Personal Water Consumption An Interactive Art Installation

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Abstract
Lack of water is a global crisis that many unfortunately do not pay enough attention to. Limited or no access to fresh drinking water is a severe health concern and humanitarian crisis, causing disease and illness in many countries. As climate concerns grow more and more extreme, Earth's water becomes more scarce, polluted, and unreliable. The goal of this art installation is to raise awareness of how individuals' personal consumption of water affects the current global climate crisis through an engaging and interactive experience. This installation will work to make users question, 'how can I make small improvements in my life to waste less water?', and 'what else causes extreme water wastage through its production and usage?'.

Related Work
For our project, we were interested in the impacts that Human Computer Interaction (HCI) can have on the current global climate crisis. Based on scientific research in many areas of global warming, climatologists have stated that changing human energy-consumption behaviours will be the most effective, and now maybe the only possible, solution to combating the effects of climate change on the globe [1]. Psychological studies suggest there are many barriers that limit the change of these behaviours, such as access to information, feedback on behaviour, and social motives, all of which are difficult to begin to break down [1]. This is where research on Human Computer Interaction and its effect on climate communication comes in. To change people's perspectives on climate change, the areas of: conveying information to different audiences, utilising

digital media to highlight complex topics, and the presentation of messaging are all critical to consider [3]. We decided to explore this more with the idea of physicalizing climate data to allow users to engage and interact with it, with the goal of invoking critical thought into how users' daily lives affect the climate and world around them.

The first interactive work we investigated was “Illuminate” from the University of Waterloo. “Illuminate” is an interactive public art installation aimed at family audiences with the goal of providing hope for a future with climate change. As a part of the ALARM exhibition at The MUSEUM in Kitchener, Ontario, “Illuminate” is designed to display current and future steps towards fulfilling the Paris Agreement. The display utilises a visual game interface that features coastal, rural, and urban Canadian landscapes, and changes based on different adaptations (ie. solar panels, building regulations, etc.). To capture and maintain the interest of museum-goers, the game display is kept to short loops on a handheld tablet. The attention grabbing qualities and interactivity of the gamification is an aspect of this particular work that we hope to incorporate into our own installation. As a whole, it is meant to educate users, create an artefact for research, and be a scalable product to be used in multiple locations.

Another work we decided to draw inspiration from is an interactive installation for environmental education on climate change in Antarctica, “The Vanishing Antarctic Continent”. This piece from the Department of Product Design at the Central South University in Changsha, China is created using Processing and Arduino microcontrollers. The work utilises temperature sensors and the mp3 Arduino module to simulate climate and seawater rise in Antarctica. Users can place their hands on the installation box, and watch as the temperature of their palms simulates the heat of the Earth. The longer the heat source is on the box, the darker the visual display of the continent will appear, and the louder the mp3 player will simulate the sounds of the sea level rising. When their hands are removed, the interface will brighten and display the future effects this level of heat will cause on the continent, allowing users to visually see consequences of climate change on the Antarctic continent. This work allows the user to feel like they are a part of the experience, and see a result from their interactive contributions. This quality provides the piece with meaning to each participant, and is an aspect we want to highlight within our own work. The installation is designed to strengthen the impact of the scientific data on the users and raise environmental awareness. The combination of audio and visual outputs work to immerse the viewer and leave a lasting impact on the participants.

These two installations work to engage and interact with users about climate data, however neither speak directly to the user’s contribution or impact on climate change. We believe this to be a gap that our installation will solve. By having users interact with data that reflects their own every day actions, the information about water wastage will be all the more impactful.

Design Concept and Problem Statement

Despite being 97% water, only 3% of the Earth’s water supply is freshwater, and of that only 0.5% is accessible to us [8]. Additionally, approximately 2 million individuals world-wide do not have access to clean and safe drinking water. This water crisis calls attention to the ways locations like North America overuse and waste our supply of freshwater. According to the Washington State Department of Health, the average person wastes 30 gallons of water every day, with approximately 580 billion litres of water being wasted in 2022 in Canada alone.

One of the main problems looking to be tackled in the area of climate change with Human Computer Interaction is the lack of access to correct information about these issues. Many are not confronted with impacts of climate change on a daily basis, and thus do not think about their own impact on the global issue. The average individual living in a developed country does not regularly consider the water wastage and implications of their day-to-day actions. In addition to not thinking about basic things like turning off the tap while brushing your teeth, many also are uninformed about the volume of water required to produce many common products, for example fast fashion clothing and farming livestock.

The user experience that is required to help combat this issue is educational. The information about one's own personal water consumption needs to be accessible, clear, and communicative about what larger problems it is fuelling. To convey this information, the installation will calculate and approximate water consumption of the individual user, similarly to the methodology presented by watercalculator.org. It will then scale down and physicalize this data by dispensing the calculated volume of water into a small container.

A typical use case may look like this:

- The user approaches the installation and is presented with different representational objects. Descriptions and relevant information is provided.
- The user is then prompted to place different objects onto the sensor pedestal, selected based on their own daily activities and behaviours.
- Once they are finished placing objects, they can take a cup and allow the installation to dispense the water used corresponding to their own lifestyle.

User Characterization

The project's target audience is undergraduate students and young adults, specifically in areas with easy access to clean water and high water wastage. This could include individuals from ages 15 - 30, any gender, little to no education on environmental science, and most importantly the experience of having lived predominantly in a water accessible location. The goal is to target those with the responsibility to understand growing global issues that will have a substantial impact on the future, and the ability to implement a change. This installation does not target individuals who currently suffer from a lack of basic necessities, as the installation assumes that the user has a house with utilities and potential access to luxuries such as travel. We will test our installation on the undergraduates of Queen's University through a project display and presentation, allow students to interact with the device, and discuss with them their own interpretations of the work, the output, and gain feedback to improve the piece.

User Scenarios

There are a few different scenarios we envision this installation will be useful. Since the primary focus and target group is undergraduate students present at university, our first scenario would be at a space similar to the Creative Computing Showcase. In this space, the installation would be set up at a booth where users can come and go as they please. Users could interact with the installation as a group or as an individual. One of our group members would be overseeing the installation to make sure users don't break or harm the different components. Each interaction wouldn't take more than 5 minutes. We believe this is the ideal situation for the installation to thrive. The reason for this is because this is where we can target users who we may not be able to target if the installation was set up within an art expedition or otherwise. The flow of the scenario would look like this:

- Step 1: The installation is set up at the booth, allowing the users to pace by or interact.

- Step 2: Upon approach, Users can ask questions to us about the details of the project including instructions on how to use the prototype or about the assembly of the hardware.
- Step 3: Users proceed to focus on the prototype using different items to interact.
- Step 4: Once the user has had enough they can carry on with what they are doing.

The other scenario that we can envision is for it to be installed within a more structured environment where it can be used without supervision. This is the goal of the project since the user interaction should be intuitive. This kind of space could be a small art exhibit. Or in an educational institution. In this space we might not target our primary user group, but at the benefit of bringing users that have real intent to use the design. In this space, it would our designs in a public environment while reaching a broader audience. The flow would be similar to scenario 1 without step 2:

- Step 1: The installation is set up at the booth, allowing the users to pace by or interact.
- Step 3: Users proceed to focus on the prototype using different items to interact.
- Step 4: Once the user has had enough they can carry on with what they are doing.

Design

Over the course of the semester, the design of our project has changed and shifted to fit the feedback of our peers and the needs/wants of the project.

The initial design of our interface (see Figure 2) was meant to reflect on the personal environment of our target demographic as well as artistically conceal the functional hardware. We decided a clever way to meld these two components, as well as integrate the necessary items (items to represent different daily uses of water, ie. bathing instead of showering, consuming meat, frequently shopping for new clothes, etc.) for our user interaction and sensor, was to mimic a city, playing to the idea of mimetic art while also incorporating the main educational aspect. This is what we accomplished with our low fidelity prototype. We incorporated the items by placing them among the related buildings in the sculpture, ie. the food products by the grocery store and vehicles parked outside an apartment building. Many of these design ideas made their way from the low fidelity prototype into the final design.

The final design of our user interface consists of two main sections, the functional hardware and artistic sculpture. To create a more cohesive theme, we drew inspirations from the colourful houses in Nova Scotia, and created a city with a Georgian-style architecture. The colourful buildings and lighthouse cover all the internal hardware components, while being aesthetically pleasing and inviting for users to engage with. The materials used included different craft supplies such as paper, popsicle sticks, and other recyclable supplies. Recyclable materials were intentionally chosen to be waste-conscious and to fit our theme of environmental awareness. Additionally, our final prototype utilised RFID sensors to facilitate our desired user interaction. A slight change was made to where the water was dispensed to, from our low-fi model to the final hi-fi. In the final prototype, water is dispensed into a small tube marked with green, yellow, and red level indicators. These levels were also calculated from our used data set and serve to quickly indicate to users the level of their water consumption at a glance.

Compared to our initial proposal, our final product is quite similar in user interaction, however underwent refinement in artistic style and technical components. The main technical accomplishment we had as a group was the ability for us to safely hide all the hardware within the installation, hiding it from the site of the user.

Prototype Development

Our installation utilises multiple forms of interaction. It is designed to allow users to select and place items from the sculpture onto a sensor, and pour themselves a vial of water which is scaled down to represent their daily water usage. The system utilises multiple pieces of hardware, Listed in Figure 6:

- Arduino Set with an Arduino Uno microcontroller and accessories (such as a Breadboard, Jumper Cables, battery adapter, etc.)
- Peristaltic Water Pump (12V)
- AC/DC Power Supply Adapter (12V)
- Relay Module (5V)
- RFID Reader Module
- RFID Tags

All electrical components of the installation use low voltages, such as 5V and 12V, which are safe to operate. The 5V voltage is intended to power the Arduino controller and the RFID sensor. 12V is intended to power the pump. The Relay module uses both voltages. The electrical connection of the installation components is made through a Breadboard. To obtain a 5V supply voltage, 4 AA batteries are used, connected via an adapter. To obtain a voltage of 12V, an AC/DC adapter is used, which converts the power from the electrical network to the required voltage. Users will be completely protected from contact with the electrical components, as a non-contact RFID sensor is used and direct contact with components that conduct electricity does not occur. The only component in which water and electricity are present is the water pump, the manufacturer of which promises safety under proper operating conditions, which we are following closely.

For the software development part of the project, we are using the Arduino IDE to create software that automates the operation of the microcontroller, using a variant of the C++ programming language.

The goal of this system is to allow users to interact with their daily water usage in a new way. The installation allows users to move objects that correspond with different preset data sets that a microcontroller uses to calculate and physicalize (via a peristaltic water pump) the user's estimated daily water usage. To estimate this calculation, we conducted tests with our water pump to measure its rate of water flow. This information is used by the Arduino to determine how long the water should be pumped in order to output the correct amount. The preset data was adapted from the Water Footprint Calculator [5].

The main aspect of our interaction is the placement of items by the user. We chose this form of interaction as it allows the user to physically feel connected with their impacts on the water crisis, and additionally is an engaging and thought-provoking process. We decided to use an RFID sensor and tokens for our interaction. To utilise the RFID sensor, the SoftwareSerial library for Arduino is used. We settled on using the RFID technology as we determined the results would be more consistent and reliable than our initial design of using a Python library to detect dominant colours through an additional camera.

During the development of the hardware part of the project, some components were replaced with more suitable ones, such as: The RC522 RFID module was replaced with the RDM6300 module due to the fact that the RDM6300 has a remote antenna, which is more convenient for our project. Also, the RFID tags have been replaced, since the RDM6300 module operates at 125 KHz, while the RC522 module operates at 13.56 MHz. Thus, the final hardware composition of the project includes: Arduino Uno Microcontroller, RDM6300

RFID module, Arduino-compatible 5V relay, 12V DC Peristaltic Water Pump, 12V Power Supply adapter, vinyl tubing, Arduino breadboard, and jumper wires. The logic of the program written for the Arduino microcontroller is that when an RFID tag is brought to the RFID sensor's antenna, its unique ID is read, then a signal is generated on the relay, which closes the pump's power circuit for a duration associated with that tag's ID. The program also prevents the user from scanning the same tag multiple times in a row. As a basis for working with the RDM6300 module, code fragments from a microcontroller tutorial website [14] were used. To control the relay, standard Arduino API methods were used to control signal outputs.

The implementation of each component went smoothly without many bugs or flaws in the system. In fact, we were surprised when we tested the final prototype's RFID sensor. The range was much larger than anticipated and allowed us to hide it within the final product. The pump wasn't as powerful as we were expecting; this ended up being a small limitation. We remedied this by changing the container that the water is held in (Figure 5).

User Evaluation

The method we used to collect user evaluation was very similar to how we collected data with our low-fidelity prototype. We tested the final design on the same people who tested the low-fidelity prototype, so they had an idea of what they were coming into, but the process remained as follows.

- The user is put in front of the installation (see Figure 4) without any instruction and asked for their first impressions.
- After first impressions, the user is explained the instructions of the installation and prompted to experiment with moving the different items, detailing their thought process.
- With guidance, the user is run through what the envisioned typical use case is for the installation and is prompted to raise any concerns they may have with their experience.

Most of the feedback we received was positive. Some of the concerns from the low-fidelity prototype were fixed although some still remained, particularly these two:

- User becomes lost when first approaching the installation. It becomes difficult to understand where to start and how to interact with the design.
- Some users were not sure what the purpose of the design was. What was the message we were trying to convey?

We were able to fix some of the feedback issues that we were having with the low fidelity prototype as well as make the prototype more eye-catching. The problem that still remains is that it isn't always intuitive to use. Through narrowing the process, the average use case will be a lot easier to follow and in turn we believe this increases the potency of the message.

A simple fix we were able to make from these recommendations was to have a written indicator of where the RFID sensor was within the installation. We found that a simple 'Scan Me' message piqued the users' curiosity to pick up the labelled objects and tap them to the scanner, even if they were not 100% sure what would occur. After tapping some items and watching the water dispense, most of the users gained a deeper understanding about the message of the installation.

There's a couple things that could happen when the user does something unexpected. For instance, to prevent simultaneous scanning of the same object. The installation is programmed to only scan an item once before requiring a different object to be scanned. When the user wants to scan the same object multiple times, nothing will happen. The range of interactions the user can take is restricted, but allows for many different combinations. The prototype incorporates the user experience goals by using water as our means of output correlating water consumption by using the resource. The most interesting part to the user was the interaction of the wireless RFID cards. One of them said it was similar to checking out with a credit card!

Discussion & Reflection

Limitations:

The project ended up being limited by the amount of power the pump could dispense and in the materials we had access to. If we had access to supplies on a larger scale we believe that the impact would be greater. If we were to do this project again, we would want to focus on the relation between interaction and the message we want to convey more. We feel as though while the interaction presented in our final prototype is novel and fun, it doesn’t correlate to the awareness of water consumption as much as we had wanted. If there is a type of interaction that correlates towards bringing awareness, perhaps a type of interaction with social media, it could even further create awareness.

Future Work:
As we move into the future, it’s important to understand the benefits we have when living in a developed country. It is human nature to take things for granted, but it is important to reflect on our actions and what we have access to, such as clean freshwater. The practical use of our design is small, perhaps it could be repurposed into an irrigation system or a ticketed water station, but the purpose is what we wanted to focus on.

Conclusion:

After finishing up the final prototype, we reflected on the design that we have been working on throughout the semester. The work we did on the initial proposal mimics the final project but has also changed in so many ways. We made it easier to understand while increasing its artistic aspects to make it eye-catching as an installation. If we were to relay a lesson learned to other designers and engineers, it would be to learn from user feedback and mistakes made along the way, and work through many drafts and iterations.

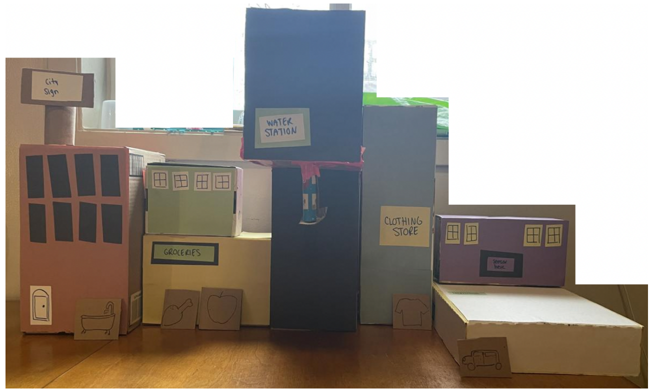

Figure 1: Low-Fi model

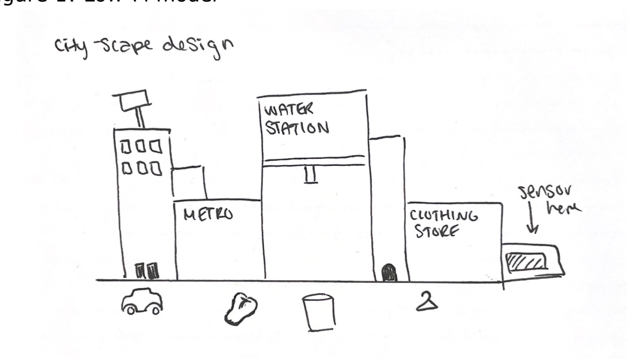

Figure 2: Preliminary sketch

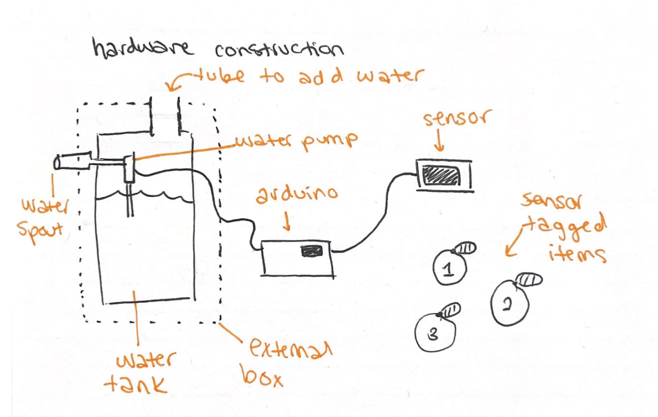

Figure 3: Preliminary sketch of proposed circuitry

Figure 4: Hi-Fi model

Figure 5: Output Vial

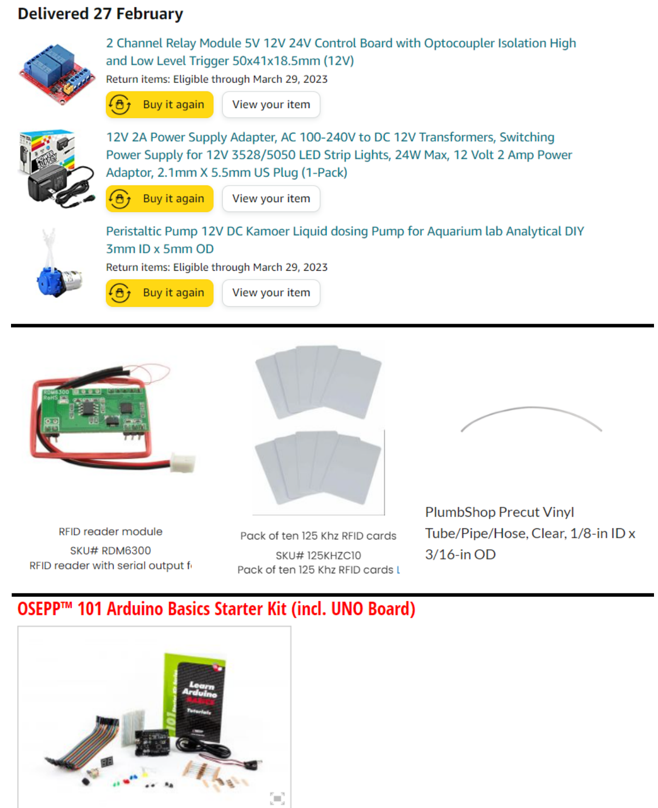

Figure 6: Hardware Components

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