meter of the respective household. Moreover, despite conducting a design-oriented research, a prototype of an application will not be established. Lastly, it will mostly focus on the behavioral side of the phenomenon and not the technical side.

3.3. Data sources and collection methods

For this research, a combination of primary and secondary data has been used to answer the research questions see Table 5. The secondary data consists of academic literature primarily found via search engines, such as Scopus and the Web of Science, and grey literature, such as policy documents and relevant company data. The primary data has been gathered via a survey, which data relates to which research question can be seen in Table 5.

Table 5 Research design and research questions

	Research Question	Type of question	Data needed to answer the question
RQ 1	How do Dutch households respond to the different features of water-saving applications?	Exploratory	Survey data on the likelihood of saving water between different stratifications[1] and their respective reactions to the Identified water-saving features.[2]
RQ 2	What are the desired features of a gamification platform for water-saving in Dutch households?	Design/evaluative	Survey data on the likelihood of water-saving caused by the identified features, background variables[3], and factors[4]

3.3.1. Literature review

For this research, a literature review was conducted to provide a background of the topic, identify research gaps, and develop a theoretical framework (Cronin et al., 2008). The search and selection of the literature were made using the following keywords: gamification, water-saving, and behavior in Scopus, Web of Science, and Research Gate. Publications starting from 2010, the year when gamification applications became mainstream, were mostly used with the exception of the literature on behavioral models. Moreover, only the publications in English and Dutch were reviewed, and additional references were identified following the reference lists of the respective literature. Additionally, search engines Google (Scholar) and DuckDuckGo were used to identify gray literature related to the topic of water-saving and to gather information on the empirical background in the Netherlands. The conducted literature review can be found in chapter 2, Empirical and Theoretical Background.

3.3.2. Household survey

This research applies an empirical research aspect in the form of a survey, which has been designed following the principles provided by Jenn (2006). The survey aims to identify which features the Dutch households respond the most to and which are the desirable ones. The survey was conducted in the Frisian village of Grou with 46 respondents. The respondents were selected following the four age ranges, namely (15-25), (25-45), (45-65), and 65+. Around 2/3rds of the respondents were aimed to be homeowners, with the remaining 1/3rd renters. These stratifications were used in order to make the sample representative for the village of Grou, based on the data from the central bureau of statistics (CBS, 2021b). Respondents were selected via the researchers' network and scouting in the area of the village. With the aim of 40 respondents in mind, the applicable population of 4785 inhabitants (above 15 years old) was multiplied against percentages for the respective age group and owner or renter situation. These percentages were calculated by dividing the population in the group by the total applicable sample. Following this procedure, the aimed number of respondents per age range and living situation, in order to get a representable sample, were calculated as shown in Table 6.

[1] Age, Gender, Owner or Renter
[2] For specification of the water-saving features: See section 2.4
[3] For specification of the variables: See section 2.2.2
[4] For specification of the factors: See section 2.2.3

Table 6 Aimed and actual sample group based on age ranges

Age group	Inhabitants	% of group	Aimed respondents	Actual respondents	Aimed renters	Actual renters	Male	Female
15-25	640	13%	5	6	1	2	6	0
25-45	1045	22%	9	9	3	1	3	6
45-65	1730	36%	15	20	5	3	7	13
65+	1370	29%	11	11	3	2	4	7
Total	4785	4785	40	46	12	8	20	26

The survey was designed in the Qualtrics software, as it allowed for quick customizability and testing. Moreover, it allowed for the application of a powerful tool, the Likert scale, more specifically the likelihood variation, as shown in Table 7, to identify how the sample responded to the identified features.

Table 7 Likelihood Likert scale

Number	Explanation
5	Definitely
4	Probably
3	Possibly
2	Probably Not
1	Definitely Not

Source: Adapted from Mcleod (2019)

The main sections of the survey consist of the introduction and disclaimer explaining the survey, getting the participants' informed consent, and providing the researcher's contact information if any problems or questions occur. This was followed by questions about age, household income, norms and values about water-saving, and what water-saving measures have already been taken by the household. The body of the survey consists of the sections of the feature categories, namely: insight and visualization, social aspects, notifications, reminders, and finally, tips. Thereafter, questions were asked about the preference for the features and possible recommendations and tips. The survey ended with a closing statement. The survey was conducted between 23 May and 5 June 2022, and disseminated using Qualtrics via a sharable link. For the design of the survey, please see Appendix 1. Survey.

3.4. Data analysis methods

For this research descriptive statistics, meaning brief statistics summarizing the characteristics of a certain data set, have been collected and related to the data gathered via the Likert scale. The data gathered from this particular Likert scale is of an ordinal nature, meaning that the ranks are higher or lower but not clearly defined. In this study, descriptive statistics such as the mode (most appearing value) and frequency distribution (how often does a value appear) are identified for each question or feature, using Qualtrics for data prepping and Excel for analyzing via cross tabs. This analysis aimed to identify the differences between the households and see which features are preferred, indicating for each feature what the mode is and how the data set is distributed.

The reasoning behind selecting the mode statistic is that since the data gathered from the survey is of an ordinal nature. Only the mode could be used with this textual Likert scale as both the mean and median were not informative in this particular context (Prita Bhandari, 2020). Pilots have been carried out to assure that the survey was error-free and deemed valid (Jenn, 2006).

Triangulation, meaning the use of multiple types of data, is used to answer the research questions. This data is gathered from different individuals/households as well as the data from previous studies to reach results that can be argued to be valid and reliable.

3.5. Ethical considerations

Before any empirical data was collected from real-life people, the ethical committee of the BMS Faculty had been consulted for approval. The survey has been done on a voluntary basis, and informed consent has been given for using the data for the thesis by including an informed consent text at the beginning of the survey. If any problems or issues were to arise, the respondent could reach out to the researcher. Moreover, the data was anonymized, so it could not be traced back to the individual household. This was done by not naming the respondents as the researcher might know the respondent and has therefore steered away from the ability to link data to persons. Moreover, no intended harm was caused by the participation in this study, and no signals of such harm have been received. Furthermore, the respondents of the survey were expected to speak on their own accord but could possibly be biased by the opinion of their partner, probably the other gender. Lastly, the information in this thesis was not plagiarized to the best of the researcher's knowledge, and the data was represented accurately.

4. Survey Results

In this chapter, the results of the conducted household survey are analyzed. The chapter was set up using the categories introduced in section 2.4 and goes into the different stratifications of age, owner or renter, gender, and their responses to the features. Graphical representations of the responses can be found in Appendix 2. Survey Responses

4.1. Feature category 1: Insights and visualization

Table 8 Central tendency insights and visualization

Feature	Modus (N)
Visualization	Probably (22)
Daily information	Probably (27)
Monthly information	Probably (21)

4.1.1. Visualization

The feature visualization its central tendency or modus is *probably*, with 47.8% of the responses. If we zoom in on age, this differs slightly, with the 15-25 age group showing the mode of *possibly (*50%*)*. The age group of 25-45 years old has a tendency for *probably* with 55.6% of the responses, as well as the age group 45-65 (50%) and the senior 65+ (45.5%) age group. The common modus of *probably* (45% male and 50% female) can be seen for both genders, which also corresponds with the overarching sample. When renters and owners are compared, it is observed that the central tendency with renters lies on *possibly* (50%), whereas the owners have a tendency on *probably* (50%).

4.1.2. Daily information (trend)

With the daily information feature, it can be seen that the overarching sample has a central tendency of 58.7% for *probably* reducing their water consumption. If we zoom in on age, we see that across the age categories, this central tendency stays the same for this particular feature. This pattern is also seen in the stratification of renters and owners and gender.

4.1.3. Monthly information

The last feature of the visualization category has a central tendency of *probably* with 45.7% of responses. If we zoom in on age, the overall modus is *probably*, except for the age category 25-45, where it is *possibly* with 55.6%. When comparing owners with renters and when comparing males with females, all of their modus are similar and in accordance with the total sample.

4.2. Feature category 2: Notifications and reminders

Table 9 Central tendency notifications and reminders

Feature	Modus (N)
Push notifications	Probably (20)
A daily reminder	Possibly (23)

4.2.1. Push notifications

For the overall sample, the central tendency for this feature lies on *probably*, with 43.5% of the sample. Across the age categories, this modus is shared, except for 45-65 and 65+ years old age groups, where the modus is *possibly*. Interestingly, the modus for renters with the feature of push notifications lies on *possibly* (62.5%), and conversely, the modus for owners lies on *probably* (47.4%). There is also a difference between the genders, with the modus for males being *possibly* with 40% and *probably* for females with 50%.

4.2.2. Daily reminder

With the daily reminder feature, the whole sample shows a modus of *possibly* (50%). Between the age categories, this modus is shared except for the age category 15-25, with them preferring *probably* with 50%. Between renters and owners, the modus again is *possibly* for both. Moreover, between the genders, the modus is also *possibly* with 50% of the respondents of each gender selecting it.

4.3. Feature category 3: Social aspects

Table 10 Central tendency social aspects

Feature	Modus (N)
Comparison neighbors	Possibly (18)
Comparison age	Possibly (18)
Comparison friends	Possibly (19)
Communal goals	Probably not (16)
Water reduction game	Probably not (16)

4.3.1. Comparison with neighbors

The feature of the comparison with neighbors has a modus of *possibly* with 39.1% of the overall sample choosing this option. Between the age categories, this modus is shared with an exception of the 65+ age category, in which the modus is also *possibly not* and *probably* with 27.3% of respondents choosing this respectively. Renters, however, respond with a modus that indicates that it will *probably not* (37.5%) reduce their water usage, with owners conversely indicating that it *possibly* (42,1%) will reduce their water consumption. Females have a modus of *probably not*, with 38.5% of females responding as such. The males, on the other hand, indicate that it *possibly* (45%) will reduce their water usage.

4.3.2. Comparison with the age category

The overall sample has a central tendency for *possibly* (39.1%) for the feature comparison with the age category. Between the age categories, this tendency is shared except for the age category 25-45, which indicates that comparison with the age category will *probably* reduce their water consumption. Adding to this, the 15-25 group has shared a modus of *probably not*, *possibly*, and *probably*, with 33.33% of the respondents indicating this for each option. Renters, on the other hand, have a central tendency of 50% of *probably not* reducing their water consumption with this feature. Owners, on the other hand, indicate that it would *possibly* reduce

their water consumption. Males indicate that it would *probably* reduce their water consumption (35%) with females, on the other hand, selected *possibly* (46.2%).

4.3.3. Comparison with friends

The overall sample has a central tendency of *possibly* (41.3%) for the feature comparison with friends. This central tendency is shared across the age categories. Renters, on the other hand, have a shared modus of *certainly not, possibly*, and *probably* (all 25%). The owners' modus, on the other hand, is *possibly* (44.7%). Between the genders, the modus is also *possibly* (40% male, 42,3% female).

4.3.4. Communal goals

The overall central tendency of the sample for this feature is *probably not*. This tendency is shared across the age categories, with the exemption of the age group 25-45 with it being *probably* (44%) and *possibly* for the age group 45-65 (40%). Renters and owners share a central tendency of *probably not* (37.5% and 34.2%). Between the genders, the males interestingly have a tendency that communal goals will *probably* (35%) reduce their water consumption. Females, on the other hand, are more in line with the rest of the sample, with having a central tendency for *probably not* (38.5%).

4.3.5. Water reduction games

The overall central tendency shows *probably not*, with a response of 34.8%. Across the age groups, 15-25 have a tendency for *probably*, 25-45 for *probably not*, 45-65 for *possibly*, and 65+ for *definitely not*. Interestingly the majority of renters think water reduction games could *possibly* reduce their water consumption and the majority of owners think *probably not*. Males indicated *possibly* or *probably* with a shared modus for this feature, and the majority of females selected *probably not*.

4.4. Feature category 4: Recommendations and suggestions

Table 11 Central tendency recommendations and tips

Feature	Modus (N)
Action tips	Probably (20)
Positive messages	possibly, and probably (17)
Rewards	Probably not, and possibly (13)
Encouragements	Possibly (14)
Monthly meeting	Absolutely not, and probably (12)

4.4.1. Action tips

The central tendency for the overall sample for action tips is *probably* (43.5 %). A tendency which is shared across all the age categories except for the 65+ group, which has a central tendency for *possibly (*45.5%*)*. The central tendency for owner and renter is *probably*, (44,7%; 37.5%), and for genders the central tendency for males is *possibly* (35%), and *probably* for females (53.8%)

4.4.2. Positive messages

The overall central tendency for the feature of positive messages is *possibly* and *probably* (37%). Across the age groups, the 15-25 age group has a tendency for *probably*, 25-45 *possibly*, 45-65 both *possibly* and *probably*, and 65+ *possibly*. Interestingly, renters have a central tendency for *probably* (62,5%) and owners for *possibly* (42.1%). Between the genders, the males indicate *possibly* (35%) and the females *probably* (42.3%).

4.4.3. Rewards

The overall central tendency is *probably not* and *possibly* (28.3%). Across the age groups, the 15-25 age group has a tendency for *probably* (50%), 25-45 *probably not* (33.3%), 45-65 *possibly* and *probably not* (30%), and 65+ *possibly* and *definitely not* (36,4%). Interestingly renters have a central tendency for *probably* (37.5%) and owners for *probably not* (34.2%). Between the genders, the males indicate *possibly* (30%) and the females *probably not* (34.6%).

4.4.4. Encouragements

The overall central tendency for the sample is *possibly* (30.4%). Across the age groups, the 15-25 age group has a tendency for *possibly* (30.4%), 25-45 *possibly* and *probably* (33.3%), 45-65 *probably not* (55.6%), and 65+ *possibly* (36,4%). The renters have a central tendency of *probably* (37.5%) for this particular feature whereas the house owners have a tendency of *possibly* (34.2%). The male majority chooses *possibly* (35%) and the females *probably not* and *probably* (30.8%).

4.4.5. Monthly meetings

The modus of the sample is 26.1% for *definitely not* and *possibly*. There is quite some variation between the age groups. For the age group 15-25, the modus is *probably* with 50%, for the age group 25-45 *probably not* with 55.6%, 45-65 with a *definitely not* (35%), and lastly, the 65+ category has a central tendency for *possibly* with 45.5%. The majority of renters (37.5%) think monthly meetings will *probably* help reduce their water consumption, with owners being way more skeptical, with the majority (31.6%) picking *definitely not*. For the male sample, the central tendency lies in *probably not*, *possibly*, and *probably* with 25% whereas the females, on the other hand, have a central tendency for *definitely not* with 30.8%.

4.6 Findings on water-use and background

In this section, the other findings get highlighted. These findings are about the preferred features as well as the background of the respondents such as subjective and normative values as well as income and their respective water use and the applications the respondents already apply to save water.

4.6.1 Preferred features

The survey included a question where the respondents could fill in their perspectives regarding preferences on features after filling in the responses to the individual features. As can be seen in Table 12, the visualization features, action tips, and, interestingly, the comparison with the age group were preferred the most.

Table 12 Preferred features

Preferred features	Count
Monthly information about my water use (such as bar charts and trend graphs).	31
Action tips (such as turning off the tap while brushing your teeth).	20
Visualization (like a bar chart).	20
Push notifications about your current water consumption (such as how many liters you have used today and what percentage that is of your future goal).	14
The comparison of your water consumption with the people in your age group.	14
Positive messages (such as "Well done" and whether you saved so much water which translates into, for example, so much soda).	11
Setting common goals (with, for example, your neighborhood or friends).	9
The comparison of your water consumption with your friends.	9
Daily information about my water use (such as a trend chart).	9
Rewards (such as badges, achievements and points).	8
Monthly consultation with your water supplier about your water consumption.	7
Encouragements (such as “Keep going”).	6
Using water reduction games to raise awareness of water consumption.	6
The comparison of your water consumption with your neighbors.	6
A daily reminder to reduce your water consumption and achieve your water-saving goals.	5
No preference.	3

4.6.2 Respondents water-use background

The survey included two additional questions regarding water consumption and money. The first question concerns what the respondent thought they spent on their water bill in comparison with their income, and the other asked if they had ever had difficulties paying their water bill. Only one household ever had issues paying their water bill, and the majority of respondents had no clue how much they spent on the water in comparison with income.

Only half of the sample filled in a response when asked about the insight into the expected water use. The rest of the respondents noted that they had no clue what their water use was, which reinforces the idea that visualization is important as this could indicate a lack of awareness and, therefore, ability to change behavior.

Another question was asked on how important water-saving was for the respondent; the modus of this response was *fairly important* (19 respondents). When asked how important their

environment thinks saving water is, the modus was also *fairly important* (24 respondents). Therefore, normative pressures could be of influence on water-saving.

Moreover, the sample shows that they already apply a variety of water-saving tools to reduce their water usage, such as a saving shower head (20 respondents). Therefore, the ability and motivation to save water is there for the majority of respondents.

5. Discussion

This chapter goes further into the results gained from the literature review and the survey to answer the research questions and gain new insights.

5.1 Dutch households' response to the features of water-saving applications

Looking at the overall data, none of the features have a central tendency of *definitely* to change the water behavior in the current sample. However, some features, such as all three visualization features, have a strong central tendency to *probably*, which also holds for push notifications and action tips. Moreover, even though some of the features have a central tendency for *possibly* and not *probably* and *definitely*, there is still an opportunity to implement these features as some of the respondents responded better to certain features. For instance, the age group 15-25 preferred water reduction games while the rest of the sample did not. Moreover, the renters responded well to positive messages and rewards, encouragements, and monthly meetings better than the rest of the sample did. An overview of the findings can be found in Table 13.

5.2 Desired features for water-saving in Dutch households

The most desired features are insights and visualization, positive messages, and push notifications. When relating back to Fogg's behavioral model (Fogg, 2009), which explains the requirements for behavior change, including these specific features would increase users' abilities, motivations, and triggers, thereby fulfilling Fogg's requirements for behavioral change. For instance, the push notification relates to the prompt or trigger. The ability to save water is created and reinforced by the action tips. The insights of the visualization features provide motivation and incentive and would, therefore, probably contribute to a change in the user's water behavior. As the three conditions for trigger, motivation, and ability are satisfied, the target behavior of saving water should be achieved. Therefore, if a water-saving application is created, these features should be implemented in the design together in order to change the overall water-saving behavior on a household level.

When comparing the survey results with the theory of planned behavior (Ajzen, 1991), it is shown that the social aspects of the survey, which relate primarily to the subjective norms of the respondents, score *possibly* as a central tendency which is not as strong as the other features above. However, if such social features would be implemented in an application, the feedback of these features might influence the background variables in such a way that behavior will possibly change for the better.

Moreover, seeing as some features work better for certain age groups and stratifications, as seen in Table 13, certain features could still be applied to these groups to reduce water consumption via profiling. By, for example, providing water-saving games to the 15-25 age group and providing monthly meetings for renters.

Table 13 Insightful findings features

Category	Feature	Findings
Insights and visualization	Visualization (bar chart)	This feature can help reduce water consumption for the majority of households.
	Daily information (trend graph)	This feature would probably reduce the water consumption of users.
	Monthly information (bar charts and trend graphs)	This feature would probably reduce the water consumption of most users. However, it might not work so well for the age group 25-45 based on this sample.
Social aspects	Comparison with neighbors	This feature will possibly reduce water consumption but probably not for females and renters in particular, based on this sample.
	Comparison with the age group	The feature would possibly reduce water consumption. Probably even more for males and probably not for the renters based on this sample.
	Comparison with friends	This feature could possibly reduce the water consumption of the user based on the sample. However, it might work less for the 65+ age category and renters.
	Communal goals	The feature will probably not reduce water consumption for most users based on this sample, except for people aged 15-25 and 45-65, and maybe for males more than females.
	Water reduction games	The feature overall will probably not reduce water consumption, but it could be for the age group 25- 45, and it has greater potential for renters.
Notifications and reminders	Push notifications	The feature would probably reduce the water consumption of users. However, it might not work per se for the renter group based on these samples, and for the males, it might only possibly reduce their water consumption.
	Daily reminder	This feature will possibly reduce water consumption for the respective users. It might work better with individuals aged 15-25 based on this sample.
Tips and recommendations	Action tips	This feature will probably help reduce water consumption, with an overall exception for the 65+ group and the majority of the male sample, which tend more to possibly.
	Positive messages	The feature will possibly or probably reduce water consumption for the respective users.
	Rewards	This feature will probably or probably not reduce water consumption or maybe possibly for some of the samples.
	Encouragements	Based on this sample, the feature will possibly reduce water consumption for most of the sample; however, with the age groups of 45-65, probably not, it might have more of an effect on renters.
	Monthly meetings with water provider	The feature will probably not have a reduction in water consumption for most people based on this sample, with the exception of the majority of renters.

6. Conclusions

In this chapter, the answers to the research questions are summarized, recommendations for practice are given, methodological limitations are discussed, and directions for further research are provided.

6.1. Answers to the research questions

The first research question was formulated as follows*: Which features are preferred by specific characteristics of Dutch households?* The features preferred by the overall sample are all three visualization features. Push notifications of the notification and reminders category are also preferred. Lastly, in the tips and recommendations category, action tips are preferred.

The age category 15-25 has a clear preference for water-saving games; in contrast, the 65+ age group has adversity against these games. Moreover, the age categories respond differently to some of the features. For instance, the 65+ age group responded fairly negatively to tips and recommendations in comparison with the other age categories. Moreover, the 25-45 group responds more negatively than the rest of the sample for the monthly update (*possibly*), water reduction games (*probably not*), and rewards (*probably not*) while being more positive towards the features of communal goals (*probably*) and comparison of age category (*probably*).

For the category of tips and recommendations, the renter sample responded more positively to the feature than their owner counterparts. Moreover, the feature of monthly meetings had a higher score for the renter sample than the rest of the sample. This might be a more interesting feature for them. However, the renters scored less than the overall sample on the visualization bar chart feature and were also more negative about push notifications. Moreover, renters did not respond well to the majority of social aspect features in comparison with the rest of the sample. However, they are more positive about water reduction games than the overarching sample.

For females, the push notifications have a central tendency for *probably* and are therefore expected to reduce water consumption more than for the males, who have a central tendency of *possibly* for this feature. The females are more strongly against comparison with neighbors than the overarching sample, with the modus laying on *probably not* for them instead of *possibly* of the rest of the sample. Females prefer action tips more than males, and moreover, they prefer positive messages more than the overall sample. As explained in the theory of planned behavior, the background variables differ between users (Ajzen, 1991). Therefore, the features explored in this research should help influence those background variables to make the behavior change happen. However, in some groups, the combined requirements for (changing) behavior might not be fulfilled for certain features as the user might not respond well to the feature or background variable, and therefore behavior change might not occur.

The second research question was formulated as follows: *What are the desired features of a gamification platform for water-saving in Dutch households?* All the features are, to some extent, desired by the Dutch households as they address certain parts of the population positively or at least *possibly*. However, insights and visualization, positive messages, and push notifications are the most desired, followed by action tips. Moreover, for the different age groups and genders, certain features are desired more prominently than others. Therefore, such features can be applied to particular groups and not others, which can be done via profiling. However, the overall sample should be leading since households may have people with

different characteristics living under the same roof. Following the behavioral models, the results of the features influence the factors of ability, motivation, and trigger for Fogg's behavioral model positively. When these three factors are satisfied to a sufficient degree, the behavior should occur as previously mentioned in chapter 5. However, differing background variables might still halt the behavior from happening for certain households and or users following the theory of planned behavior (Ajzen, 1991).

6.2. Recommendations

For the eventual implementation of a water-saving platform, the focus should lie on getting the visualization right and including the action tips and push notifications. Moreover, implementing these features as soon as possible and starting with an opt-in method would be a worthwhile effort to start water-saving. Additionally, the features preferred by certain age groups, gender, and house situations should be more catered to and made available to them. It could be recommended even going as far as having an opt-in system for all the features depending on the user.

Other potential features were recommended by the respondents, such as environmental insight, which could further enhance water-saving, next to implementing the identified water-saving features. Implementing less technical intensive features for the elderly, such as monthly reports, that could also be sent in the mail or by letter, instead of just in the application, could be a very worthwhile endeavor.

6.3. Methodological limitations

The survey method that was adopted in this research had four overarching limitations. Firstly, the current study is bound to one specific village in the northern part of the Netherlands. One way to deal with the specifics of this limited sample is to replicate the survey on a larger scale throughout the Netherlands to improve its generalizability.

Secondly, the set-out goals of respondents to be included in the sample were higher in the age groups of 15-25 and 25-45. However, with the renter's sample, only eight respondents were included instead of the aimed twelve. Moreover, 56% of respondents were female, with the remaining 44% indicating to be male, which should both have been 50%. However, the survey respondents were very close to the set-out goals of making it representable based on the percentage of certain groups in the village of Grou. On the contrary, the choice was made to include more respondents rather than hurting the practicality and feasibility of the research (Richiardi et al., 2013). Additionally, an analysis of the education level was not performed since this was not expected to be representable as the majority of the sample (52%) completed an HBO-level education. Therefore, it could not be considered representable, as the average in the Netherlands is 25% (Maslowski, 2020).

Thirdly, the multiple-choice questions might not be able to provide a complete picture of the situation. As such, an open question was asked if there were any other comments or recommendations for features that were not covered by the survey but could be relevant.

Lastly, the survey could have gone deeper into the underlying ability (Fogg, 2009) and perceived control (Ajzen, 1991). However, I did not investigate these factors as it would require hands-on testing of the features, which was beyond the scope of this research, and testing would have to be done for each feature to see if the behavior would actually happen following Fogg's model (Fogg, 2009).

6.4. Further research

Based on the methods and results of this thesis, three future research directions are identified. Firstly, as the survey focused on a small village in the Netherlands, further research should be performed on larger sample size and more regions, both national and international. A larger sample size will be more representative of a population fand therefore provide more accurate results seeing as the population gets closer to normally distributed. Moreover, this research is only focusing on one particular village. It could be argued that the results are a bit one-sided since all these people have a common background, namely the village they live in. Secondly, several survey respondents noted the privacy concern with these gamification features. Therefore, further research can be conducted into the privacy issues of such features and their respective platforms. Lastly, gamification features require technical components such as a smart water meter and software-backed platforms. More research should be performed on how to translate these features into practical applications for households.

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Appendices

Appendix 1. Survey Design

Consent
Completing this questionnaire is entirely voluntary. You may stop filling in anytime by closing this window or program. If you have any questions regarding the questionnaire, do not hesitate to ask them at j.f.hoekstra@student.utwente.nl

Your privacy is protected in this anonymous questionnaire. We do not ask for personal details such as your name, email address, or telephone number. Your data will be used for graduation research into water-saving 'features' (resources/options) and will be deleted six months after the date or sooner at your request. By checking the option below, you give permission to participate in this research and to use your data.

Section 1: Background
In this section, we will discuss who you are and some background information.

What is your gender?
- Male
- Female
- Other

What is your highest finished level of education?
- Primary school
- Middle / high school
- MBO
- HBO
- WO bachelor
- WO Master
- PHD

What is your age category?
- 15-25
- 25-45
- 45-65
- 65+

Section 2: Living situation

Are you a renter or a homeowner?
- Renter
- Owner

Whom are you living with?
- Alone
- With partner (without kids)
- With partner and kids

- Without partner with kids
- With roommates
- Other namely:

If “kids” are selected, the following question arises:
How many kids do you live with?

If “housemates” are selected, the following question arises:
How many housemates do you have?

Section 3: Water use
In this section, we go into your water use and water-saving.

Which household appliances do you use water for?
- Shower
- Toilet
- Washing machine
- Sink
- Doing dishes with hand
- Dishwasher
- Taking a bath
- Washing clothes without machine
- Drinking
- Cooking
- Other namely:

How much water you use (estimation)?
- Slider (0-500 Liters)
- Don't know

Percentage of water use in comparison to income
- Slider (0-100%)
- Don't know

How important do you think water-saving is?
- Not important at all
- Not that important
- Fairly important
- Very important
- Extremely important

Do you already apply measures to save water?
- No
- Water-saving shower head
- Shower timer
- Reuse rainwater
- Reuse (grey) water
- Other namely:

How good with technology would you describe yourself?

- Clumsy, basic use only
- I use technology to send and receive information
- I use it for more than just basic information
- I use many different applications
- I often try new applications and applications with success.

To what extent do you think it is important to your environment that you save water?

- Not important at all
- Not that important
- Fairly important
- Very important
- Extremely important

Are you having trouble paying your water bill?

- Very often
- Often
- Sometimes
- Rarely
- Never

Section 4: Insights and visualization

- How likely would a graphical insight of your water consumption reduce your water usage?
- How likely would daily trend information on your water usage reduce your water consumption?
- How likely would a monthly report on your water consumption reduce your water consumption?

Section 5: Social aspects

- How likely would the comparison of your behavior with your neighbors reduce your water consumption?
- How likely would comparing your behavior with your age category reduce your water consumption?
- How likely would the comparison of your behavior with your friends reduce your water consumption?
- How likely would the setting of communal goals reduce your water consumption?
- How likely would the setting of community water reduction games reduce your water consumption?

Section 6: Notifications and reminders

- How likely would push notifications about your current water consumption reduce your water consumption?
- How likely would a daily reminder to save water consumption reduce your water consumption?

Section 7: Recommendations and suggestions

- How likely would daily action tips reduce your water consumption?
- How likely would positive messages reduce your water consumption?
- How likely would rewards such as badges and achievements reduce your water consumption?
- How likely would encouragement reduce your water consumption?
- How likely would monthly face-to-face meetings reduce your water consumption?

Final section

Which feature(s) do you prefer? (multiple answers possible)

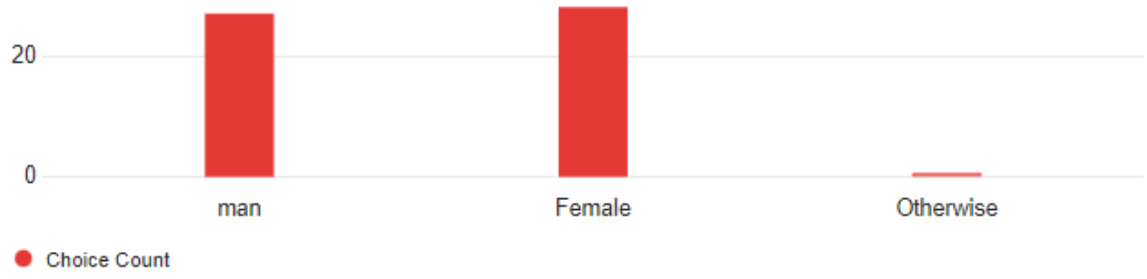
- Visualization (bar chart)
- Daily information (trend graph)
- Monthly information (bar charts and trend graphs
- Comparison neighbors
- Comparison age category
- Comparison friends
- Communal goals
- Water reduction games
- Push notifications
- Daily reminder
- Action tips
- Positive messages
- Rewards
- Encouragements
- Monthly meetings with water provider
- No preference

Are there any other comments or recommendations for features that were not covered in the survey but may be relevant to reducing your water consumption at home?

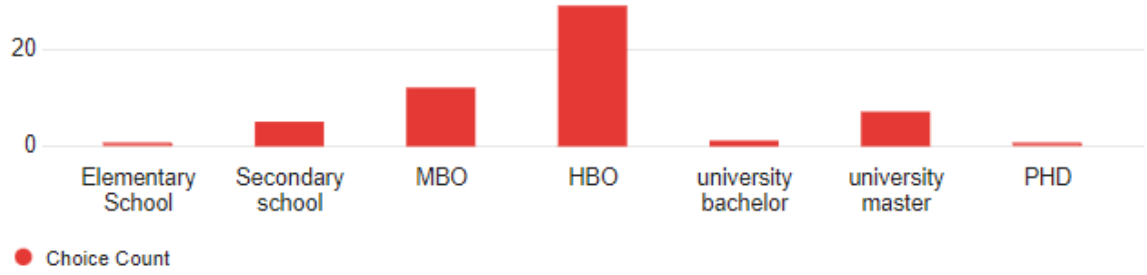
Appendix 2. Survey Responses

Section 1 Background

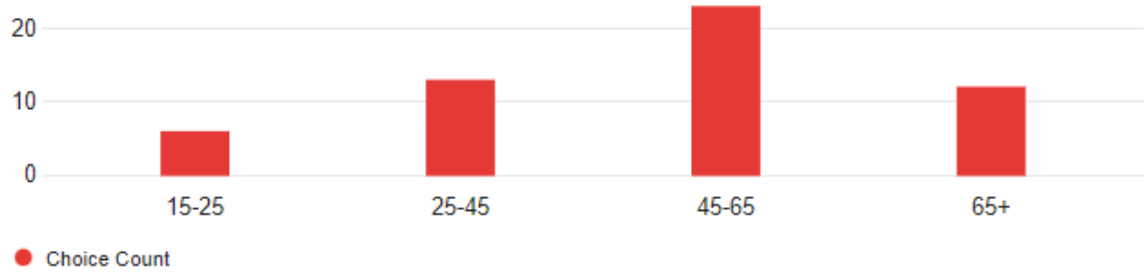
What is your gender?



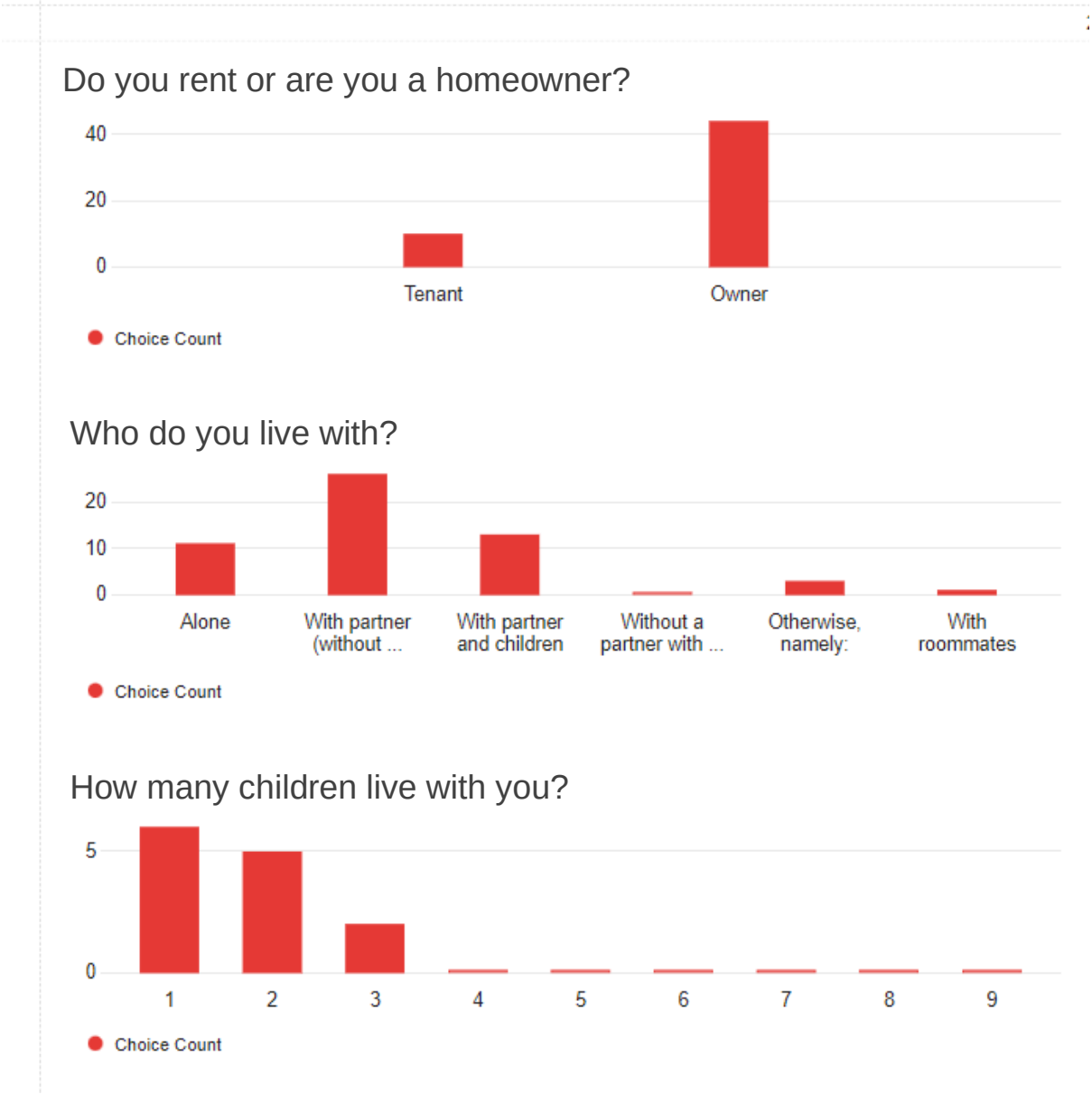
What is your highest level of education completed?



What is your age category?



Section 2 Living situation



3

How many housemates do you have?

Section 3 water use

What household appliances do you use water for? (multiple answers possible)

What do you expect to be your daily water usage in liters?

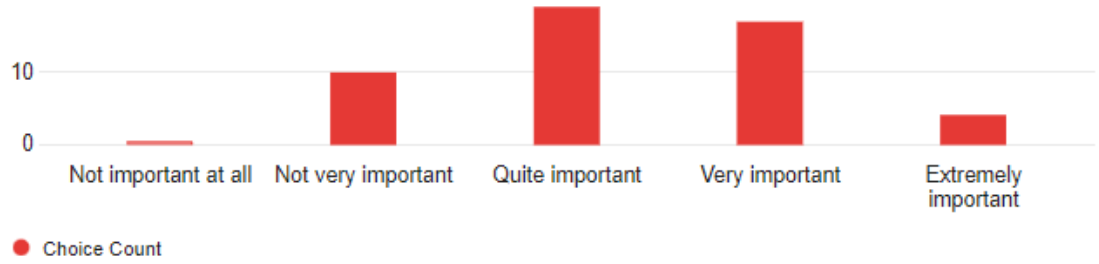
Field	Min	Max	Mean	Standard Deviation	Variance	Responses	Sum
Daily usage in litres	35.00	500.00	176.25	115.68	13382.69	24	4230.00

What is your expected percentage of income spent on water?

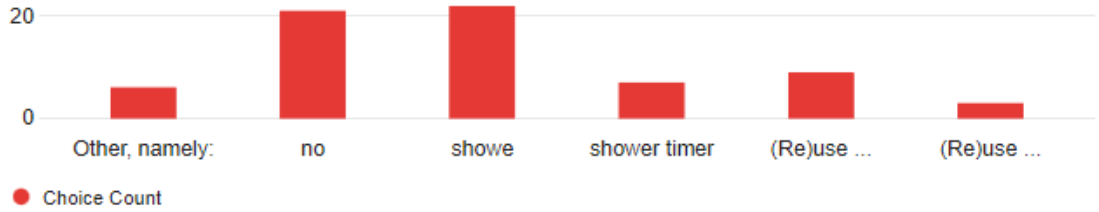
Field	Min	Max	Mean	Standard Deviation	Variance	Responses	Sum
Percentage of income water use?	0.00	15.00	4.65	4.06	16.46	26	121.00

4

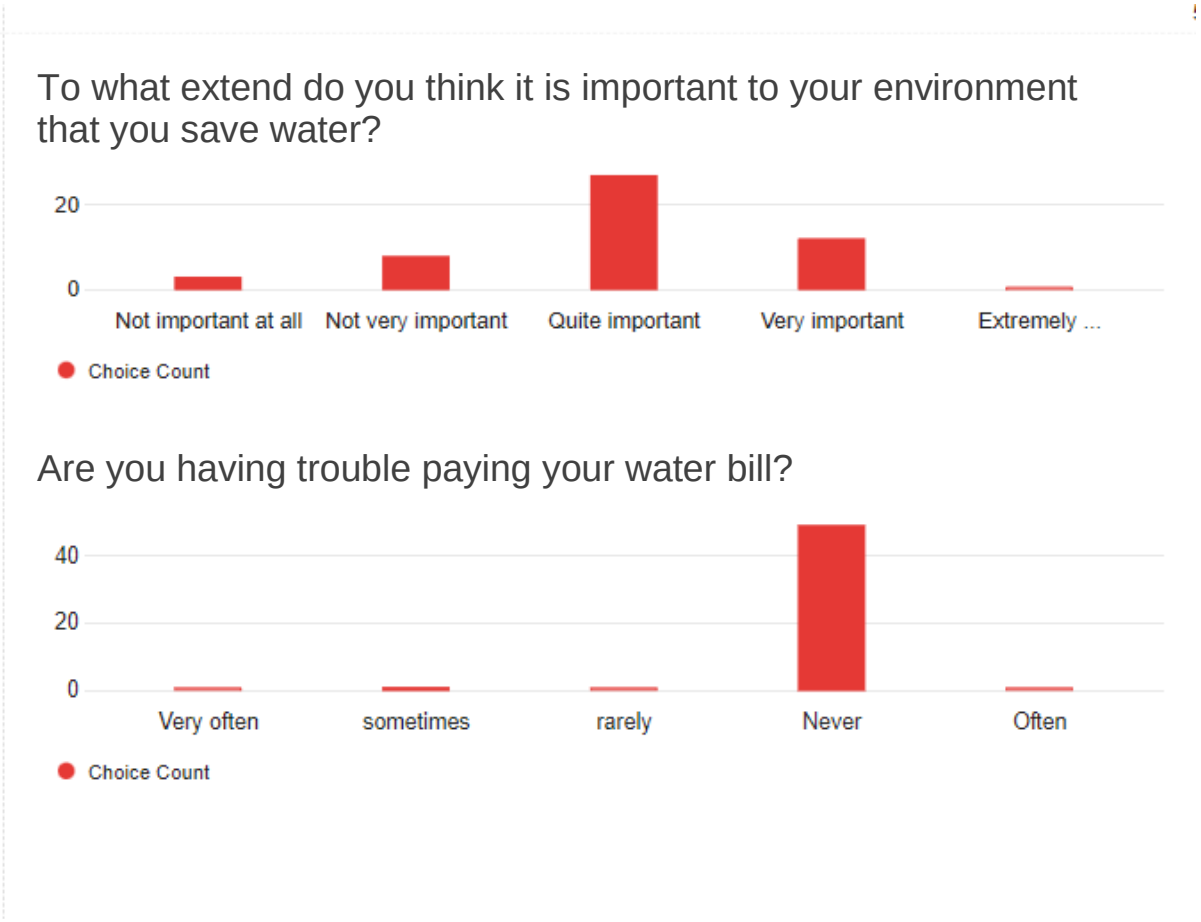
To what extent do you think water saving is important?



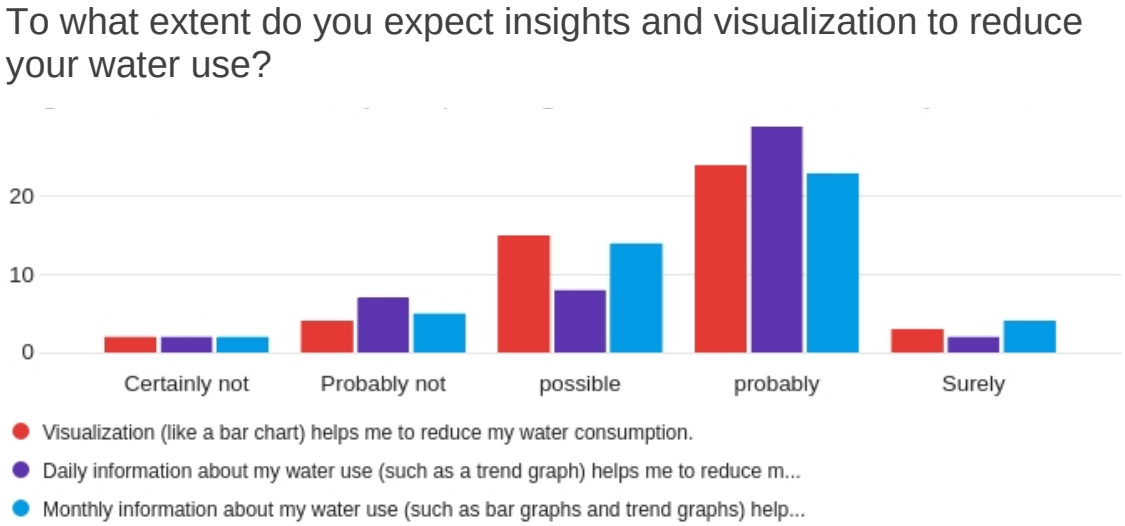
Are you already taking measures to save water?



How good with technology would you describe yourself?

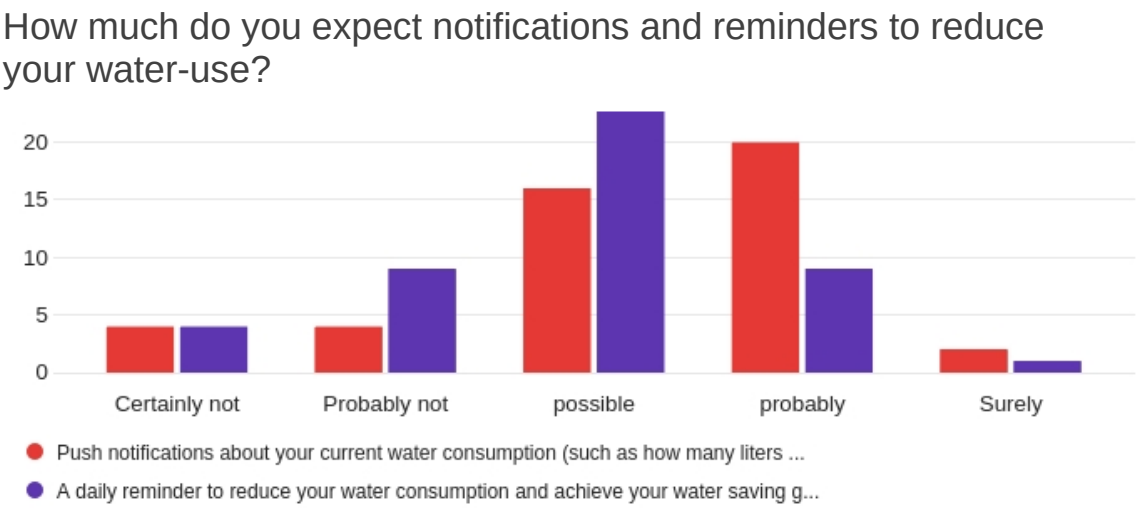


Section 4: Insights and visualization

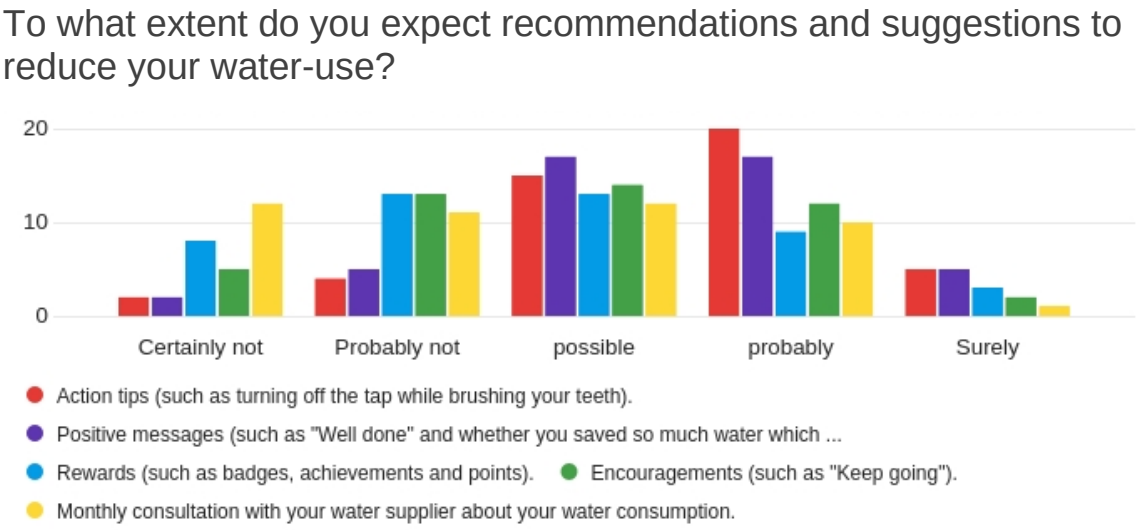


Section 5: Social aspects

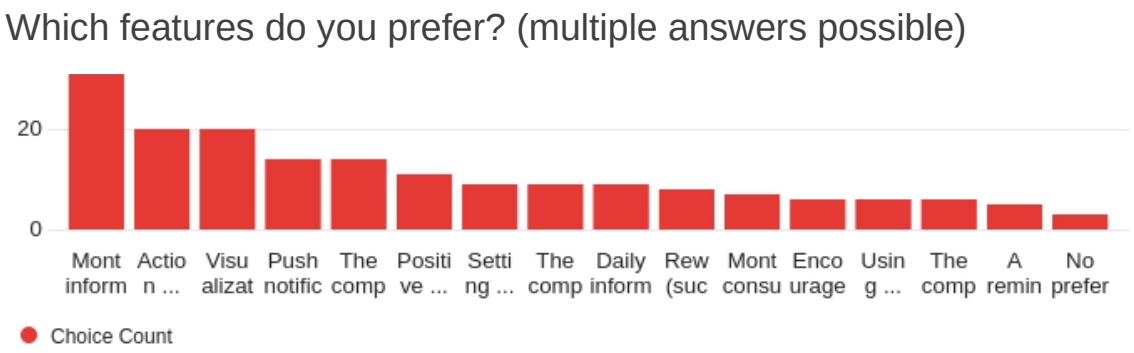
Section 6: Notifications and reminders



Section 7: Recommendations and suggestions



Final section (8)



Are there any other comments or recommendations for features that were not covered in the survey but that may be relevant to reducing your water consumption at home?
No
I have answered "(certainly) not" several times because I am already as economical as possible in all operations with water.
For example a signal after 10 minutes of showering
Better development in floor warming
Make it more expensive 😉
Find public comparisons radical with, for example, the neighbors. A national average in terms of some other consuming households relative to your own is confronting enough (if I speak for myself.
visualization of costs per day/week/month
Impact on the environment if you reduce water use