UNIVERSITY OF OTTAWA – FACULTY OF ENGINEERING

ENGINEERING DESIGN

GNG1103

Project Deliverable F: Prototype I and Customer Feedback

Felipe Ortiz Figueiredo
Precious Eze
Tasha McDonnell
Cami Tiffin
Raphaelle Jean-Baptiste

March 2020

Table of Contents

List of Figures

---

1. Introduction

The opioid monitoring device that we have designed can greatly benefit society by saving thousands of people from overdosing on opioids. Thus far we have identified client needs, design criteria, created several conceptual designs and constructed a schedule for our product. Our next step in ensuring we can produce a quality product is prototyping. Prototyping will allow us to determine which aspects of our device are well designed and which parts need improvement. The objective of this prototype is to communicate the ideas of our opioid monitoring device to the client in a clear way so that we will be able to receive constructive feedback. Our first prototype will also allow us to better assess risk or errors in our product design so that we can find a solution early on. By prototyping we can test different features of our device and improve them until we reach our desired criteria.

2. Prototype description

2.1 Hardware Prototype

In this first prototype, the hardware would be presenting prototypes that are focused on ensuring convenience of using the device and displaying sensor and communication accuracy. To improve the convenience of locating the device on the ear, we would be testing the physical prototype in figure for the weight of the device, the size and visual to ensure that the device is discreet as well. For the accuracy of sensors and communication between components we have made a schematic block diagram of the overall view of the system as in Figure 1. This expresses the connection between the user, the overdose detection device and the application on the user's phone.

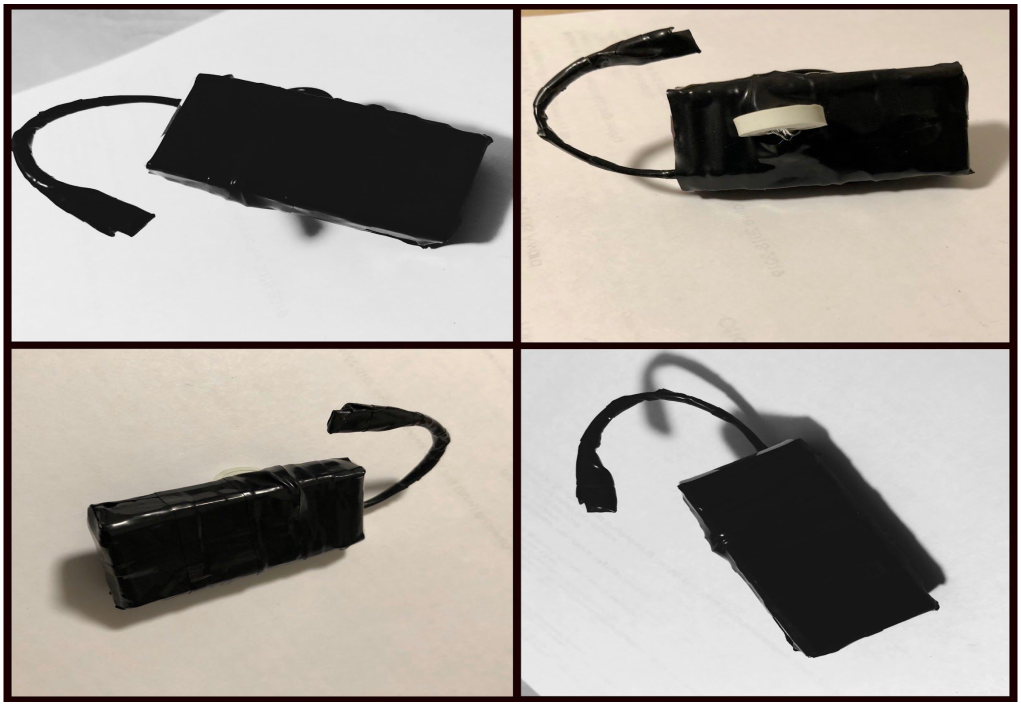


Figure 1. Pictures of the Physical Prototype to test for discreteness and convenience

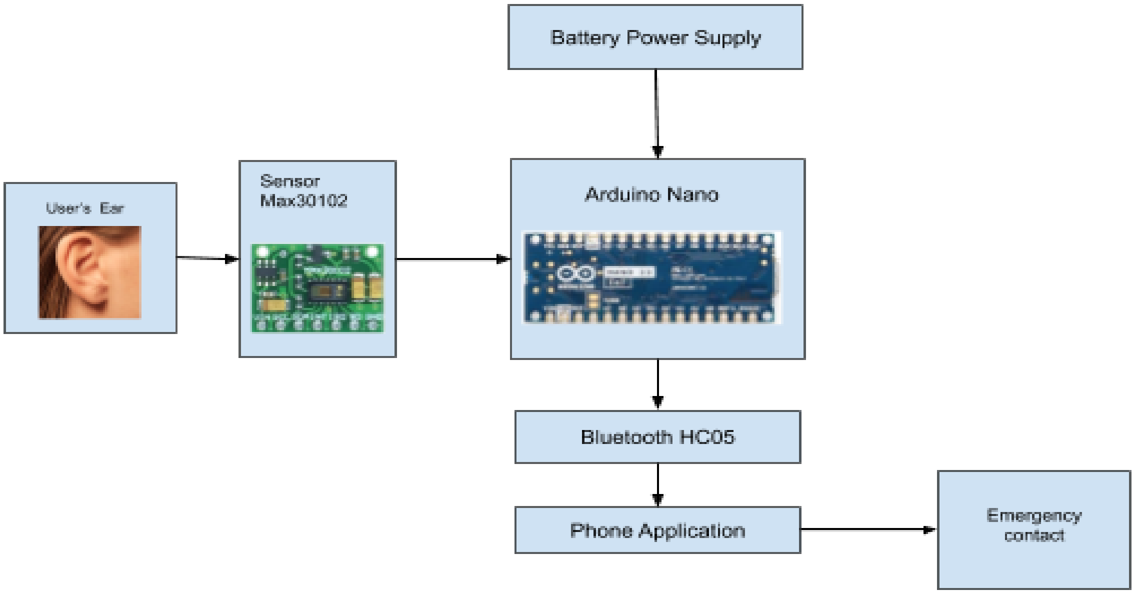


Figure 2. Schematic diagram of overall system

Here we see that the device located on the user's ear comes in contact with the sensor which is connected to the Arduino board. The Arduino board which would be powered by a battery would then send the sensor read value to the user's phone via Bluetooth and this can be seen on the built phone application. In the event of an overdose, the application would contact the emergency contact of the user. An extra feature that may be included in the case of extra time is an inbuilt alarm on the device would be triggered to alert for help from anyone around if immediate response from emergency contact is not provided.

2.2 Software Prototype

For the software, we intend to focus on the code concept and the outline of our pseudocode. For the bluetooth portion of the device we plan to create a code using arduino that will send a text message alert and user location to a loved one by connecting to the bluetooth in the users phone (automatically forwarding the text). Then the loved one can either administer naloxone or call for an ambulance for the user. The text alert cannot go directly to emergency responders because they are not able to receive automated messages.
An outline for the bluetooth code:

```
1) Check for input
2) If sensor value < 90% or if sensor value < 10 breaths/minute
3) strcpy(message, "The user is overdosing! Administer naloxone or call for an ambulance");
4) strcat(message);
5) Serial.println(message);
6) Else check for input
```

For the other major section of our solution, we plan to accompany it with an app. In terms of UI and UX, we want to make it as simple as possible for our first prototype, since this prototype is a proof of concept. For the app's backend, we have decided to outline the major section needed to create in the form of a pseudocode whose major functions are described below:

Pseudocode for the user's location

We are obtaining the user's location by creating an app that sends the user's cell phone location(GPS) to the Arduino. This connexion between cellphone and Arduino is made by Bluetooth. The user can turn it on or off the connection through the app.

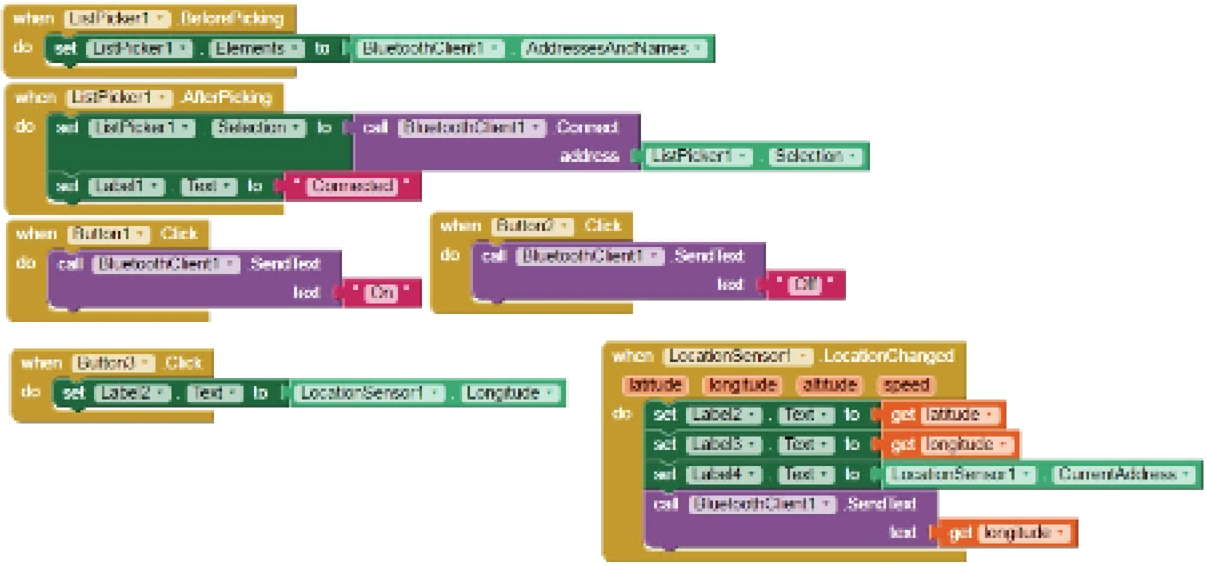

when ListPicker1 . BeforePicking
do set ListPicker1 . Elements to BluetoothClient1 . AddressesAndNames
when ListPicker1 . AfterPicking
do set ListPicker1 . Selection to call BluetoothClient1 . Connect
address ListPicker1 . Selection
set Label1 . Text to " Connected "
when Button1 . Click
do call BluetoothClient1 . SendText
text " On "
when Button2 . Click
do call BluetoothClient1 . SendText
text " Off "
when Button3 . Click
do set Label2 . Text to LocationSensor1 . Longitude
when LocationSensor1 . LocationChanged
latitude longitude altitude speed
do set Label2 . Text to get latitude
set Label3 . Text to get longitude
set Label4 . Text to LocationSensor1 . CurrentAddress
call BluetoothClient1 . SendText
text get longitude

Figure 3. Pseudocode of bluetooth communication.

Pseudocode for the oximeter and respiration rate

```
1) Set LED using MAX30100 to detect oxygen saturation
2) Check for storage space
3) Detect the first beat and last beat
        Check for the beat(led)
          i)  If waiting for the beat, take minimum and try again to detect the beat and
              find the beat/Period (Masking)
          ii) If the tracking is lost reset and restart
4) Check for bias(error)
5) Check temperature by comparing with sample temperature
6) Get HearRate
    a) Use pulse
    b) If pulse !=0
       Return (1/(pulse*1000*60)

7) Get SpO2
        interim=(FirstLEDvalue)/(SecondLEDvalue));
        interim2=115-25*interim;
8) Check temperature
9) Return information
```

3. Test Objectives Description

3.1 Specific test objectives

Our objective for this test is to determine the physical size i.e weight and discreteness of the device, establish communication between different components and determine the basic outline of our pseudocode. We will use simple materials to accurately represent the physical size of the device so that we can determine if placing the device on the earlobe is a feasible idea. From this physical prototype we will also get a good idea of how discrete the device is and we can determine ways to make it more discrete. An important part of this test is to ensure that all the different components of this device can communicate and are compatible. We need to know that our product will be capable of measuring oxygen concentration and respiratory rate, then communicating that if it is too low an alert needs to be sent. From this we need to have that bluetooth and GPS components of the device interacting with each other to send an alert for help. We will be creating an outline of our pseudocode to test if the different components of our device can communicate.

3.2 What exactly is being learned or communicated with the prototype?

For our first prototype, our goal is to have a proof of concept. In other words, understand if the solution brainstormed by the team is feasible under the various constraints that were given to us. The first prototype is used to create basic visual concepts for clients as well as depict an overall view of the pro and con of the design. We have developed various test cases which include the following sectors: sensor and communication, device discreteness, pseudocode. They were to evaluate our design, determine the area that needs to be redesigned and create the foundation for our model. The test cases related to sensor and communication will primarily be focused on accuracy and feasibility. Concerning the device's discreteness and physical size, we will evaluate how suitable is the device in aspect of size and positioning in respect to a human body and also how discrete is the device, an essential feature of the device.

Since our project is divided into two major subsections, the software related portion of this prototype will be centered around the pseudocode specifically the logic and flow of the various components of the app. The software section will overlook the UI/UX, storage and display of the information, as well as the alert to the third-party. This will create a foundation to build on later and prevent major mishaps later on. For the software section, the goal is to create an overall flow from the user perspective as well as from a structural and algorithmic perspective. So this aspect of the project, we will have the detailed idea of what the user should go through and how they would interact with the app. In addition we will have a proper learn about the loop-whole we might have missed when thinking about the algorithm and the UI/UX.

3.3 Possible types of results?

In terms of possible type results we may have several. The ideal situation would be that all our tests and our first prototype is perfect and the device needs little to no modification. In contrast, we also have the option that both our hardware and software, completely fail and we will need to go back to the brainstorming stage, and rethink our design taking into account the reason why the device failed in the first place. The most likely situation, is that your device will need some major/minor modification base on the type of error or road block we encounter.

Some possible type of result we may obtained are:

- the oxygen saturation is not measured accurately
- The alert is not sent/ or accurately sent to the third-party
- The oxygen saturation/respiratory rate is well calculated and displayed
- User can't find/modify the information inputted
- Data not displayed correctly
- Device is not comfortable/durable
- Aesthetically pleasing, easy to use and comfortable
- The data from the hardware is not send correctly
- Device sent alert on time and to the right people

3.4 How the results will be used to make decisions or select concepts

Based on the information/result we obtain in the testing phase as previously mentioned, we will modify our design based on the error obtained. If the particular sub system depends on another system, we will have to go through every other system that was required by the faulty system and evaluate them separately to determine the one at fault. If the test's failure is due to inaccuracy or miscalculation we will have to review and modify the algorithm. In the cases related to design, the design itself will have to be rethought in terms of the constraint requirement by the client as well as new information that was given through the test cases. A particular system will be chosen based on how well it performed in contrast to the other concept. The different concepts will be benchmarked against each other using a table with the different applicable requirements which can include the following: cost, time, size, weight, accuracy, aesthetics, safety and other related requirements.

3.5 Criteria for test success or failure

Hardware: We are developing a physical design to define the size of the device in order to make the user feel comfortable while using the device. Therefore, a failure is making the prototype disproportional, prejudicing the comfort of the user. The success is the opposite, making a prototype that fits well with the users' body, is lightweight, discrete and does not affect their well being.

Software: Seeing that we are only outlining the pseudocode the success would be having the code working by itself, not as a part of the entire device. We separated the software for the first prototype in three parts, obtaining the user's location, sending an alert, obtaining oximeter and respiration rate. A failure would not have one or more parts working. Since we are not working with any of the sensors nor the Arduino, "not working" would be not having the code of one or more parts compiling on the IDE.

3.6 What is going on and how it is being done

The type of prototype we are doing is a focused prototype; we are only going to be implementing a few attributes of our product. The reason that we are doing this type of prototype first is because we need to validate initial concepts of our design and get answers to questions we have about our product before we put time, money and resources into a more comprehensive prototype. Completing a more simple, focused prototype first will allow us to communicate ideas and any problems in our design in an inexpensive and quick way. Our focused prototype will be the physical design of the device and the basic pseudocode.

3.7 Testing Process

Hardware: We made some sketches and picked the best one based on aesthetics and size. Then, we searched the internet to find similar-looking headphones. When we found a similar headphone we obtained its dimensions from which we will reproduce our sketch on SolidWorks and then we 3D print the model. In order to test the hardware, the team will place the prototype in different people and ask for feedback on the comfort of the device. The feedback must include the size, weight, and aesthetics of the device.

Software: We looked for codes on the internet separately in three different parts: oximeter, alert and, the user's location and used them to analyse our pseudocodes. In order to test the codes completely, we must compile them in their respective IDEs, user's location code on MIT app inventor and alert and oximeter code in the Arduino IDE to look and fix errors.

3.8 Information being measured

-Size: we want to find the optimal size so the device can have all the desired features and also be discrete in order to avoid discrimination against the user.

-Level of comfort and usability: the device has to fit well with the body of the user and also be aesthetically pleasing, the user will not use a device that makes them uncomfortable.

-Functionality of software: the software has to pursue all the functionalities that were planned, if the software does not have the functionalities, the device will be incomplete.

3.9 Information being observed and how is it being recorded

In order to complete a full analysis of the current stage of development, it is important to thoroughly reflect on all results. Observations involving the sensors and communication of data should include accuracy of sensor measurement, accuracy of calculations, whether data is correctly displayed, and difficulty for the user to access data. Repeated tests are an effective way to analyze trends in how the hardware and software are interacting. Creating data tables of these results will allow us to ensure consistency in the results. These tests should include measurements of the oxygen saturation and respiratory rate. To test the accuracy of the pseudocode calculations, we should compare the results to manual calculations, and ensure consistency between tests using the data tables. When testing convenience, subtlety, and comfort of the device, the focus of testing should involve real-world analysis by considering how users respond to the device, and examining its practicality and convenience. Real-world testing can also help us determine how users respond to the aesthetics of the device. We can record feedback on comfort and aesthetics and make modifications accordingly. Durability can be tested using a variety of physical tests, guaranteeing the device will be reliable in user’s every-day lives.

3.10 What materials are required and what is the approximate estimated cost?

3.10.1 Bill of Materials

MATERIALS	COST(Taxes not included)
Bluetooth (HC05)	$11
Arduino Nano (regular)	$22
Oximeter (MAX 30100)	$24
3mm Red Led	$0.03
1KΩ Resistor	$0.15
Push Button	$0.60
Battery (5V):	$23
Solidworks earpiece case	$0, To be built on Solidworks and 3D printed at the University.

3.10.2 Estimated Cost

Total Estimated Cost of materials = $80.78

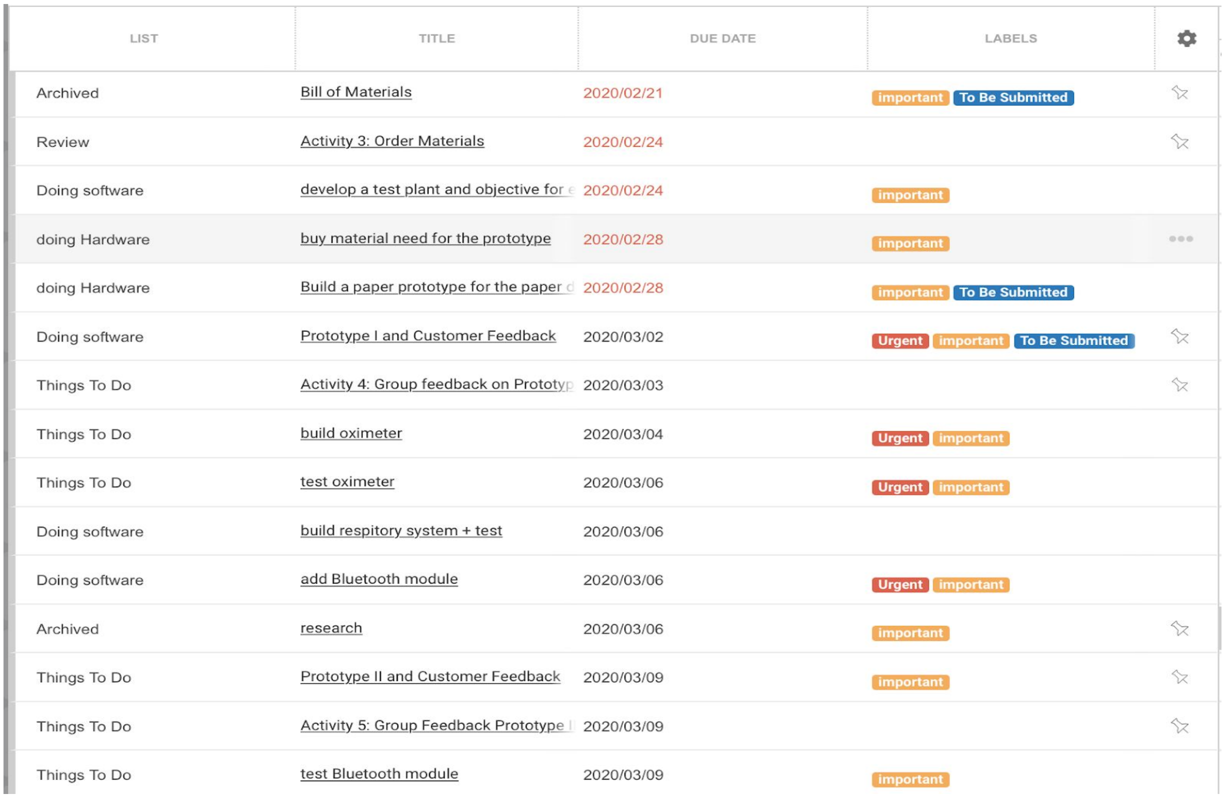
3.11 Work to be done

In order to complete this prototype, we must ensure all tasks and dependencies are done effectively. Both the software and hardware should be tested to ensure their function. We must begin with writing the code and building the physical prototype. Once the software and hardware are running, we can begin to test for accuracy. Testing should include measurement of sensor and communication accuracy, analysis of the discreteness and convenience of the device, and logic and and flow of the pseudocode (eventually the final code as well). Researching and comparing our current design to other options and ideas is important in the design process. When all data is collected, analyzing the results helps to conceptualize any necessary modifications that should be made for future designs. Comparing our current design to other options and ideas is important in the design process.

4. Analysis of Prototype Test Plan

4.1 How long will the test take and what are the dependencies

To analyze our first prototype we would be performing tests which include testing the feasibility of locating the device on the ear, the size and weight of the device and the pseudocode of the program that would enable communication between the device components. However, before these tests can be performed there are certain tasks that need to be done and they have been included as subtasks in our overall project schedule as seen in the figures below.



LIST	TITLE	DUE DATE	LABELS
Archived	Bill of Materials	2020/02/21	important To Be Submitted
Review	Activity 3: Order Materials	2020/02/24	
Doing software	develop a test plant and objective for	2020/02/24	important
doing Hardware	buy material need for the prototype	2020/02/28	important
doing Hardware	Build a paper prototype for the paper	2020/02/28	important To Be Submitted
Doing software	Prototype I and Customer Feedback	2020/03/02	Urgent important To Be Submitted
Things To Do	Activity 4: Group feedback on Prototyp	2020/03/03	
Things To Do	build oximeter	2020/03/04	Urgent important
Things To Do	test oximeter	2020/03/06	Urgent important
Doing software	build respitory system + test	2020/03/06	
Doing software	add Bluetooth module	2020/03/06	Urgent important
Archived	research	2020/03/06	important
Things To Do	Prototype II and Customer Feedback	2020/03/09	important
Things To Do	Activity 5: Group Feedback Prototype	2020/03/09	
Things To Do	test Bluetooth module	2020/03/09	important

Figure 4. Screenshot showing the dependencies in a list form

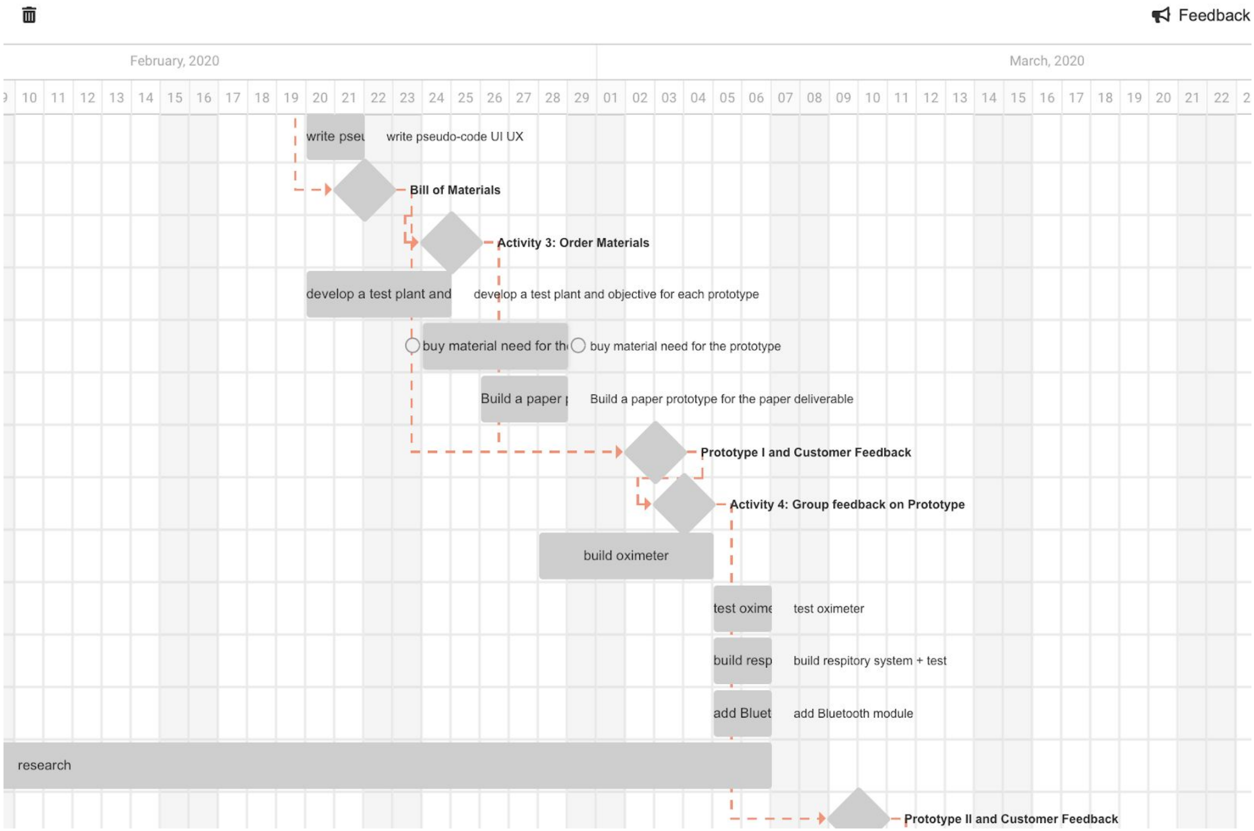


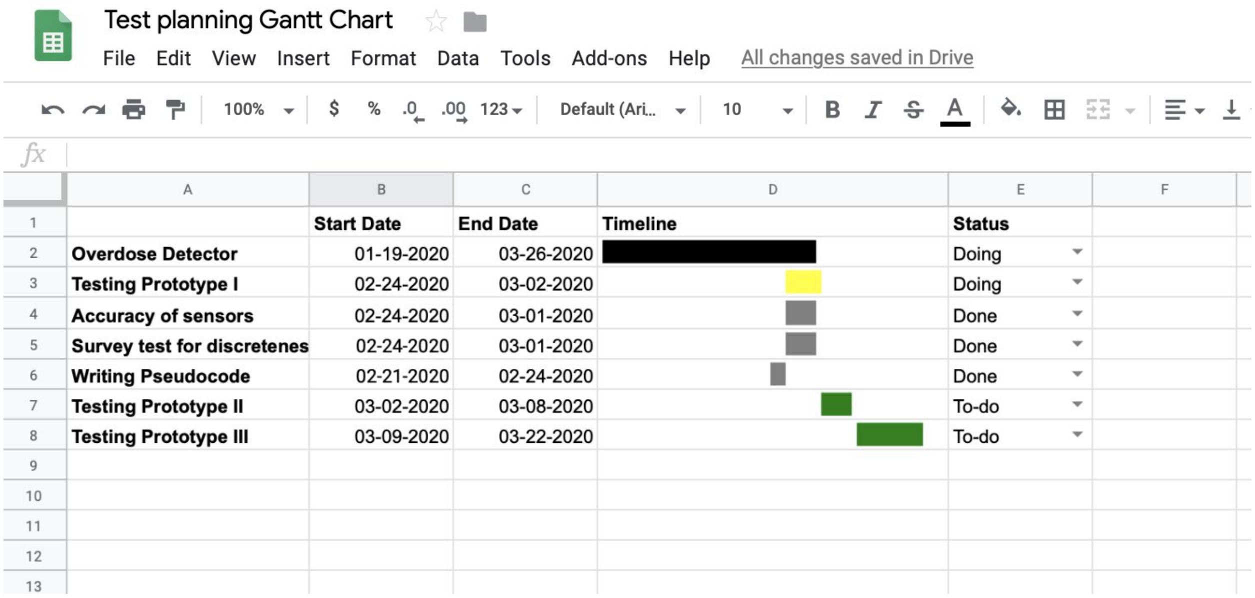
Figure 5. Screenshot showing the dependencies as a gantt chart

From these figures we have a clearer view of all subtask on which the testing of our first prototype depends and they include briefly:-

- Creating a final visual design to have a view of how the hardware components would be placed.
- Writing the pseudocode for the software.
- Developing a test plan for the prototypes.
- Purchasing the necessary materials.
- Building the prototype.

4.2 Test planning Gantt chart

To help keep track of our testing plan for all prototypes leading up to the final design, we have made a simplified gantt chart using google sheets. Subtasks for the first prototype have been included in this gantt chart and tasks are marked as either done, doing or to-do. We can also see the progress of the overall task(colored black), which takes into account the progress of subtasks. For the next prototypes we would also be including subtasks that would be done before their due dates. Attached below in Figure 5 is a screenshot of this separate test planning Gantt chart.



	A	B	C	D	E
1		**Start Date**	**End Date**	**Timeline**	**Status**
2	**Overdose Detector**	01-19-2020	03-26-2020	⬛	Doing
3	**Testing Prototype I**	02-24-2020	03-02-2020	🟨	Doing
4	**Accuracy of sensors**	02-24-2020	03-01-2020	▨	Done
5	**Survey test for discretenes**	02-24-2020	03-01-2020	▨	Done
6	**Writing Pseudocode**	02-21-2020	02-24-2020	▨	Done
7	**Testing Prototype II**	03-02-2020	03-08-2020	🟩	To-do
8	**Testing Prototype III**	03-09-2020	03-22-2020	🟩	To-do

Figure 6. Gantt chart of testing plan

5. Analysis of Prototype

5.1 Analysis : Sensor and Communication accuracy

From testing the quality of communication between the components in the device and the accuracy of the sensors in taking oximetry and respiratory rate readings, we would be able to certify the compatibility of the components. After performing the measurement and communication accuracy, if need be we would quickly make arrangements for alternative components. This test would enable us to present to our client a prototype that shows quality communication and accuracy when detecting an opioid overdose as this was a requirement in our design specification. Testing for this prototype would be completed once compatibility and accuracy of components have been established. Below is a figure that shows how the internal components of the hardware would be connected.

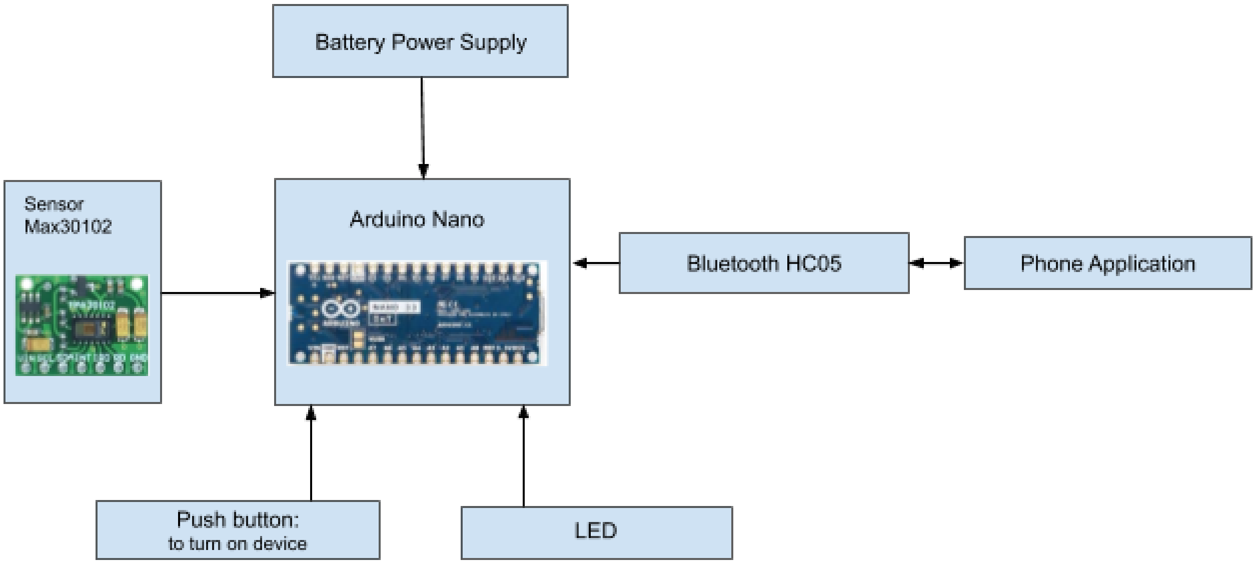


Figure 7. Block diagram of the connection between hardware components

5.2 Analysis : Discreteness and Convenience of device

Another criteria for which we would be testing a prototype for are the convenience of the location of the device and the size of the device. Considering that our final visual design for our overdose detector was made to look very much like a mono headset as in Figure 7. In order to eventually develop a final prototype that would be used by many in the existing market, the test prototype in this case would look really similar to our final solution. Similarities would include the volume, weight and shape as we would not want to end up with a working device that is too big or heavy to be worn on the ear. By testing the prototype we would be aware of changes that could be made to the size and shape of the device. The test would mainly be through feedback from potential users from which we could develop an analysis of the percentage of people who are likely to use a device located on the ear knowing it would help save their life. Completion of this test would be marked by obtaining a high number of positive feedbacks from the current location or in other case relocating the device to a more acceptable part of the body.

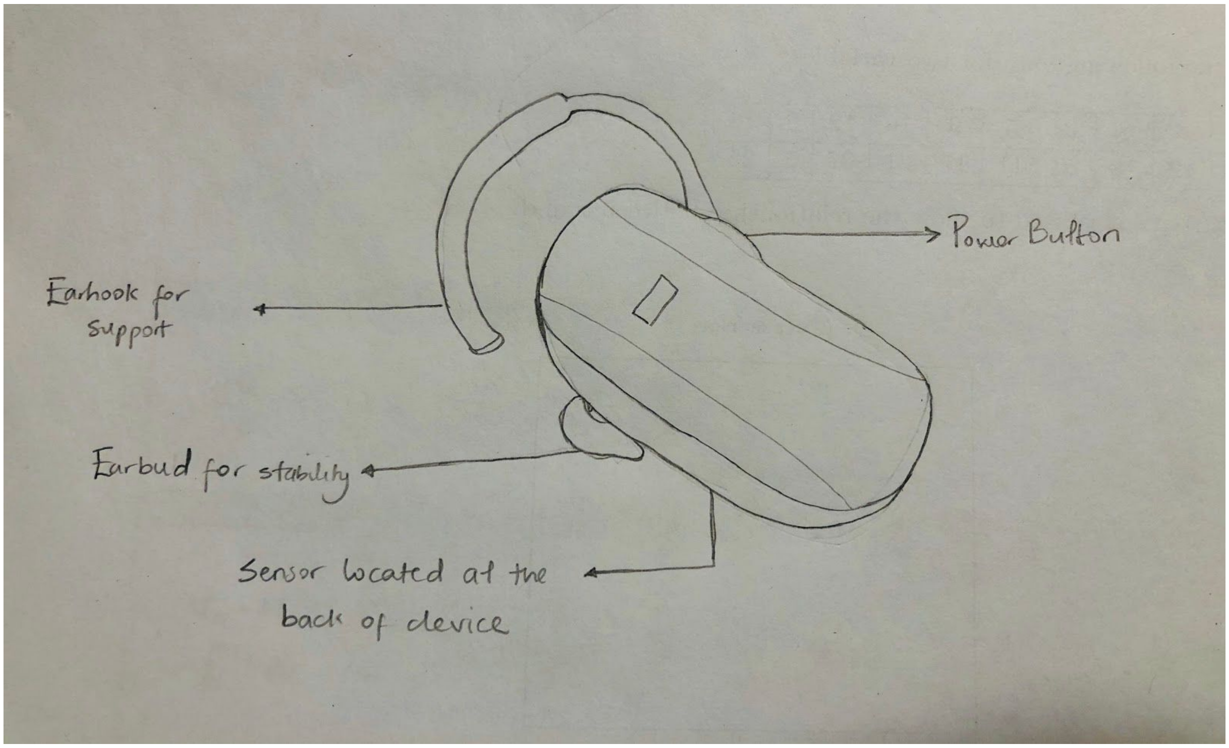


Figure 8. Final visual design similar to a mono headset

5.3 Analysis : logic and flow of the pseudocode

For the software aspect of our first prototype, we have prepared a pseudocode that expresses the logic and flow of the program. This is a sketch of the program that would help control the communication between the hardware and the application on the phone. Similar to the communication between sensors, the program plays an important role in achieving a final device that accurately detects overdose. From analysing the pseudocode and comparing it against the time factor we would have an exact view of the requirements that should be prioritized and those that can be dropped. This test would be marked as completed when the aspects of the software to be completed lines up with our timeline of events as seen in our overall gantt chart (figure 4).

6. Feedback

As previously mentioned, after brainstorming the team came up with a final solution to present to the client. Though we presented all three solutions to the client we focused on the one we were going to move forward with to get more specific feedback. After discussing with the client, she noted that the device should not be dependent on wifi or cellular data since not all our clientele have access to it. We also received feedback from our TA, who advised us to not include the respiratory sensor since we would not be very likely to complete it under our time constraint so as a result we have decided to drop it. As a result, of feedback given by the client we reduced the location to a single headset shaped earpiece to make it easier for the user to interact and adopt the device. In addition, we talked to Professor Knox and he advised us to make sure the client would use it. Though, he said we would not have time to completely change the direction of our project we should keep in mind our client age range and type and see if they would want to wear this type of device in their daily lives or else it would defeat the whole purpose of the project.

7. Conclusion

The purpose of this prototype was to help us learn how we can improve our design visually and give us a basic understanding of the components of the pseudocode that we will later integrate into the fully functioning device. A focused prototype was the best type of prototype to use at this point in our design process because it allowed us to implement a few attributes of our product at a low cost. In this prototype we measured the size, level of comfort and basic functionality of software. We observed how people interacted with the device in a real-world setting and recorded their feedback on how to improve the device. We also benchmarked our prototype with other products to help further develop our product and generate new ideas. From feedback we have received we have decided to drop the respiratory rate sensors in our design due to limited resources and time. Moving forward we need to develop the pseudocode in more detail and work on combing the code for obtaining the user’s location, sending an alert and obtaining oximeter readings. Our next steps in the physical design of our prototype would be to design a model in solidworks of the earpiece that contains the hardware for the device so that we can 3D print it.

8. References

- Knox, David. "Arduino Sensors and bluetooth w20." Jan. 2020, Ottawa
- Knox, David. "Lecture 11 - Giving and Receiving Feedback and Prototype Test Planning." Jan. 2020, Ottawa
- Instructables, “Arduino Pulse Oximeter Using MAX30100,” *Instructables*, 19-Sep-2017. [Online]. Available: https://www.instructables.com/id/Arduino-Pulse-Oximeter-Using-MAX30100/. [Accessed: 02-Mar-2020].