Our Flower: Final Report

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Introduction

Many individuals have no choice but to be separated from their loved ones due to the global pandemic. Considering the current state of the world, more and more people are relying on technology to reunite with their family and friends virtually. Taking inspiration from the current situation, this project provides people a new way to send messages to their loved ones through programmed artificial flowers. Aiming towards a wide range of audience such as long-distance couples, family members, and friends, when basic phrases such as "I love you" and "I miss you" are said to one flower, the other flower lights up and plays a soft tune. Loved ones are able to connect through an innovative and unique way through everblooming flowers.

Related Work

The project takes inspiration from the practices of tangible and embedded human-computer interactions as noted in TEI'S *Proceedings of the International Conference on Tangible and Embedded Interaction* which is an annual conference that hosts a collective of research and projects on topics related to HCI issues, design, interactive art, user experience, tools and technologies. The type of HCI this project focuses on is how to emulate physical closeness through the digital world. We have witnessed a demand for platforms that offer such interactions throughout the pandemic. For example, schools rely on Zoom to emulate the presence of a physical classroom and people rely on video calls to emulate physical closeness to family and friends.

Touch at a Distance for the Remote Communication of Emotions by Gabriella Le Bihan is an interactive installation project that is intended to *"Provide an alternative way of experiencing interpersonal touch at a distance… allowing people to share emotions and have a feeling of presence at a distance."* Le Bihan's project is that of which two smartphones screens' light up depending on if two users touch the screen at the same time. The project is inspired by the study of active perception and how touch is an integral part of the transmission of emotions. Our project echoes the transmission of emotion and closeness through active perception as well in which the users can receive a sensory feedback (lit up flower) depending on a motor command which in this case will be vocal instead of touch. Le Bihan notes that *"It is in this sensory-motor dynamics that the perception of an object occurs."* Another point of interest in our project is how the lit-up flowers mimic an emotional response when told specific phrases physically. In Le Bihan's project, this is described as *"When two individuals interact at a distance, they are both untouchable and 'untouching'*

for each other. By contrast, in this interaction space, when the two individuals interact, they are at the same time touchable and 'touching' for each other." Hence, in the interaction space of our project, the input/output process serves as a digital replication of one being told endearing phrases in real life.

Cubble: A Multi-Device Hybrid Approach Supporting Communication in Long-Distance Relationships by Robert Kowalski, Sebastian Loehmann, Doris Hausen is an interactive installation project that is intended to *"enable partners to share their emotions, simple messages and remote presence. The prototype offers color signals augmented with vibration patterns and thermal feedback."* This project's main component is that of which two cubed like objects interact with each other digitally depending on the input of the user. For example, touching one of the cubes will prompt the other one to change colour or vibrate. Whilst the main functionality of this project is very similar to the previous one, this project offers a better input into its design process as eminent in the project's research paper. According to the researchers, *"133 participants from various countries, backgrounds and professions answered our initial online questionnaire. The gender ratio was balanced and the age ranged from 19 to 58 years (avg. 27)."* This information is vital to our project as we can loosely determine what age groups would most likely be our target age group. Hence, influencing our personal design process to be aligned with those of said target age group. Additionally, the research notes that *"While physical objects offer something tangible when a partner is away, people often do not want to carry extra items around. Mobile apps are easy to bring along, but lack any physicality and are limited by the capabilities of the hosting device. Traditional channels can help couples to feel connected, but are not effective at facilitating intimate communication."* This insight showcases some idea about the implementation of our interaction design. Firstly, our art installation will not be portable as it needs to be always plugged to a power source. If this was not the case, the installation will lose its purpose as it is supposed to light up upon spontaneous input (voice). Additionally, for the affordance of the project, we want to make sure that the app that comes with our installation is merely for instructional and connection purposes as we want the main interactions to be happening within the flowers themselves.

The critical aspect of both these projects is the fact that these projects try to emulate the sense of touch or physicality whilst having the subject touch a digital object (A smartphone, Cubble). Hence, the feeling of "touch" is only being emulated based on the feedback of the other connecting object's output. In a sense, "touch" in these projects is measured based upon what the other person sees (a lit-up phone screen) or feels (vibration from cubble). Therefore, instead of trying to emulate a sensory feeling in our project we decide to emulate an emotional one such that in what ways does a lit-up flower playing a soft tune make the user feel knowing it was prompted by another user.

Design Concept

The artwork takes the form of two artificial flowers made from worbla that light up and play music when recognized audio phrases are inputted by the user. For example, when "I love you" is said to a flower, the other flower will light up a warm colour and play a soft tune, making the receiving individual feel as if their loved one is present with them. Many people are

separated from their family and friends during the pandemic and cannot unite physically. For individuals especially across the world, it is almost impossible to be able to reunite under the current circumstances. The artificial flowers fill in the presence of the individual's significant other. The artwork provides a way for people to connect and feel connected. Real flowers bloom and inevitably die as that is their life cycle, and when a bouquet of flowers from your loved one is gradually dying, it is common to feel a little melancholy. The artificial flowers are "everblooming" and represent everlasting love from one's loved one. Even though your lover, family, or friends might not be physically next to you to hold hands with you or embrace you, they can use the flower as a device to communicate their love and longing.

User Characterization

Given the intended purpose of the design project to emulate closeness amongst loved ones from a distance, the target age group has been evaluated to 14+ and is suitable for all genders, as well as for those with technology awareness and those who have access to unlimited Internet. Additionally, the project is not suitable for portability and therefore its expected environment is a stable place which is observed frequently within a household and near a power outlet.

Since the final product encompasses two interactive flowers, in most cases two individuals would own each one of the pair of flowers in order to relay loving messages amongst each other. Therefore, this project's culture centers around the concept of the special closeness between two pairs of people. This type of relationship could encompass one amongst couples, friends, families etc.

Design

The initial design of the project we had in mind was a pair of 3D printed roses that are stabilized by attaching an acrylic base at the bottom of each rose. The roses would be connected through microcontrollers with built-in WI-FI modules and a web server. Each one of the two flowers can act as the input and output interchangeably.

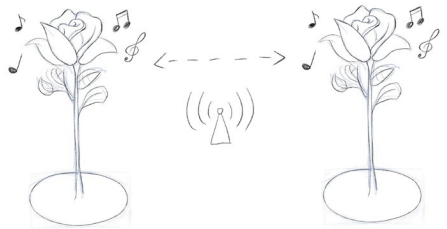

Figure 1. Initial design draft

Worbla was used to build both the low **and** high-fidelity prototypes. Worbla is a brand name for a line of thermoplastics, which is frequently used in costumes, props, set design, etc. It is a plastic that can be molded into any shape once it is heated up, and it holds its shape and hardens once cooled.

Figure 2. Final design of prototype

The low-fidelity prototype was approached with simplicity in mind; the whole purpose was to test the user interface without having to worry too much about visual aesthetics. Thus, the flowerpot and stem both remained worbla's original sandy colour as no paint was applied.

Moving on to the final design of the project- the original plan was to 3D print both flowers to create a high-fidelity prototype. However, due to time and budget restrictions, it was decided to continue using worbla to build the models. The final prototype of the flowers will be painted with acrylic paint to enhance visual aesthetics and completeness. At the same time, the concept of "roses shared between couples" was changed to "flowers shared between loved ones" to reach a wider target audience. This design decision was made partially because of the unsuccessful plan of 3D printing the models, which made assembling the rose head extremely challenging since rose petals are very intricate. We decided that we should follow the design for our low-fidelity prototype for the final design since the pot was the best way to contain the microcontroller and sensors.

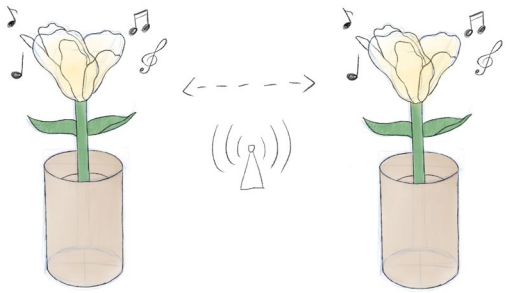

Figure 3. Illustration of final design

Overall, the decision to switch from a pair of roses to normal flowers was confirmed based upon three reasons/complications:

1. Unable to 3D print made crafting rose head challenging because it is difficult to make multiple layers of petals to mimic the look of layered rose petals with existing materials.
2. To make the design of the project more reasonable; roses are not typically found in flowerpots.
3. To eliminate possible limitations on target audience; aside than lovers, family and friends can also enjoy the product.

The process of building the high-fidelity prototype remains the same as the process of the low-fidelity prototype for the most part. To stabilize the flowers as well as providing sufficient space for the microcontrollers and wires, a pot was made for each flower. There is a soil looking "lid" inside the pot to stabilize the stem of the flower. A hole was cut out of the lid so there is space for the stem to pass through.

Since the stems need to be hollow to feed in wires from the bottom of the pots to the flower heads, a wide plastic straw is used as the core of each stem. The straws were wrapped around by worbla to avoid visible wires in transparent stems. Each stem is then inserted into the hole in the "lid". To stabilize the stems, we used small pieces of worbla to "glue" the intersections where the stems and lids met. Lastly, two layers of gesso were applied to the stem and pot before painting them green and clay brown, respectively.

Transparent worbla was used to make the flower petals. Several pieces of petals varying in size and shape were cut out. Transparent worbla is much harder to work with as it does not have the same adhesive qualities as the regular worbla we used, and it requires a much higher activation temperature. We used craft glue to attach the flower petals to the top of the stems individually after heating each one up.

Figure 4. Close-up of flower head

Using the acquired knowledge of discrete design principles, the circuits were placed carefully inside the prototype with the wirings concealed to the user. The microcontrollers are situated vertically inside the pots directly below the stem. A small hole was cut along the bottom of each base to allow room to connect the power source. The speaker modules were placed within the base itself whilst jumper wires were fed into the stems to connect to the LED. The LEDs are visible in the center of the transparent flowers for them to light up the flowers efficiently when instructed through voice command.

Figure 5. Final design

In all, the technical aspects of the project remain the same as our original proposal, but the design concept went through some revision along the process.

Prototype Development

The final project's development commenced with the creation of an IOS app using bubble.io, a drag and drop app building software. The phone app serves as the interface in which the connection between 2 unique flowers is initialized at any given time. The user is prompted to sign up and connect their flower using a unique ID (created based on if the app and flower is connected to the same Wi-Fi). Both users who are willing to connect their flower's interactivity are then prompted to enter each other's unique ID, establishing a secure and mutual connection to the dweet.io server. Once a connection is confirmed, the phone app will display connected, and the user may begin talking to their flower to relay a message to the other.

Since the core circuit of our initial prototype was functional and working. All that was needed to be done

was to create another identical circuit using the same components and modules. The main difference in the previous prototyped circuit was the inclusion of a voice recording module. This is so that the user can speak to their flower directly without having to use Siri or an external voice input. Therefore, the final circuit consists of the Arduino Uno WiFi Rev2 for high-speed internet connectivity, 3 LEDs (one red, one yellow and one green), jumper wires, piezo buzzer and finally the MIKROE-1534 voice module. The MIKROE-1534 voice module was crucial to the development as it handles both the voice input and translating them into strings which are needed for the JSON based web server (dweet.io). The circuit's code was created using the Arduino IDE and implemented the WiFiNINA library for Wi-Fi connectivity. Lastly, the circuit utilizes a 300mA Universal AC adapter to power the microcontroller and subsequently the circuit.

The testing of the project was conducted via the serial monitor on the Arduino IDE. The code includes several serial monitor print statements that display a successful connection establishment to the Wi-Fi, the connection to another flower, the connection to a mutual server and most importantly the voice line being recognized. For the most part, testing was successful but there are some notable bugs and unexpected behaviour such as:

- The voice module interpreting a voice line wrong (failed speech recognition)
- Lag between transitioning from one flower state "I love you" to another such as "I miss you".
- Transitioning to a new flower state without playing the subsequent tune.

Limitations & Non-implemented features:

There are some design limitations as well as a very important feature that has not been implemented due to time constraints.

The first feature that would be implemented is the ability to get an indicative visual queue that a message has been relayed to another flower. That way, it does not appear to the user that they are speaking to thin air and they are made aware that their message has been relayed.

The second feature would be the ability to mute the buzzer (sound tune) as some users may be inclined to have a quiet background during certain settings (in a call, whilst sleeping).

For the limitations of our project, the first one is that there must be a short distance between the user and the flower for the voice module to work. This is partly due to the fact that voice modules can only recognize clear and concise phrases.

The second limitation is that since our power source does not incorporate a switch, the flower's circuit is using power constantly as long as it's plugged into a power socket. That could pose as an electric safety issue as well as an issue pertaining to utility bills.

The last limitation is that the LEDs are not strong enough to clearly light up the flower in the morning, which may not be visually stimulating to the user.

Usage Scenarios

Scenario #1:

Sarah and Josh are a long-distance couple who live 5 hours away from each other and only can meet once a month. Sarah is a strong and independent female who is career-driven and passionate about her job. She pushes herself to succeed and values her career very highly and avoids stumbling upon failures in the process. On the other hand, Josh has a stable 9-5 job, and he enjoys side hobbies such as video games. He tends to be insensitive and too blunt sometimes, and he is not the best at comprehending Sarah's emotions. One day, Sarah comes home after a dreadful day at work where she was scolded by her boss for being incompetent. Sarah slumps onto her bed and delves into sadness and starts to doubt her own abilities. Sarah then FaceTimes with Josh and chats about her thoughts. Josh doesn't sense her vulnerability and self-doubt, which provokes Sarah, and the two break into an argument. Sarah lies on her bed after the call ends, engulfed in misery and shedding tears. Some time passes by, and suddenly, she hears soft music playing, and out of the corner of her eye she sees a warm light coming from her desk. It is the artificial flower Josh gifted her for Valentine's Day. For the first couple of weeks after they got the flowers, they played around with the devices multiple times a day, anticipating how the other person would react when they see their flower light up and play a soft tune on the other end. The excitement around the flowers died down after a while, and both Sarah and Josh seemed to forget about them. Sarah gets up and walks towards her desk. She looks at the "blooming" flower; the soothing music sounds as if Josh is softly apologizing to her. Reminded of all the happy memories she shared with Josh, especially ones with the flowers, Sarah wipes her tears away. Just then, her phone rings. She smiles and picks up Josh's call.

Scenario #2:

Emily and Liam are a long-distance couple who live on different continents. Due to the global pandemic, the couple cannot reunite, and they have not seen each other in person for over a year. However, the two remain incredibly close. They make phone calls/video chats daily, and if unable to for that day then they make sure they still send text messages to each other. Unfortunately, for the past month, Emily and Liam have not been in as much contact since they both have an overwhelming amount of work at their respective job. Even though the couple desperately wants to communicate with each other just like before, going through a whole day of work with masks on is more than enough to knock them out right after getting home. The dreadful workloads continue for a couple more weeks, and one day, Emily has just finished work and arrives at her apartment building. She steps out of the elevator, rubbing her eyes and yawning, and she sees a red box sitting at her door; it is well packaged with a cute ribbon on the top. Emily picks up the box and attached to it is a card that reads "Happy Valentine's Day baby". Upon reading the message, Emily has just remembered that it is February the 14th. Pumped with excitement and affection, Emily enters her apartment and unwraps the box. Inside is a beautifully 3D printed flower. Just then, she receives a FaceTime call from Liam. Emily happily expresses her surprise at the gift, and Liam explains that he got a set of the flowers so that even when both of them are too busy or tired to call, they can use the flower to send a message of love to each other. Liam demonstrates the devices' functionality by saying "I love you" to his flower. After a

brief pause, the flower in Emily's hands shines a warm light through its petals and starts to play a soft tune. Emily is delighted upon seeing this sight, and the two promise to try to keep in more contact.

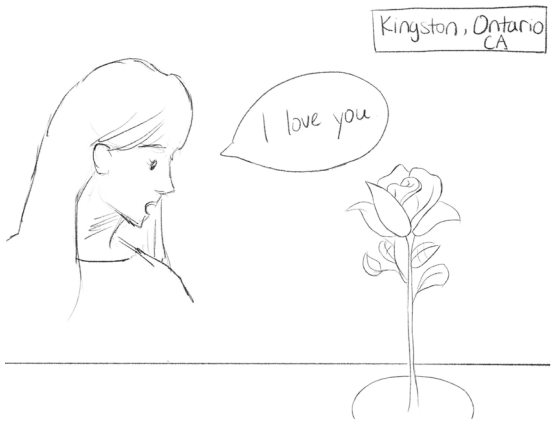

Figure 6. User interaction

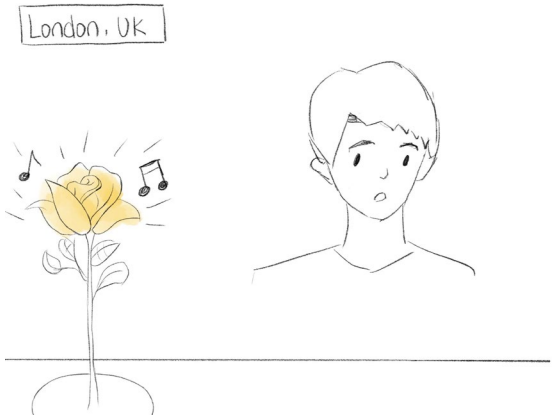

Figure 7. User interaction

User Evaluation

Method:

We have designed an extensive online user evaluation process in order to simulate the real-world interactions of the flower despite user testing occurring online.

For our user testing, we have decided to invite 6 people (in pairs) with different relationship statuses between each other based on our target users as well as varying age groups onto a video call via discord. These people consist of (not real names):

- ***Friends***: Mohamed (17) & Daniel (22)
- ***Couple***: Victor (27) & Brianna (21)
- ***Siblings***: Dua (15) & Katherine (29)

Since it was evident our participants could not speak to the flowers directly, we disabled the voice module temporarily for the testing and reverted to using the Siri for voice inputs similarly to our initial prototype. We instructed our participants to download a Siri Shortcut and then allocated a specific flower to each pair. Since both testers (Isabella and Brie) were on the call, Isabella's webcam showed a live feed of Flower 1 whilst Brie's showed Flower 2.

For example, Victor was allocated Flower 1 and his Siri shortcut relays his voice input to Flower 2 whilst Brianna was allocated Flower 2 and her Siri shortcut relay her voice input to Flower 1.

The users were then instructed to voice out any thought or opinion during the process as we opted for an open discussion user testing session rather than a feedback form as we thought it was more effective to hear their thoughts about the interactivity, visual and

sound stimuli as whilst it was occurring live. We then noted the conversation as well as asked any specific question we were curious about.

Findings:
Issues & Limitations: During our test sessions, 4 out of 6 of our users brought to our attention a crucial design issue in terms of voice interaction with the flower. The users questioned why there was no voice prompt to explicitly start the flower interaction. One of our test users, Katherine stated:

> "What if I told someone on the phone that I loved them, if I was close enough to the flower, would it send the corresponding commands to the other flower?"

Another issue that was raised was the extent of how much the flower was lighting up. Our testees find that some commands lit up the flower better than others.

All of our users expressed they would like to see a visual queue from the flower that is relaying a message in order to affirm that a message command has been relayed.

Lastly, the testers expressed if the commands and song choices could be customizable via the phone app interface in order to relay more personalized interactions such as by saying "Happy Birthday" or a seasonal greeting.

User design experience: Whilst the testers had to vocally interact with the flowers using their phone. The testers were made aware that the vocal interaction aspect of the flower was remote and that the microphone was directly inside the flower. The testers expressed positive feedback on this aspect of the flower as some participants mentioned that the personal interaction with the flower made the experience "more real and wholesome".

The testers also liked the fact that the flower could be powered up via a power socket plug or a computer USB as they felt that they would most likely place the flower by their bedside or by their working station. Hence, the physical user design of the flower was convenient.

Recommendations:
The first and most crucial change that was deployed was to set a voice prompt before interacting with the flower. The voice prompt "Our flower" needs to be called first before a user can send a voice command input.
The flower's code was also changed so that users had the ability to send a custom message by choosing a specific colour of LED to light up and play a tune of their choosing. This can be done via the phone app interface that comes with the flower.

Unfortunately, we did not have LEDs that could potentially light up the entire flower. Therefore, in the future, stronger LEDs need to be acquired in order to achieve that effect.

Discussion & Reflection

Limitations:
Our group faced several limitations and challenges throughout the design process. As mentioned in previous sections, our most ideal plan of implementing 3D printed flowers could not be executed due to time and budget restrictions, which made us shift to crafting

the entire interface by hand. This change in plan was rather sudden, so we had to find possible materials within a small time frame. Some materials such as the transparent worbla was extremely hard to work with, so during the process of crafting the models we had to sacrifice details for general aesthetics of the flowers.

Additionally, assembling the circuit inside the flower model was difficult as the jumper wires that were used were quite small. Therefore, the wires had to be soldered several times which was time consuming.

Lastly, the components of the circuit were extremely costly. It would have been cheaper to buy a separate Wi-Fi module component instead of two ARDUINO UNO WIFI REV2 microcontrollers. To also save costs, we could have purchased a microphone module and created the voice recognition system from scratch using a voice bit server however due to our limited knowledge and time constraint this was not possible.

Future Work:
Moving forward, if we were to work on a project similar to this in the future, we would definitely still opt for the 3D printing method simply because its results are the most clean and professional looking. The concept of the project would probably remain close to the original idea, which is artificial **roses** instead of general flowers. The acrylic base in which each rose would be attached to would probably be modified into a much thicker platform considering the amount of space the circuit requires. In the beginning stage of our project, we were mainly focusing on designing the visual aesthetics as well as mechanics of the roses, so the positioning of the microcontroller and sensors was neglected in the process. If the project were to be started all over again, we would put in more thoughts on creating an overall uniform and balanced model in which the design of the base would be more practical as well as harmonious with the rest of the design and aesthetics of the model.

Conclusion:
The group worked harmoniously throughout the whole process by assigning tasks depending on each person's strength. As a result, the progress the group has made followed our initial plan for the most part except we needed an extra week due to the complications with 3D printing. That extra week was dedicated to crafting the flower model and painting it.

If this project could be redone, the main priority would be placed on being cost efficient with the components and modules for the circuit. It would also be recommendable to purchase stronger LEDs and longer jump wires for the circuit's connectivity.

This project demonstrated the full capabilities of the Arduino microcontroller that has Wi-Fi accessibility. We were able to learn for the first time how to read JSON files and send POST or GET requests to a web server as well as how to create one. That is because we challenged ourselves throughout the project to learn new features and experiment with new microcontroller capabilities. This was especially notable as we opted not to use a phone-based voice input, but an internal microphone built into the model.

Hence, we believe the root of our project's success lies in the fact that we took risks and were experimental with our project's functionality despite not having any extensive microcontroller knowledge prior.

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