Prototype Progress Report

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https://lksuenfa.github.io/cart360/

Intent Statement

As the population ages and the demand for long term increases despite the healthcare being unable to accommodate the current demand for health services, it is primordial to find ways for people to receive appropriate care from home. Adherence to pharmacological treatment is key to the maintenance of well-controlled medical conditions, one of the most important factors for home-based care.

The standard of care at the moment is the use of plastic one-time use blisters filled by the pharmacy. These can only accommodate for a maximum of four doses per day in a blister pack and have a limited capacity due to the small size of the blisters. Such a device are not interactive and offer no feedback or reminder to the user to encourage them to take their medication. Moreover, during my professional practice, I have also noticed that patients using these devices are more likely to lose touch with their pharmacotherapy as time goes by as they relinquish the control of their treatment to a third party. Many become unfamiliar with their medications which can have adverse consequences on their health.

Therefore, the overall goal of this project is to develop a tool which would stimulate patients to stay adherent to their medications.

Initial Concept
[abandonned]

The Conceptual Phase

The initial concept consisted of a paper circuit made with conductive ink which would be directly printed onto sticker sheets used to seal commercial blister packs. Touching and opening the blister would be detected by the artefact and a alarm system would notify the user if they had forgotten to take their dose or if they had taken the correct of incorrect one. The detection of the opening of a blister would be a separate circuit using a multiplexer and the touch sensing ability would come from a different circuit using a touch sensor.

We looked into the different materials available on the market and decided to prioritise graphite based conductive paint over silver based inks as graphite based paint would be more sustainable. We started prototyping this circuit by testing the resistance of conductive ink over paper and by testing different patterns which could accommodate 2 separate circuits on a single sheet of letter size paper.

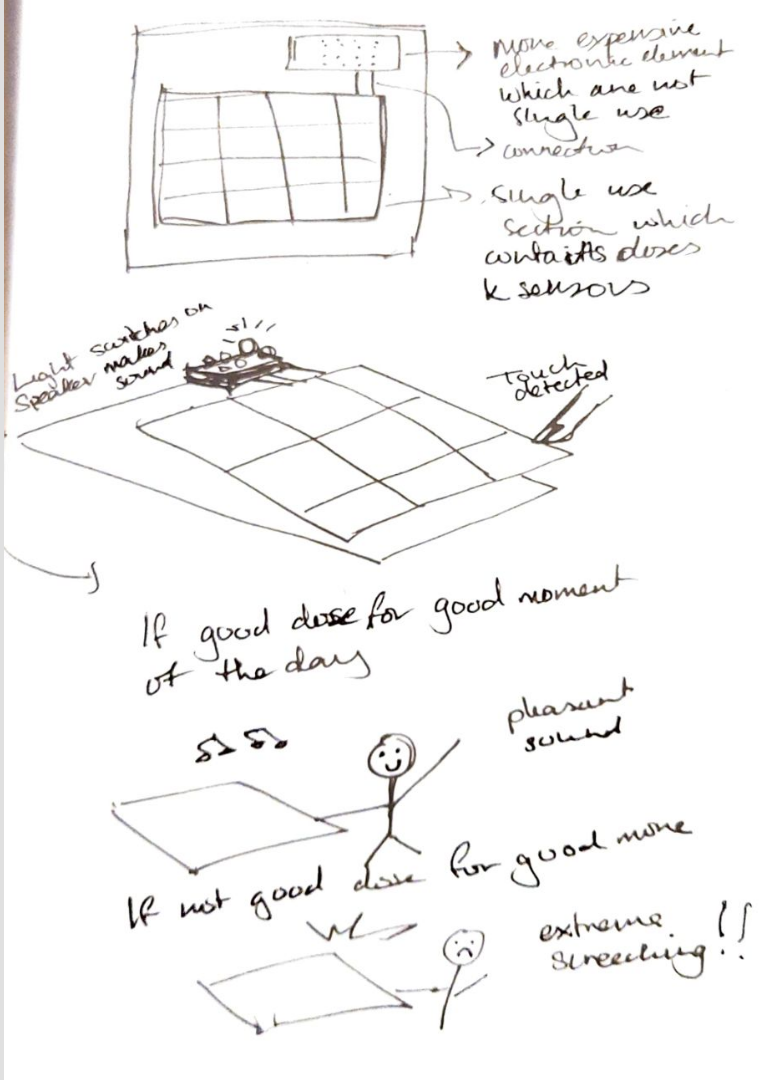
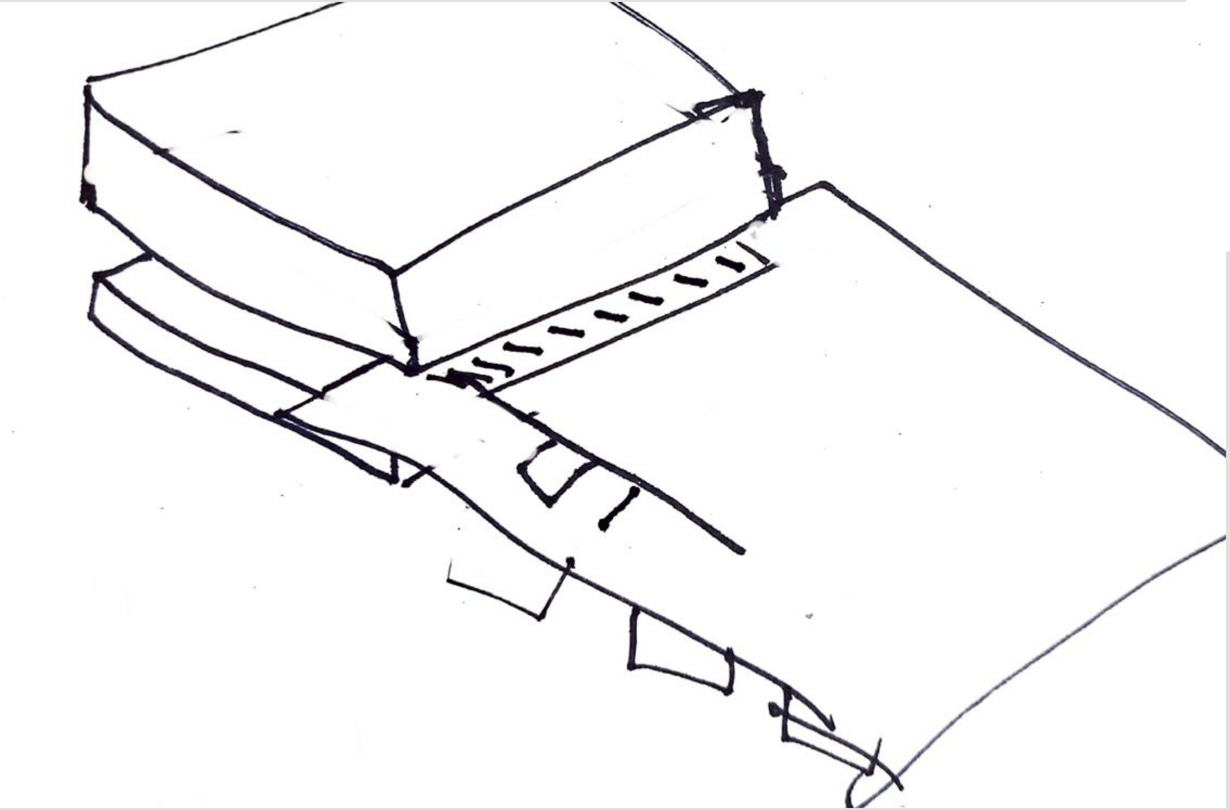


Illustration of the paper circuit with electronic components encased in a wooden box



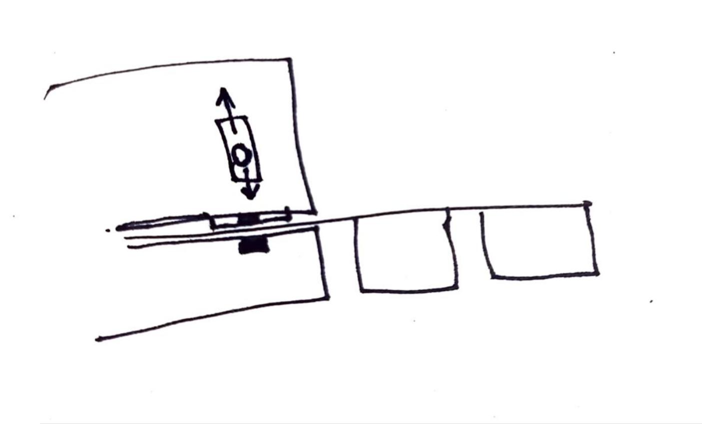
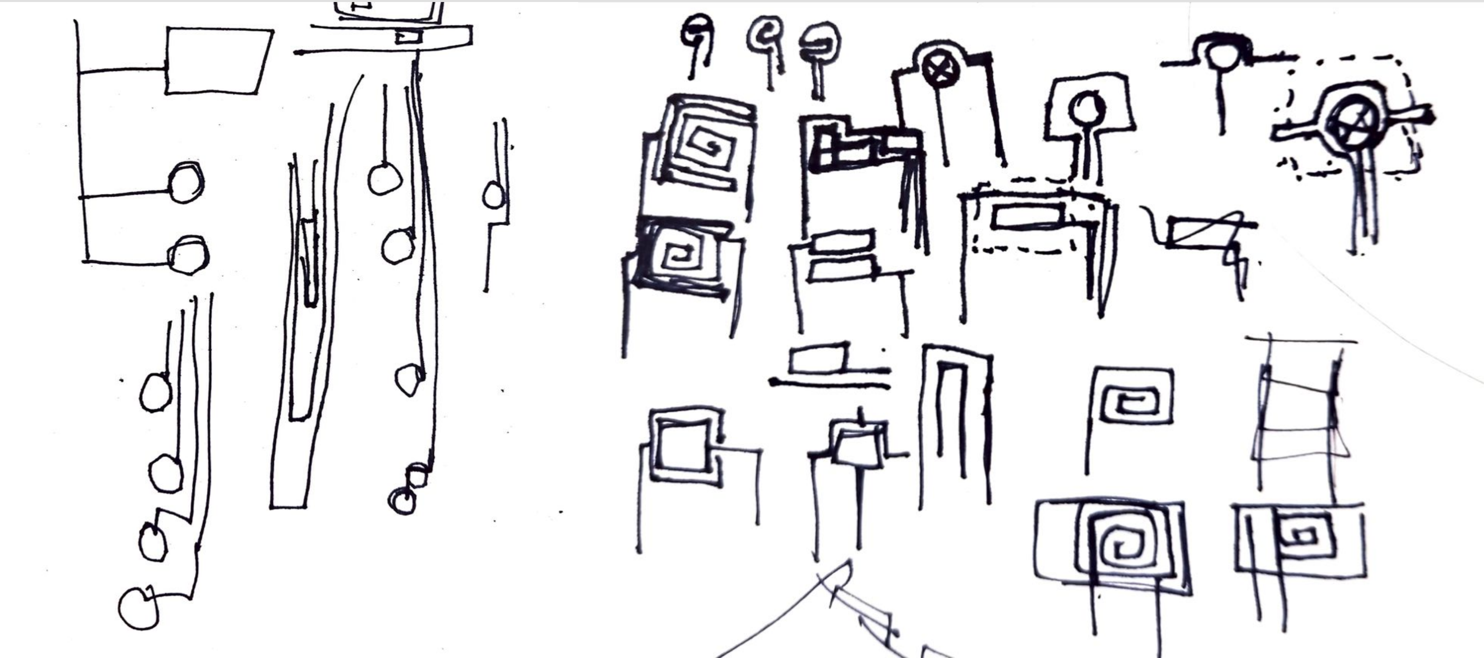


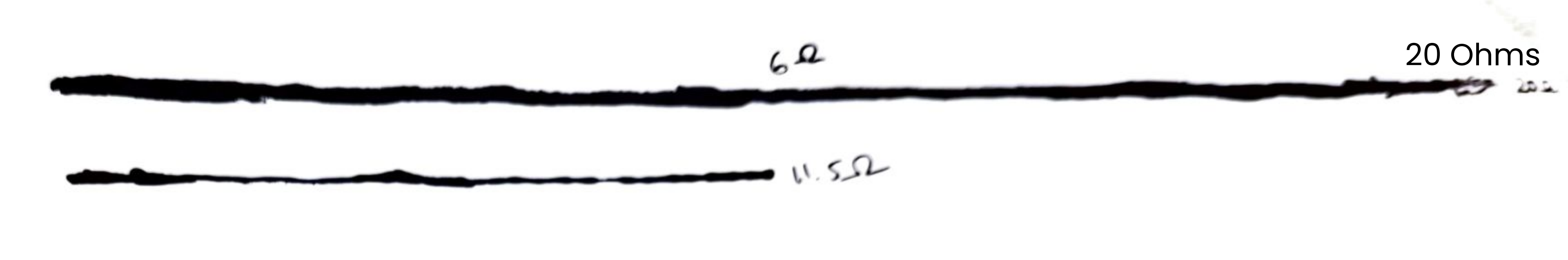
Illustration of mechanism within wooden box to maintain blister package in contact with the rest of the circuitry within the box. A wooden block within the box applies weight onto the blister package and it can be raised up to allow blister package to come out.

Brainstorming of illustrations of parallel double circuits patterns which could fit onto a letter-sized paper



However, we had to abandon this concept as the differing resistance of conductive paint over distance would lead to complex and unpredictable changes in resistance from one end of the blister pack to the other. Moreover it was very difficult to fit the circuit pattern onto the letter-size paper without the use of a printer and inkjet conductive ink was extremely expensive.

Resistance testing of conductive paint across a sheet of letter-size paper

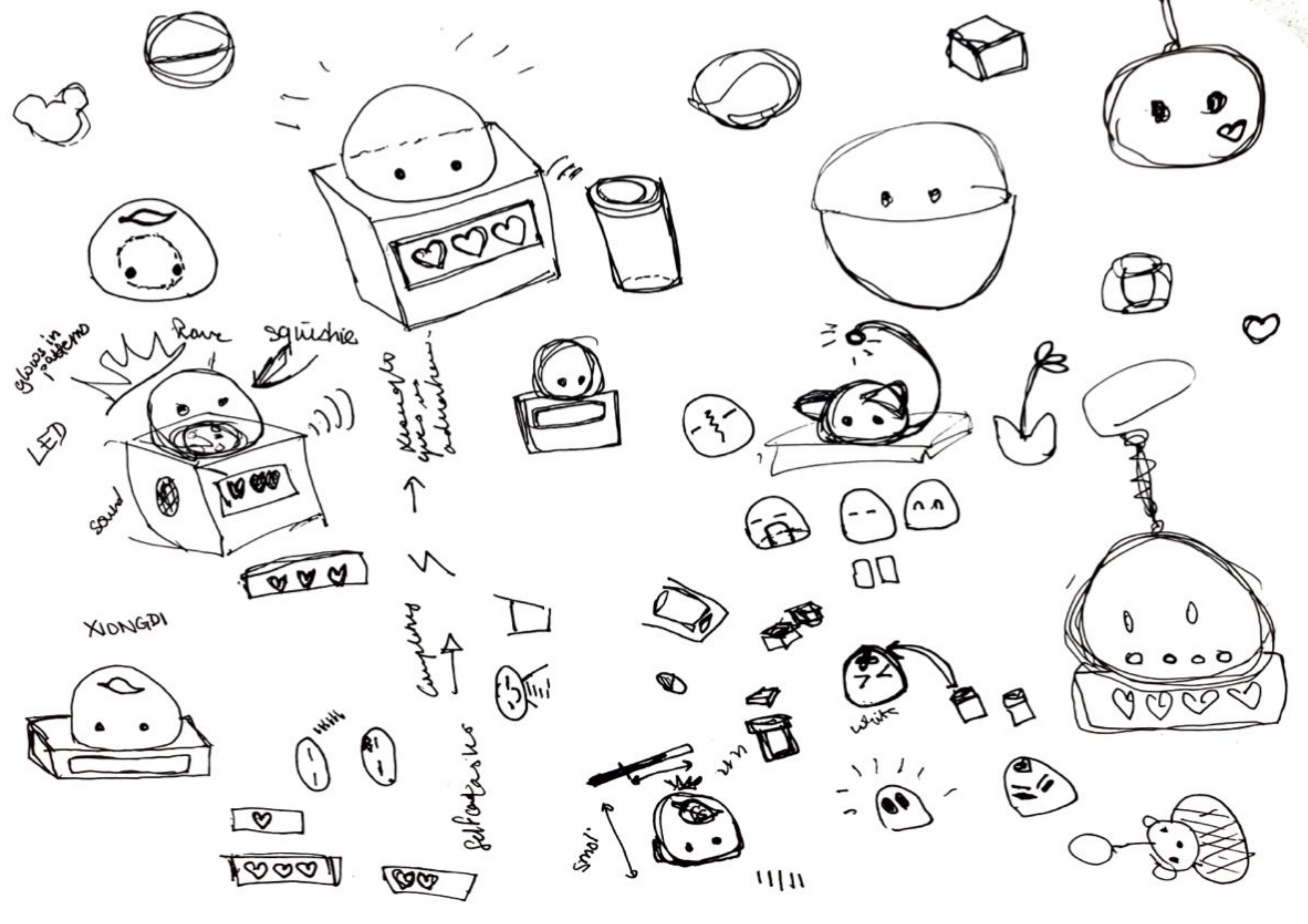


Second Concept
[same purpose,
different form]

The Conceptual Phase

As the first concept, was deemed to difficult to execute with available tools and materials. We decided to change the concept. The intent of the artefact would remain the same however. We still wanted to create an artefact which would help people be more adherent to medication however we rethought the ways by which we could do so.

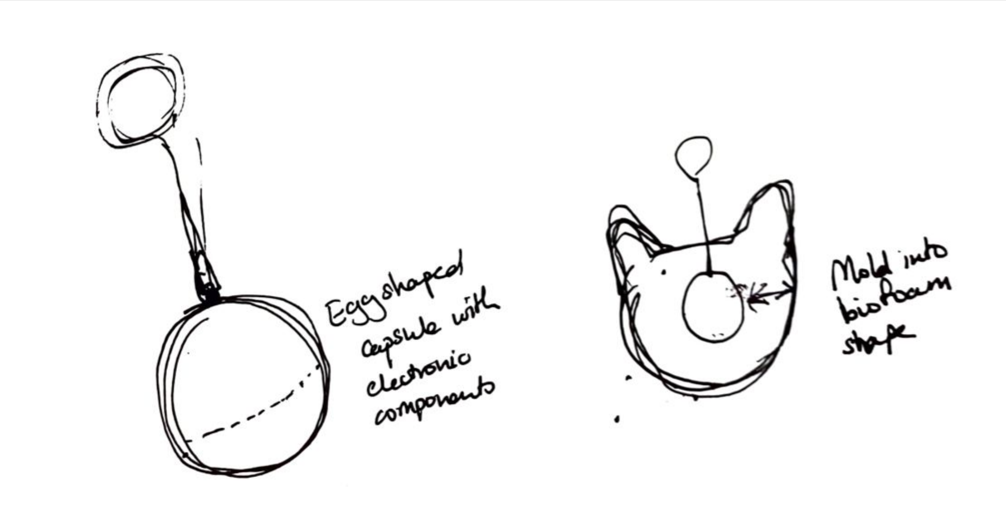
As we couldn’t interview any elderly patient to know their opinion about the medication adherence issue, we decided to broaden the target population to be able to interview patients on chronic medication first hand. Due to time limitations, we could only interview one person who was a young adult on several chronic medications and who had a history of non-adherence to medication. As they were being treated for psychological conditions like anxiety and depression, they formulated the wish to have an assistant device which they could relate to. They wanted something cute and small which made they feel like they were taking care of a pet by interacting with it. They felt that this kind of interaction would feel more meaningful to them and would motivate them to take their medication as they would feel a sense of responsibility toward the animated pet assistant. Taking these considerations in mind, we designed a different concept which would still allow for medication dose and timing verification and an alarm system as a reminder.



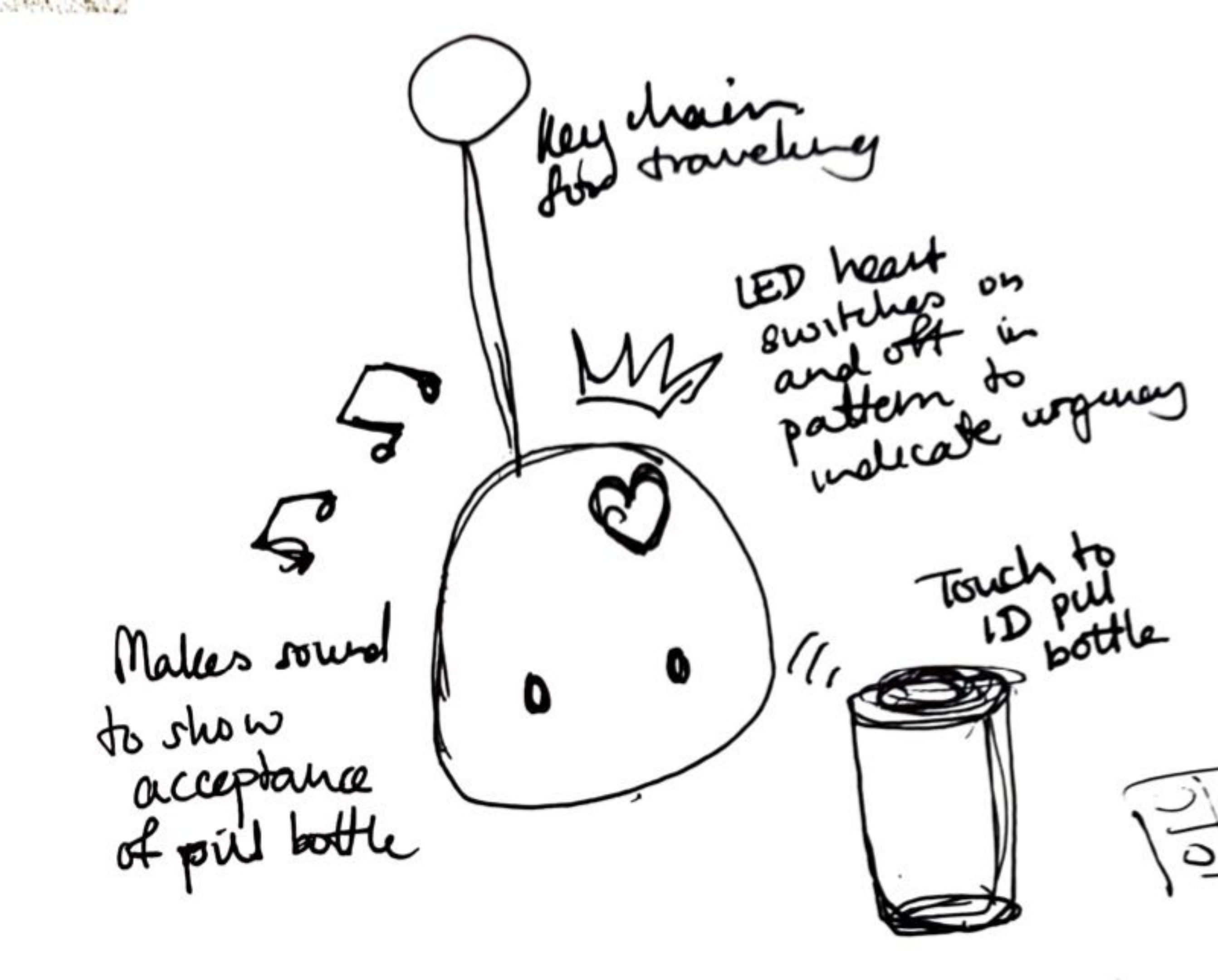
Brainstorming assistant pet devices in a cute shape

We decided to go for biofoam or bioplastic as main material for the body of the artefact as we wanted to have an interactive squishy surface which would not remind the user of cold metal/plastic electronic devices and would make the artefact less mechanic and more life-like. As that material is transparent and bouncy, it reminded us of cute slimes often portrayed in games and fantasy novels so we followed this idea and conceived the artefact as a friendly little slime.

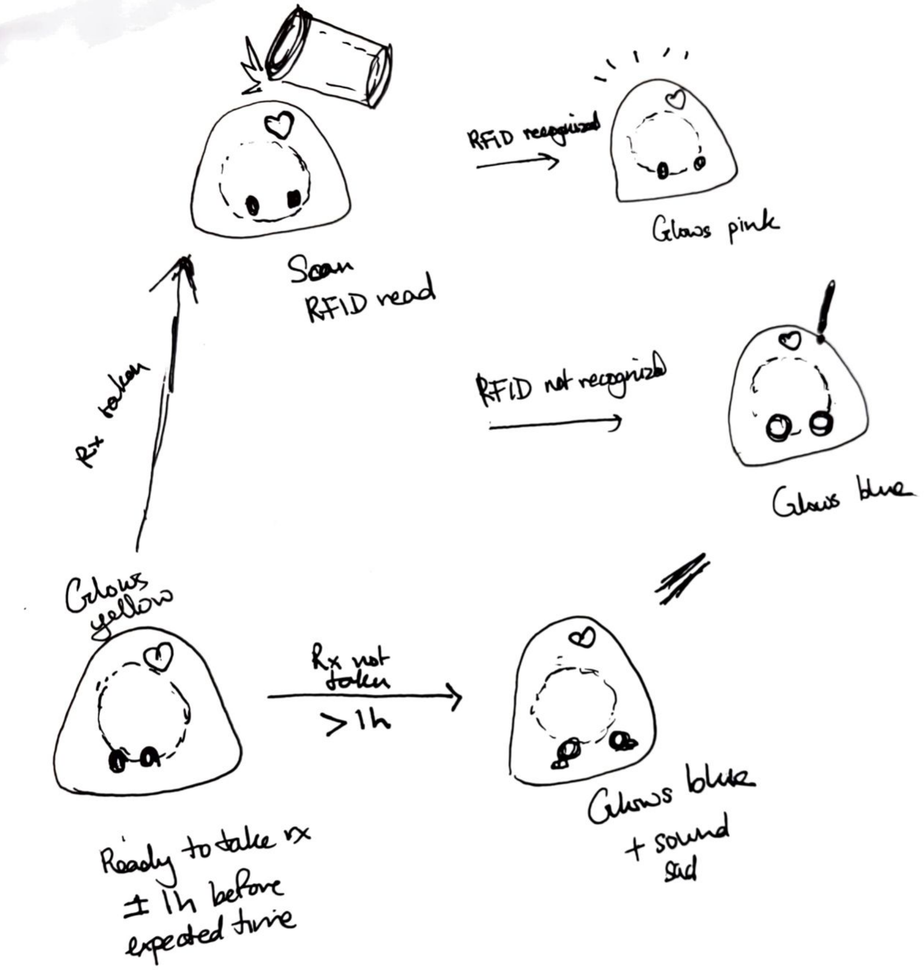
The electronic components would be contained into a plastic core within the jelly-like biomaterial. If this artefact were to be commercialised, we would imagine providing users with the biomaterial ingredients and molds of different shapes so that they would be able to co-design their own assistants to make the artefact more personal to them.



Storyboard showing use
of the artefact.



An RFID reader would be key component allowing interaction with the artefact. A tag would be placed in each pill bottle or pillbox section and scanning this tag would give the user some visual and auditory feedback confirming whether they scanned the proper medication at the proper time of the day. The artefact would glow in different colours as feedback and as such would require some kind of transparency. The core would need to be waterproof to keep the electronics safe when they would be submerged into liquid bioplastic during the moulding process.

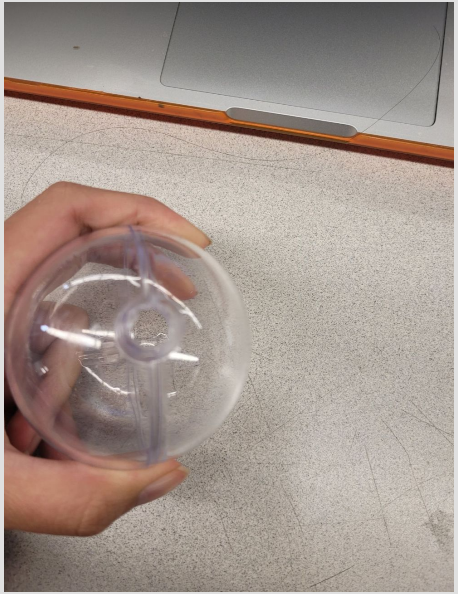


The Development Phase

The Core

Instead of fabricating the core where the electronics would be kept from scratch, we decided to use a commercially available and seasonal plastic Christmas bauble.

A hole was made in the prototype’s core bauble in order to allow wires to come out as we wouldn’t have committed to soldering the electronics at this step in the fabrication process.



Making a whole in the
bauble using a rotary
tool in the woodshop

Biomaterial

We tested different biomaterials (gelatine biofoam, corn starch bioplastic and gelatine bioplastic) to make the body of the artefact. Different thickness of biomaterials were produced to test the overall desired squishiness and to find out the minimum required amount of biomaterial we need to produce that squishiness. All recipes were found in “The Bioplastic Cook Book” by Margaret Dunne(Dunne) and we used the version of the recipe with the most glycerin to maximise squishiness.

Making a whole in the bauble using a rotary tool in the woodshop

Making of the biomaterial

Corn starch bioplastic
(Glycerine 20g, Water 80ml, Corn Starch 1.6g, Vinegar 15ml)

The corn starch bioplastic took several days to set which was not appropriate for the artefact. We do not want users to not be able to access their assistant pet for several days because they are changing their biomaterial layer.

Gelatine bioplastic
(Glycerine 7.2g, Water 60ml, Gelatine 12g)

The gelatin bioplastic had an nice squishiness and was also semi-transparent which was an advantage because we wanted to use LED to provide feedback to the user. As time passes, it tends to dry up and curl on itself. Moreover, if it is in a colder environment, it is less flexible and squishy than in a warmer one.

Gelatine biofoam
(Glycerine 60g, Water 60ml, Gelatine 45ml, Soap 6ml)

The biofoam was also very squishy. It provided the most satisfying bounciness compared to the other material. However, it sets very quickly and is difficult to work once it is cold and it becomes extremely sticky. The one downside is that it is not transparent. It reacts less to room temperature and loss of water compared to the bioplastic

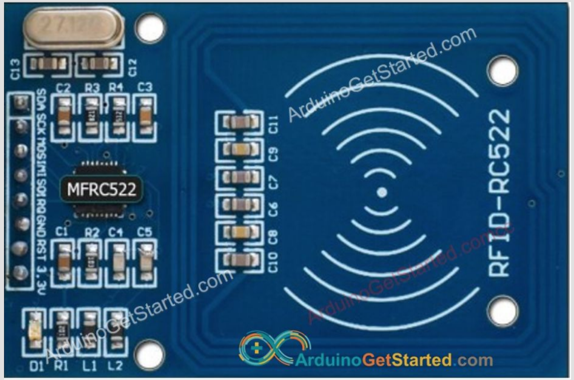
Adding colours

We also tested adding colour to the material using food colouring and thermochromic pigments. The food colouring produced a transparent bioplastic while the thermochromic pigments made the bioplastic opaque. However, thermochromic pigments do not dissolve in water and produced uneven coloration and residual powderiness on the surface of the bioplastic. Warming it in the hands is not enough to produce a change in colour in a thick slice of bioplastic. One of the possible reasons is probably due to the insulative properties of bioplastic. As it does not conduct heat very well, the pigment do not warm up sufficiently and uniformly enough to make the whole object turn translucent.

Sensors

RFID Reader and Tags

RFID-RC522 Module



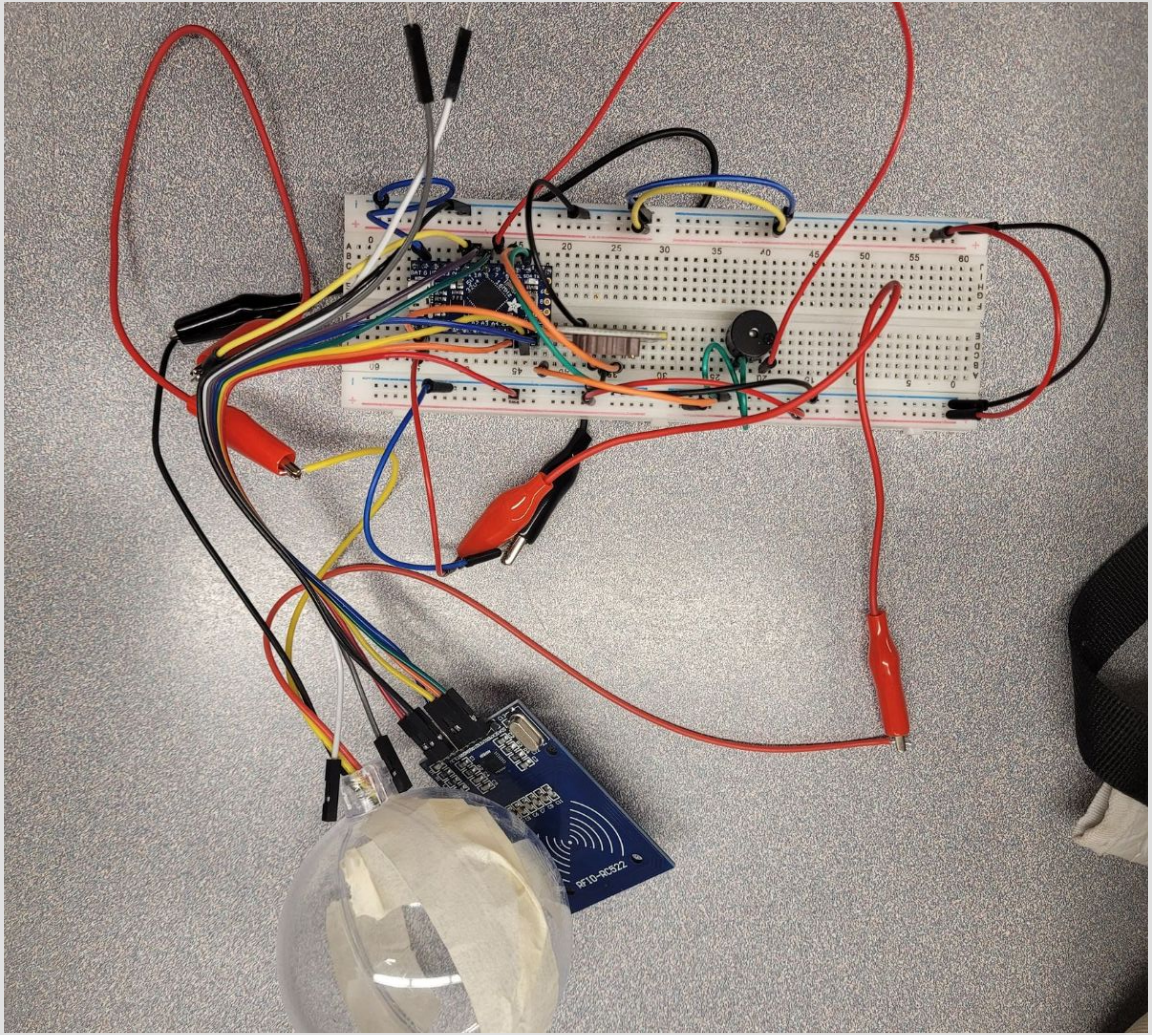
The RFID reader is the main sensor responsible to initiate all the interaction which will be produced by the artefact. It produces electromagnetic energy through its antenna which allows it to detect a tag with the same radio frequency as the reader. When a tag is placed close to the RFID reader, this electromagnetic energy induces an electric current powering on the tag and broadcasting its data. The reader then interprets that signal (Sparkfun).

The RFID reader and tags allows the user to interact with the artefact. Each pill bottle can have a tag so the RFID reader can identify each one of them. At this level, the interaction between the user and the artefact is reactive. You present the tag and an LED switches on. However, there is more going on through the code of the artefact to turn this reactive interaction into a conversing one. The time and number of medications per time of day will be provided to the artefact. Based on this information and through the use of a real-time clock module, the artefact will also expect the user to interact with it and will produce a signal (visually through LED blinks and auditorily through sound) if the user has not within the expected time frame.

Code

https://lksuenfa.github.io/cart360/assets/Prototype3.zip

Circuit


RFID-RC522

Conclusion

As a design student, we are already familiar with the design process. After I came out with my first concept for the proposal, I had to adapt it into a different concept with similar intention as I found out that the initially chosen materials would not be able to provide the functionalities and the scale I was expecting. I think recognising when something is not going to work as early as possible is very important to a designer and this project provided with this experience. As I made early inexpensive and quick tests with the materials to explore the conductivity of the conductive paint for example, I could already see what challenges this material would bring to the process. Overall I am glad that I changed concepts because the second concept is even more fun to work on and provides me with the chance to work with biomaterials, something I wanted to try for a long time.

Working on the electronic components was also very interesting. I feel like I now understand better how to research the use of an unknown electronic object, how to set it on my arduino and how to troubleshoot both the code and the physical electronics themselves, which is a reflex that I still need to acquire as I am more used to looking into troubleshooting my coding than thinking about what could have gone wrong with the physical electronics. Overall the past 2 weeks have helped me consolidate my understanding of the course material through first-hand practice.

Works Cited

Dunne, Margaret. *Bioplastic Cook Book*. https://issuu.com/nat_arc/docs/bioplastic_cook_book_3. Accessed 4 Nov. 2022.

RFID Tags and Readers - SparkFun Electronics. https://www.sparkfun.com/rfid. Accessed 4 Nov. 2022.