Development of an Emotional Interface for Sustainable Water Consumption in the Home

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Abstract. The design of an application to monitor, analyze and report individual water consumption within a household is introduced. An interface design incorporating just-in-time feedback, positive and negative reinforcement, ecological contextualization, and social validation is used to promote behavior change. Reducing water consumption behavior in the shower is targeted, as it is the leading source of discretionary indoor water use in a typical home. In both in-shower and out-of-shower scenarios, interface designs aim to address user needs for information, context, control, reward, and convenience to reduce water consumption.

Keywords: Emotional design, Water Conservation, Home, Shower, Sustainability.

1 Introduction

Depending on the duration and equipment used, on average, taking a shower consumes 40 to 80 liters of water per day [1]. Showering is one of the more easily controllable water consuming activities and accounts for a significant proportion of discretionary use. It is inconvenient to measure water consumption in our daily lives and it is even harder to translate it's impact on the environment. An interface to measure the amount of water consumed during a shower can significantly improve general attitudes towards sustainability. A general lack of awareness and difficulty in connecting personal consumption with consequences for the environment is an ongoing challenge. As showering is the leading source of discretionary water-usage in the home, designs are presented that adopt a user centered approach to providing real-time feedback of water consumed in the shower.

2 Emotional Design

Traditionally, advertising campaigns designed to persuade and modify consumption behavior have been the vehicle by which conservation policy is enacted. As Aronson

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discovered, while such an approach can produce attitude change, the effect is frequently short-lived [2]. It is also known that while messages praising the value of water conservation succeed in changing people's attitudes, they do not translate into new behaviors [3]. Social psychologists have long been aware that the link between attitudes and behavior is problematic [4]. Simple communication of conservation policy does not guarantee reduced consumption. Flemming emphasizes not only the importance of real-time feedback, but the method by which feedback is provided [5]. Careful consideration for user emotions in the feedback provided is needed to influence user action.

In the case of showering, solutions must inform users of the volume of water used in a manner that persuades reduced consumption. An example of designing with emotion is WaterBot [6]. WaterBot is a device attached to household faucets that promotes water conservation. Using simple visual and auditory reminders, WaterBot rewards users for turning off the tap where possible.

Donald Norman describes emotional design as "a framework for analyzing products in a holistic way to include their attractiveness, their behavior, and the image they present to the user - and of the owner" [7]. According to Norman, product design should address three different levels of cognitive and emotional processing: visceral, behavioral, and reflective. Emotional design is about "designing for affect - that is, eliciting the appropriate psychological or emotional response for a particular context - rather than for aesthetics alone" [8]. Using emotions as a primary driver of design considerations requires a greater focus on user needs, desires and emotions.

3 Design Process

3.1 User Needs Gathering

An ethnographic approach was employed to gather information about the perceptions and behaviors people have towards water usage and conservation. Using open-ended questions around such aspects as daily showering experience, perception of consumption habits, means to improve consumption, and reactions to over consumption by members of the household was collected. Although quantitative conclusions cannot be drawn from this line of enquiry, qualitative insights into how people perceive water conservation in the shower was collected. Typically, it is assumed that how an individual behaves is a function of their knowledge and perceptions, which in turn are directly motivated by their underlying needs. To inform design requirements and leverage user emotions, an understanding of user needs motivations is necessary. As it pertains to conserving water in the shower, and satisfy user needs, it is important to support a link between individual water consumption and environmental consequences. The following represents different user needs:

1. **Information.** At present, conventional shower systems in the home do not have the required mechanisms to provide feedback about an individual's water usage, in a given instance or over time.
2. **Context.** A disconnect exists between water usage in the home and the impact on the environment.
3. **Control.** Individuals desire the freedom to choose shower settings and usage targets, and would not enjoy following a prescribed solution.
4. **Reward.** Individuals may not always make choices for a greater good, and look for incentives linked to personal values to influence behavior change.
5. **Convenience.** Showering is commonly seen as a cleansing and satisfying experience; any technology introduced into the shower should enhance, not encumber the experience.

In addition, past studies on energy conservation have also shown that feedback of aggregated energy use often does little to motivate conservation over the short term [9]. In order to be effective, information feedback must be presented in combination with some other encouragements to modify behavior such as to spur competition, set a goal, or obtain commitment from the consumer [9]. Applying this understanding to the problem of water conservation in the shower requires designs to incorporate the following elements:

- Encourage friendly competition towards a shared objective to reduce discretionary water usage
- Support individual and communal goal setting
- Promote participating individuals to want to conserve water

3.2 User Needs Scenarios

Through informal interviews and group discussions with users, five underlying user needs pertaining to showering and water conservation were identified. These needs informed the development of use-case scenarios and specific interaction schemes. The scenarios are as follows:

User Need for Information (Individual Consumption & Real-Time Feedback). Designs must provide users with quantitative metrics about their water consumption behavior. The following represents a summary of individual information needs:

- Monitor and report consumption metrics such as time spent, and volume consumed (which is affected by the water-flow rate) in real-time;
- Maintain an audit trail of the amount of water consumed and saved relative to a desired goal
- Understand water usage trends over differing periods of time such as time-of-day, weekly, monthly, and seasonal differences, etc.

User Need for Context (Relative Consumption and Associated Costs). Users must be able to connect reduction in water usage to a quantifiable benefit and avoid acting in isolation. Users see greater contextual awareness as a means to form meaningful relationships with others and achieve a sense of fulfillment. Greater contextual awareness therefore helps users:

- Understand the cause and effect of incremental water usage
- Identify the sources of high water consumption to allow for targeted or incremental adjustments
- Learn about personal water consumption using relevant but non-traditional metrics such as economic costs and ecological impact
- Achieve a broad perspective by placing and comparing personal consumption with family and community
- Engage in shared experiences with others toward a common goal

User Need for Control (Control Over Settings and Usage Targets). Users indicated a need to decide how their values affected their actions, whether it be for water conservation or otherwise. The user need for control can be represented through scenarios that speak to the ability for individuals to:

- Maintain control over their shower settings, such as flow rate, temperature, and duration
- Relative to a goal, set acceptable upper and lower limits for water flow

User Need: Reward (Behavior-Modifying Incentives). Users expressed a need to reward good behavior while dissuading wasteful action. An individual's values alone may not be enough to produce lasting change. It is therefore desirable to reward and punish users based on the amount of water they conserve or waste. To satisfy the user need for rewards, the interface must allow individuals to:

- Earn and lose valued incentives in relation to acts of consumption
- Educate users about water conservation using meaningful metaphors

User Need for Convenience (Unencumbered Showering Experience). Individual perceptions of showering range from it being an unavoidable necessity to an enjoyable luxury; in attempting to promote water conservation, the design must avoid inconvenient interactions. To create a convenient user experience, users need to:

- Relate information in a way as avoid significant interaction in the shower
- Minimize unnecessary time in the shower

3.3 Design Requirements

Careful consideration of user needs resulted in a basic set of requirements that were used to inform design alternatives. User needs and their corresponding design requirements are captured in Table 1.

Table 1. Determined design requirements necessary for satisfying different user needs towards achieving water conservation in the shower

User Need	Scenarios	Design Requirements
Information	Monitor their showers using relevant metrics such as time spent, and volume consumed in real-time	Real-time graphical display of elapsed showering time and total water consumed
	Learn how much water is being saved or over-utilized relative to a desired amount	Graphical display that emphasizes the magnitude of water consumed, over or under a relative goal
	Understand water usage trends over differing periods of times such as time-of-day, weekly, monthly, and seasonal differences, etc.	Graphical display comparing usage trends of water consumed/saved over differing spans of time
Context	Understand the cause and effect of incremental water usage	Use a representative metaphor to demonstrate the value in saving the natural environment
	Identify the sources of highest consumption to allow for targeted or incremental adjustments	Allow for respective users to be uniquely identified and provide tailored tips and reminders during the shower, in real-time, to allow the user to modify their behavior
	See the bigger picture, in terms of consumption relative to their household and community	Visually differentiate water consumption at the household and community levels
Control	Maintain control over their shower settings, such as flow rate, temperature, and duration	Allow water settings to be user-controlled rather than automated by the system
	Set their own acceptable upper and lower tolerances for shower settings, relative to a goal	Facilitate users to create their own action plans for water reduction, over a chosen period of time; incremental goal setting via system administration
Reward	Earn or lose user-valued incentives according to their water usage; reinforce positive behavior with rewards and admonish negative behavior with disincentives	Create a sense of urgency in the user by rewarding (earn) or punishing (lose), based on the duration of their shower relative to a stated goal; these changes should be able to be represented in the system metaphor
Convenience	Relate information in such a way as to not require significant interactions while in the shower	Minimize or remove user contact and allow for system administration to be carried out in a non-shower context such as on a computer or mobile device

4 Prototype

Iterative scenario-based design sessions, followed by rapid development of prototype designs yielded several designs. Where in-shower scenarios take place, as part of the functioning of the system, the use of an LCD display in the shower is envisioned while the out-of-shower scenario to administer the system would be facilitated through a computer interface outside the shower**.** Fig. 1. shows the various user-flows in the designed system for both in-shower and out-of-shower scenarios. The light-gray boxes under the left-hand column represent the various screens that a user would encounter within in-shower scenarios.

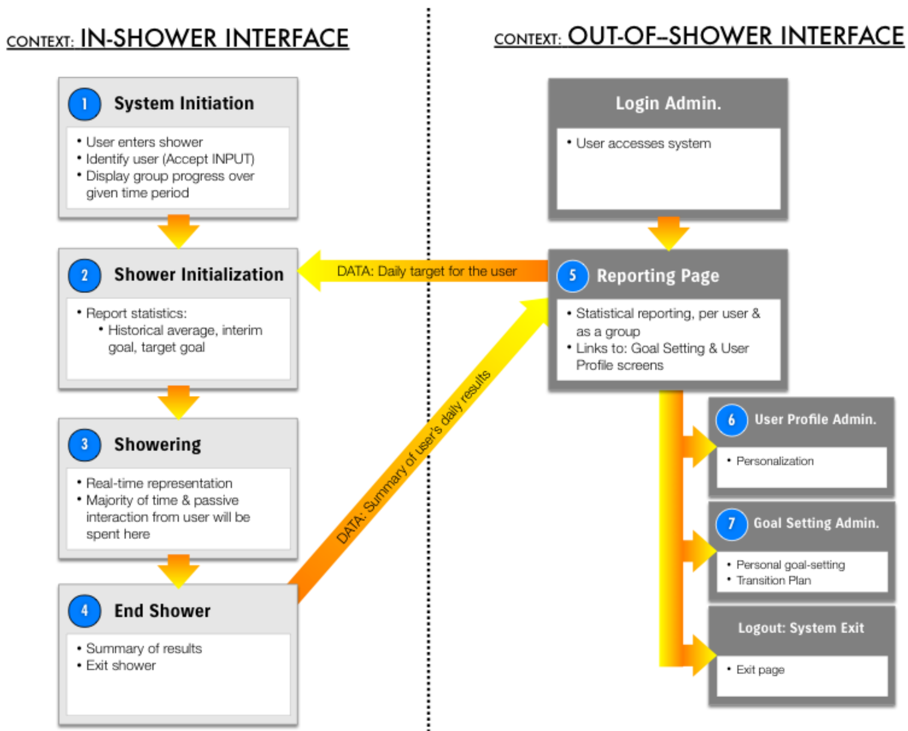

Fig. 1. Interaction scenarios. The light-gray boxes under the left-hand column represent the various screens that a user would encounter within in-shower scenarios. Dark-gray boxes under the right-hand column represent the various back-end screens a user would review in the out-of-shower context.

The following interface design shows the initial screen presented to a user upon entering the shower. As displayed in Fig. 2., users select their profile button to identify themselves and initiate tracking. Users can view the family's progress-to-date, as represented by a 'pond' ecosystem. Individual users and their creatures are differentiated by color.

Fig. 2. This initial screen is presented to a user upon entering the shower. The interface includes system initiation buttons for each user. The user with the highest liters saved, and therefore greatest diversity, is placed on top. The also interface represents a virtual 'pond' ecosystem showing total volume of water collected from all four users and all creatures earned by the household. On the right, a comparative progress bar captures the number of milestones achieved by each user. Upcoming milestones are shown as a 'treasure chest' that can be 'unlocked' as users increase the amount of water saved. The interface displays the volume of water saved and the length of time since the creation of the ecosystem.

Following initialization, and when showering begins, the interface in Fig. 3. is presented. This interface allows the user to monitor real-time water usage & shower duration. To provide added context to information presented, all data is shown relative to targets. Also, a pipe-and-valve metaphor is used to show connectivity to various family members and their respective water-reserves.

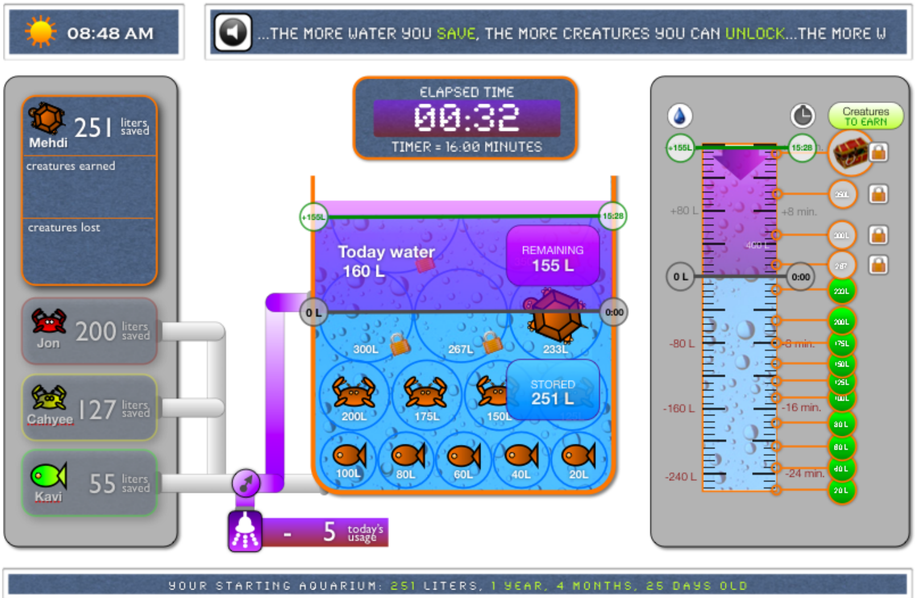

Fig. 3. This screen is displayed while showering to provide real-time feedback on water usage and shower duration. For added context, data is shown in relation to tracked targets. This interface includes a shower summary section to display the number and species of creatures earned and lost over the course of a shower. A central vessel shows the user's personal aquarium. The purple-colored water, above the "0 L/0:00" guidepost represents the user's allotted water for daily showers. The blue-colored water displays the level of water conserved. Creatures are shown in separate 'bubbles' to convey their individual water requirements. 'Locked' items allude to the potential for users to earn creature using a increasing amounts of liters conserved. A pipe-and-valve representation, connected to a shower-head, shows the water source (by color) and the source of water withdrawal.

Statistics on all family members are collected by the system and is accessible to members of the household outside of the shower. Fig. 4. shows one of three system functions available to users in the out-of-shower scenario. The reporting functionality allows users to compare usage statistics for different users, and reflects areas of improvement, individually and collectively.

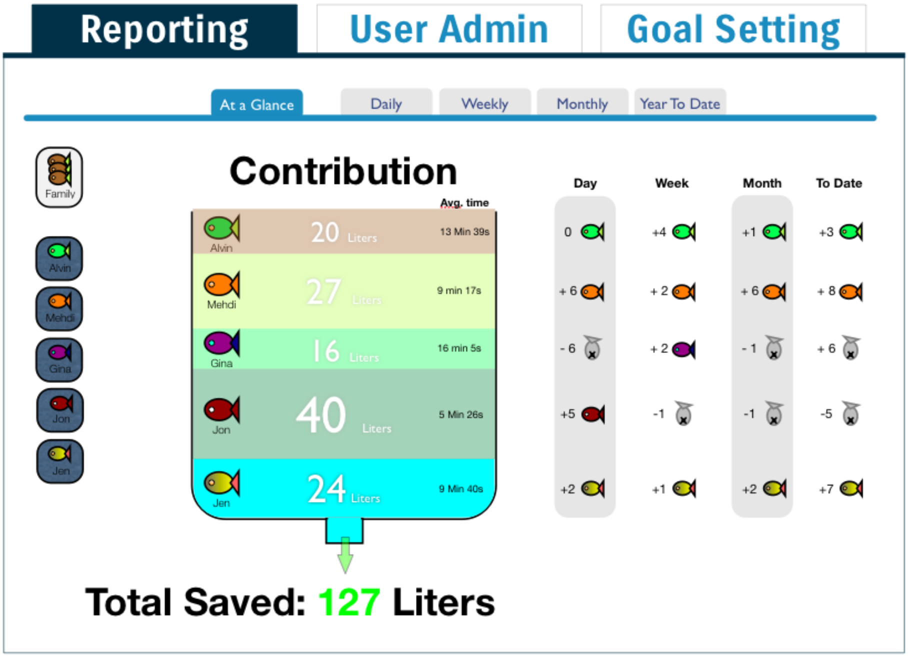

Fig. 4. This is one of the three system functions that a user is able to select by using the out-of-shower interface. The reporting functionality allows users to view and compare usage statistics among users. Features of this screen include tabs for global navigation in the out-of-shower interface. Available data views include: At a Glance (currently shown), Daily, Weekly, Monthly and Year-To-Date summaries. The interface also captures each user's relative contribution to the communal pool of water. The system also displays each user's average showering time, the total volume of water saved and the count of creatures earned/lost over different
periods of time.

5 Conclusion

5.1 Extending beyond the Shower

Such an approach to water conservation can be applied to various domains. Where detailed reporting is available, ecologically representative metaphors can be extended to include all water management systems. The use of such an approach will be plausible as technology in the home converges to integrate toilets, faucets, dishwashers, laundry machines, etc.. Such an approach to water conservation can also be applied to other resources such as electricity and carbon based fuels.

5.2 Further Investigation

Goal Setting. Consideration for user's perception of collective efforts and their view of the fairness where goal setting is concerned was noted. Irresponsiveness to improvement is of primary concern as it can dissuade the collective from active participation. Understanding drivers for user engagement will allow for more personalized designs to cater to individualized incentives.

Complexity. Much discussion was devoted to representing all phases of water management process including replenishment phases of the life-cycle. Further inquiry would be needed to assess user's reactions to a metaphor that conveys the total effort required to purify and process water (including procurement, processing, use, reprocessing, and re-introduction back into nature). Although adding aspects of realism would, on the one hand, increase transparency and promote understanding, it would conversely add layers of complexity to the metaphor and may diminish the simple intent of the system.

Maintainicng User Engagement over the Long-Term. As user interacts with the interface over a long period of time, the question becomes how to make the interface engaging and scalable in order to maintain user interest and engagement. The concept of indefinite growth was discussed as a possible solution, using scalable ecosystems (i.e. lakes, seas, oceans), but more thought needs to be put into understanding how these interactions might occur. A deeper level of understanding is required.

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