Project Deliverable H

Prototype III and Customer Feedback

GNG 1103 – Engineering Design

Team 2

INTRODUCTION

After completing our planning for the project, building a few prototypes centred around the idea of aesthetics and practicality, we are now prepared to design our actual working prototype which will be presented to the client. This prototype will function as an almost final product. It includes the functional components such as the oximeter and bluetooth device.

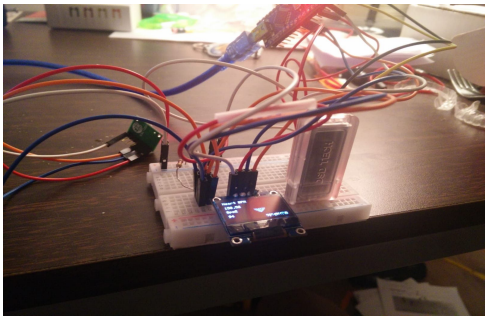
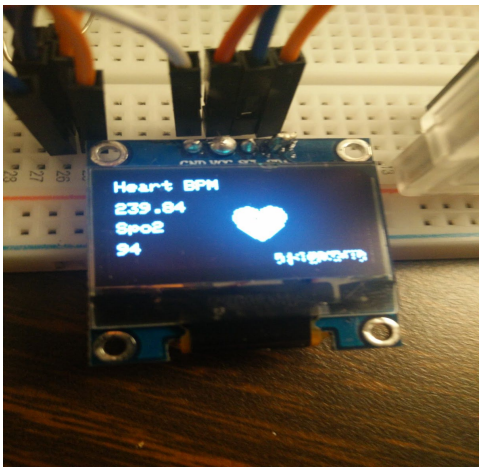
The aim of this prototype is functionality. The ability of our design to read oxygen levels and connect via bluetooth is the primary objective of this prototype. We have programmed the oximeter to read levels and display them on a screen along with heart rate. The bluetooth device has also been connected and functions with an app created for smartphones.

When our team met with the client in the first meeting and the presentation we had the chance to receive feedback and incorporate it into our prototype. Some of the comments received were related to naloxone injection, comfort of the device, and the ability of an individual to wear it throughout the day in a practical, discrete fashion without any issues such as battery life.

Combining the lessons learned in the previous client meets, presentations, labs and classes along with our previous prototypes we plan on making a prototype which not only improves past designs but also functions as an almost final product.

FINAL PROTOTYPE SYSTEM UPDATE

PROTOTYPE 3: PHOTO REFERENCES

PROTOTYPE	DESCRIPTION
Prototype Hardware	
 *Figure 1*  *Figure 2*	Figure 1:Connection of all hardware components of the device when the device is turned on. Figure 2: Display on the OLED screen when the device is turned on. Figure 3:Subsystems featured: Bluetooth module, OLED display screen, oximeter and Arduino Nano.

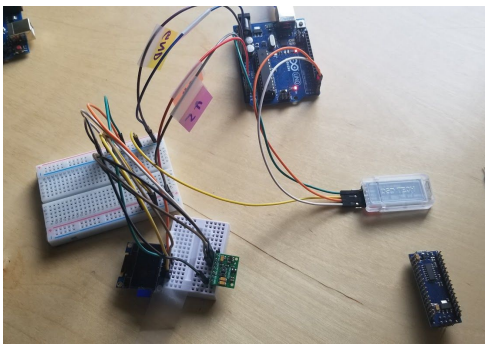


Figure 3

Device Casing

Figure 4

Figure 5

Figure 4: Picture of adjustable arm strap that would have been used in final design

Figure 5: Picture of adjustable strap on arm of a tester.

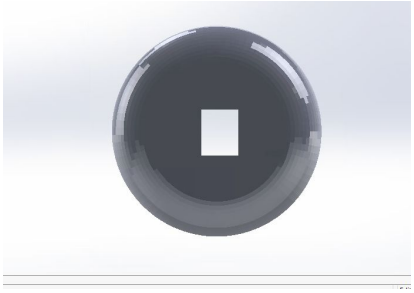


Figure 6

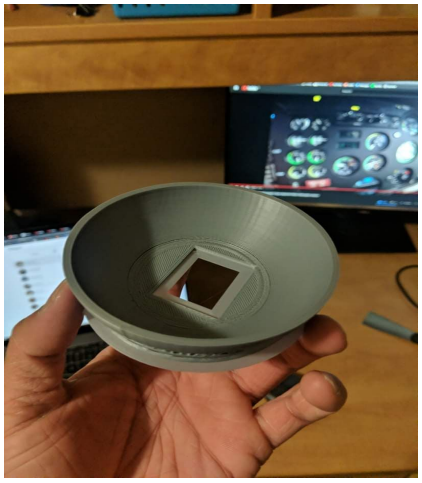


Figure 7

Figure 6: CAD drawing of second device casing design

Figure 7: 3D printed model of device casing that would have been used to store all of the device hardware.

Application

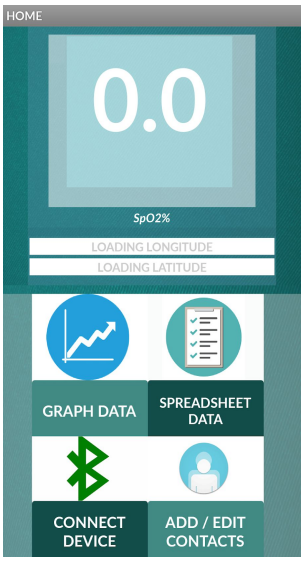


Figure 8

Figure 8: Layout of home screen of the device application.

Features:
-User blood oxygen level display
-User location display
-Data representation/storage functions (graph/spreadsheet)
-Emergency contacts storage

0.0 **%SpO2**

Figure 9

Figure 9: Graph data screen

Figure 10

Figure 10: Spreadsheet data screen

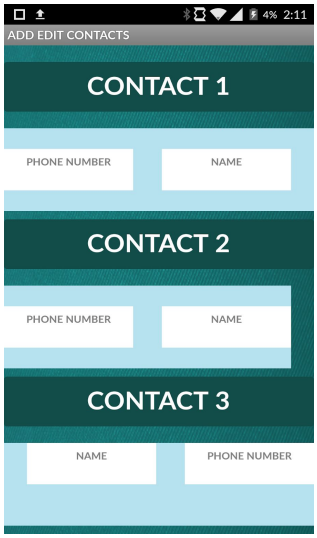


Figure 11

Figure 11: Emergency contacts screen

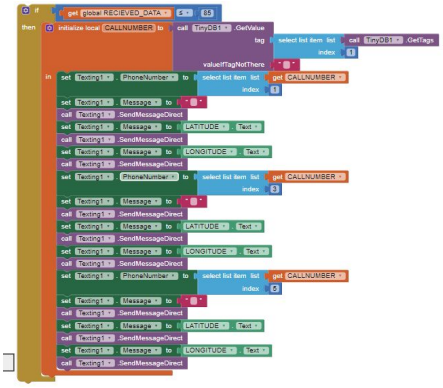


Figure 12

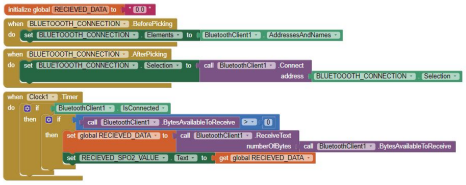


Figure 13

Software Used for Main Application Functions

Figure 12: Code used to call emergency contacts when the users blood oxygen level reaches under a preset threshold.

Figure 13: Code used to connect application to bluetooth module

VIDEO OF WORKING SYSTEM

https://youtu.be/eHZKTtoq1e0

REDUCING RISK / UNCERTAINTY:

The building of our final prototype occurred during the COVD-19 facility closures, so our group began to work faster as we were not sure how we would be able to meet as many of our group members use public transportation to reach campus. At the beginning of the design stage we decided to prioritize soldering the functional components so that once the hardware components were finished, all coding and deliverables could be done online from home.

Another method we implemented to reduce risk was to take all of our prototypes and materials from our STEM locker. This was done near the end of the prototyping stage in case we were not allowed to enter university facilities due to the COVID-19 virus. We also decided to only give one group member all of the hardware components so device tests could be completed more efficiently during quarantine.

In order to avoid shipping delays, our group also ordered the majority of the parts necessary for the function of the device within the first week of the prototyping process. By implementing this strategy we were also able to start testing early to find any noticeable bugs; giving us more time to fix them before the deadline.

PREVIOUS PROTOTYPES

From previous prototypes, our group has learnt many things regarding the hardware and software aspects of our product. In terms of hardware, we have learnt that it’s easier to solder wires that are not copper based, as copper wires are thicker compared to the general

metal alloy. On top of this, we found that copper is less conductive than the typical jumper cables. This was learnt when soldering the copper wires. We realized copper wires required more solder and greater precision as the solder spreaded and nearly touched other hardware parts on our oximeter board.

During our first attempt at wiring the bluetooth module, oximeter, and oled screen, we found that it was much easier to wire everything to one breadboard compared to having everything separate. We also found that soldering directly to components allowed for the connection to be more secure compared to curling the wires around the connection sites during testing.

When the device application was first created, the main colours that we chose to implement were red and orange. However, we quickly realized that these colours could cause anxiety in user (this rule was used in hospitals) which led to us switching the colour scheme to various blues and dark greens to create a calming environment for the user.

INTEGRATION OF CUSTOMER FEEDBACK

In the first client meeting, we learned many useful things that we have successfully implemented within our final design. These included design limitations that we were not aware of until the meeting, such as how the device cannot be allowed to inject Naloxone directly into the user. As well as how the device cannot be allowed to directly contact Emergency Medical Services when the device detects an overdose. Despite setbacks in the beginning, we successfully implemented all of the initial design criteria into our final solution by creating a product that has the capability of contacting (up to) three emergency contacts once the device

detects user SPO2 levels reach a dangerous level.

In the second client meeting, we received a lot of beneficial feedback, directly for our prototype and in general. One of the main comments we received suggested that we needed to ensure that our device is comfortable. We tested and optimized on this trait by asking volunteers to wear our device/arm band for 12 hours (regular work hours) and received feedback regarding the comfort, weight and secureness of the device. Another important piece of feedback we received from the client was in regard for the battery life. It is very important to ensure the battery of the device has enough power to last an entire work day. Although our group never had the opportunity to experiment with our battery pack due to difficulties caused by the COVID-19 virus; we did conduct calculations for a rechargeable battery that can power our device for 12 hours at a time.

During our lab session, we learned from our T.As that the main focus for design day and for the project should be about user experience. Additionally we learned how the non-functional requirements for our device are equally important to the functional requirements. An example of this can be seen through the design of our device casing, in which we chose a container that is concealable, appears more natural to others around the user and feels more natural for the user to move around in.

FINAL PROTOTYPE: DESCRIPTION

Our device is divided into two main subcategories; software components and hardware components. All of the hardware subsystems are featured in the actual device and are responsible for obtaining the necessary information inputs while producing the intended device

outputs. In contrast, the software components are responsible for the communication between each subsystem, especially when it involves transferring information between each subsystem. All of the software components aside from the device code are located through our device application. The hardware subsystems compose of the Bluetooth module, oximeter, OLED and Arduino Nano. For user input, the user's blood oxygen level and heart rate are detected through the IR sensor on the oximeter. From there the Arduino Nano will transmit the data collected from the oximeter to the Bluetooth module and OLED display screen; which will display both the user's heart rate and blood oxygen level. After the Bluetooth module receives the blood oxygen level it will relay the data to the device application which will be downloaded on the user's phone. However, this process is only possible if the user's phone is connected via Bluetooth to the device module. The application will continue to monitor the user's blood oxygen and will notify the emergency contacts set by the user when the user's blood oxygen level drops below a certain level.

FINAL PROTOTYPE : PURPOSE AND FUNCTION

Our final prototype represents a functional, high-fidelity prototype that is physical and comprehensive. In order to create our final prototype, we incorporated all of the individual hardware and software components that we successfully tested back in Prototype II. We wanted to verify that all of the subsystems of the overall device functioned together as intended, while verifying that the device is receiving valid inputs while producing the desired outputs. Multiple tests were created (as shown below) which specifically address the communication and data transfer of subsystems and the capability of the device to produce the desired outputs.

FINAL PROTOTYPE : USER INTERACTION

Our device is designed to be strapped onto the user's upper arm through the usage of an adjustable armband; allowing for a comfortable but secure fit. The device does contain a small user interface on the armband with the incorporation of an OLED screen which displays the user's blood oxygen level and heart rate. The OLED screen was incorporated as it makes the device easier to use while maintaining discreteness. By adding the screen, the user is not solely dependent on viewing their phone for data regarding their blood oxygen level or heart rate; it also adds reassurance to the user by providing them with easily accessible data.

The majority of the user interface for the device is provided within our device application. When the user downloads the device application on their mobile device and successfully connects it to the Bluetooth module; the device will automatically begin sending the user's blood oxygen data to the application. We specifically designed the device application to prioritize user usability. For the aesthetics of the application, we originally decided on basing the colour pattern around the colours red, orange, white and yellow; however, we realized that these colours may induce increased stress and anxiety to the user. This resulted in us changing the colour pattern in our final prototype into a dark green / turquoise which we believe promotes a more relaxing user environment. For the final prototype of our device application, we incorporated only the necessary functions that the app may need to operate. By making the app as simple as possible our philosophy is that it will be friendlier to the user and promote a better user interface. The app itself features two main displays and four main functions. The main display that is featured on the homepage of the application will directly display the blood oxygen level of the user transmitted by the Bluetooth module. Underneath the main display are two smaller displays,

showing the current location of the user. One display will feature the latitude while the other the longitude. These displays notify the user that their location sensor is working properly; additionally, the user may also feel more relaxed in knowing that the app is monitoring their location in case an emergency were to occur. Finally, the app features four functions in which the user can activate on command. The first two relate to app data storage. On the home screen, the user has the ability to view the data saved on the app. The app has the ability to sort the data that is transferred to the user's mobile device (heart rate & blood oxygen level) and display the data through a graph or spreadsheet. In case of an emergency overdose, the saved data can also be beneficial for any physicians that would be examining the user as it provides them trends for the user's condition. Aside from data storage, the application also gives the user the ability to enter three emergency contacts which the app will store. When the application detects a blood oxygen level lower than the overdose threshold of 85%, it will automatically send an SMS text to each of the contacts that the user has inputted simultaneously. These texts will contain information regarding the current situation of the user along with their location and instructions for contacting emergency services.

PLANNED EXECUTION UNDER NORMAL CONDITIONS

UNCOMPLETED ASPECTS

For our original project plan to be completed we needed access to both the 3D printer and soldering kit within Makerlab. However due to the outbreak of the COVID-19 virus we were unable to complete these tasks. Our device's speaker system was one of the subsystems that was affected by the closure of Makerlab. Originally we had planned to attach

our speaker system to the main device through soldering pins onto the speaker and connecting it to the device arduino through wires. In the end we were unable to accomplish this task due to not having access to a soldering iron. We attempted to use other methods to connect the speaker system to the main device, such as through the usage of jumper wires, but they all failed. Another problem that we faced as a result of the closure of Makerlab was the inability to transfer our prototype onto a PCB board. This was a result of our group being unable to solder the individual sub-systems and permanently attach them onto the PCB board. Because of this setback, our final prototype still utilizes a breadboard and jumper wires for connection; it also prohibited us from fitting the hardware into the device's 3D printed casing.

Another component of our final design that we were unable to complete was the final design casing. Throughout the project we designed three main casings to store the hardware of our device. Only the second design was 3D printed and physically tested; the first design was created using household items while the final design could not be printed due to the COVID-19 outbreak. Final testing revolving around our device casing was also cancelled due to the inability of producing a physical prototype and the difficulty in finding volunteers to test the device due to the quarantine.

Additional setbacks were also experienced in the shipping for material. Materials that we needed within the last two weeks of our design schedule, such as a battery pack and arm-strap could not be shipped within the time limit of the project due date.

ACTION PLAN

DATE	TASKS
MARCH 16	Program the app. **Deliverable J.** Work on the next deliverable throughout the week.
MARCH 17	Program the app throughout the week.
MARCH 18	Work on deliverable J.
MARCH 19	Prepare for final presentations. Work on deliverable J.
MARCH 20	**Project final presentations.**
MARCH 21	**Finish the application.**
MARCH 22	**Deliverable I.** Work on the next deliverable throughout the week.
MARCH 23	Work on deliverable I.
MARCH 24	Work on deliverable I.
MARCH 25	Final test to ensure the final design is fully functional. **Finish up Deliverable I.**
MARCH 26	**Design day.** Prepare the presentation area and present the final design and idea.

Gantt Chart can be found here: Gantt Chart

FINAL PROTOTYPE TESTING

PROTOTYPING TEST PLAN WEEK #3		
Objectives		
Finish Speaker Testing	Criteria/Objectives	The main objective of this prototype test is to successfully integrate the speaker system. This is the last main subsystem to our device. Verifying that the speaker performs its designated function is an important aspect to our device, because it works as a failsafe. If the emergency contact doesn't respond or arrives too late, the alarm goes off then it will attract someone to come assist the user in need.
	Execution/Process	To execute our plan for this prototype, we are going to take the following steps. First, we will hook up the speaker to the breadboard with the arduino, and run a basic code on it to ensure that the speaker is making an audible sound. Secondly, we need to make sure our oximeter readings are synced with the arduino. After agreeing on a certain oxygen level, we'll edit the code so that when the oximeter detects that oxygen level the alarm will sound.
	Dependencies	There are many dependencies in order for the speaker to function in sync with the oximeter. But for the individual speaker testing, all that is required is a breadboard, an arduino, and a functioning code for the speaker.
Call Function	Criteria/Objectives	The goal for this prototype test is to have the call/messaging function on the app fully operational. This is a crucial test that must be completed in order to ensure that our device will be able to solve our problem statement. We are evaluating messaging ability as well as response time.
	Execution/Process	The execution of this test is straight forward. We will connect the app on the phone to the device via bluetooth. In the code for the oximeter, we will adjust it so that it sends out an emergency message when the blood level reaches 95% for example, just because we are unable to simulate too low of a blood oxygen level without passing out. Once this is done and the level is reached, we will see if the phone sends out the message to the listed emergency contact. A secondary test that we will conduct once we know the function works, is

		timing how long it takes for the message to be sent out once the “desired” blood oxygen level is reached.
	Dependencies	A key dependency that must be achieved before we can work on this test is to have the bluetooth module working between the device and the user’s phone. This is because the bluetooth module is the only means of communication between the phone/app and the device.
Printing / Testing Final CAD Model	Criteria/Objectives	The main aim for this step of the process is to design necessary components of our design on AutoCad and print them using a 3D printer. After integrating the printed components into the design the model will be tested.
	Execution/Process	For creating the cover for our device, we will need to use either AutoCAD or Solidworks design software to make a 3D model of what the cover will look like. Once we decide on the appropriate parameters for this device, it is just a matter of making the design on the software and 3D printing it from a STL file. Once the device is printed, then we will perform a drop test to identify the strength of the case. Dropping it from a series of different heights and accessing the damage after each trial.
	Dependencies	There are no immediates dependencies for this prototype, since accomplishing the test doesn’t rely on any of the other parts of the device.

CONCLUSION

This project started with an idea that later became a reality. The idea was to develop an oximeter that could detect SPO2 levels and detect an opioid overdose. As presented in this report, this was successfully achieved. Our previous prototypes were feasible and easy to work with. They gave us a good representation of our device and how it will aesthetically appear, as well as how it will function when fully assembled, but they did not go in detail about the functionality of the device. Many issues were met along the way. These include issues with the code, using the wrong source code, as well as not properly setting up our oximeter device. These issues were tackled by our team as we continued to put effort to complete and enhance the device. In the previous prototype, we concluded that the armband was too large, and that this would hinder the user's comfort. In the third prototype, we made the armband smaller to reduce the weight and make it easier to wear for an entire day. In addition, we set up a screen display as well as the oximeter, which can not only read oxygen saturation levels, but also heart rate. The final budget of our final prototype was $71 CAD.

To conclude, a significant milestone has been met. We created a device that is not only inexpensive, but also discrete, that allows for the monitoring of oxygen saturation levels for opioid users. It includes an armband that is lightweight and easy to wear for different sizes. Our Oxi-Flex device is unique, discrete, comfortable and reliable.