GNG1103

Deliverable D: Conceptual Design

Opioid overdose prevention device

Submitted by

GNG 1103, Section C01, Group 1

Adam Howe, 300111705

Tristan Brady, 300105281

Tyler Yu, 300133533

Zacharie Lefebvre, 300107348

Callum Lindgren, 0300121840

February 9th , 2020

University of Ottawa

Table of Contents

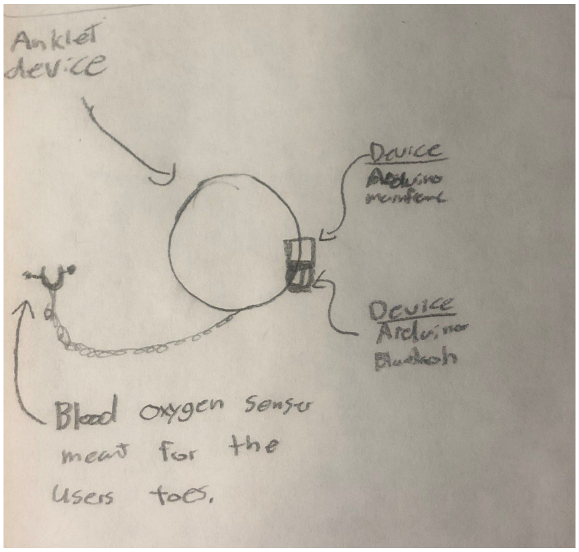
Introduction

The objective of this deliverable was to produce and come up with a multitude of design concepts for the opioid detection device. The strategy we adopted was to assign each team member 3 to 4 design concepts to come up with on their own and to later compare everyone's separate ideas using design criteria. This way we could get a broad view of our team members ideas and not have to rely on group think. This strategy will allow us to have an ideal prototype and be more prepared for upcoming work on the device. Each team member will use the problem statement (shown in deliverable B) as a foundation for their own individual concepts. The use of a numerical scale based on the previously stated and developed design criteria. The numerical scale will also allow for a fair and equivalent way of evaluating each team members ideas. At the end of this document the highest ranking concepts will be compared with other high ranking concepts in order to select a final design concept the team can agree on.

The goal of a problem statement is to outline the given problem and prioritize the needs of the customer's. When developing concepts it is crucial that they are relevant to the problem statement. As a team in deliverable B, a problem statement was created, "A need exists for opioid users to safely consume opioids without having the risk of overdosing through a portable device designed to activate EMS, effectively measure blood saturation while being cost effective." The team previously developed a list of functional and non-functional requirements that the final prototype would require. Some of the functional requirements for the device are real-time tracking of oxygen saturation percentage, real-time tracking of breaths per minute (BPM), alerting emergency services, being bluetooth compatible and not inhibiting movement or control. In addition to the requirements listed, a list of identification needs was used when creating ideas and concepts. The highest ranked needs for the project where to make the device discrete, have a long lasting product life, be between 100-200$ of cost, able to notify EMS and finally have high detection accuracy. A ranking system of 1-5 was used throughout this process, where 5 (ideal), 4 (good), 3 (manageable), 2 (had some problems problems), and 1 (was non-passable based on our needs).

Team Member Concepts

Adam’s Concepts

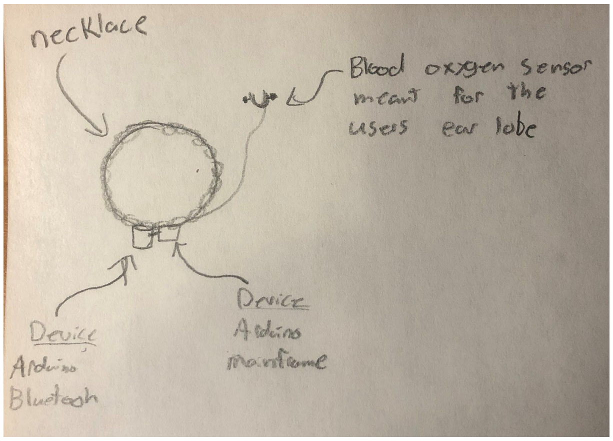


Concept 1: Anklet Device

For this concept, the blood oxygen sensor will be attached to the users toe, with the arduino compartment of the device attached to an anklet. This concept also includes bluetooth, and the capability to notify EMS.

Pros: Discrete

Cons: Discomfort

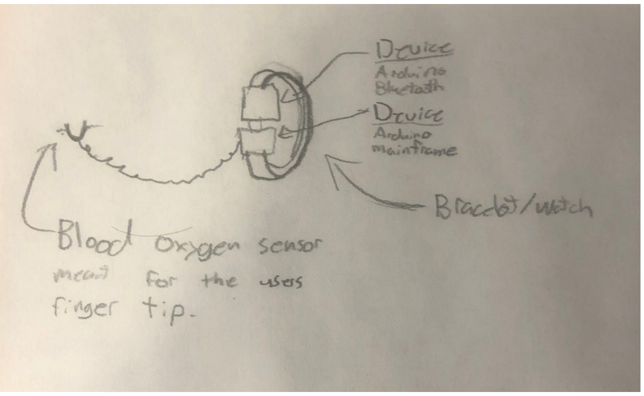


Concept 2: Necklace Device

Similar to concept 1, concept 2, consist of a blood oxygen sensor attached to the users ear lobe. As well as a necklace that supports the devices arduino compartments. This concept also includes bluetooth, and the capability to notify EMS.

Pros: Accurate blood oxygen level detection.

Cons: Not very discrete, discomfort



Concept 3: Watch/Bracelet Device

For the third concept, the overdose detection method will be the blood oxygen level. This device has the blood oxygen sensor attached to the users finger tip, the arduino comportements are attached to a bracelet. This concept also includes bluetooth, and the capability to notify EMS.

Pros: Accurate blood oxygen level detection

Cons: Interferes with users capability to use opioids

Evaluation of Adam's Concepts

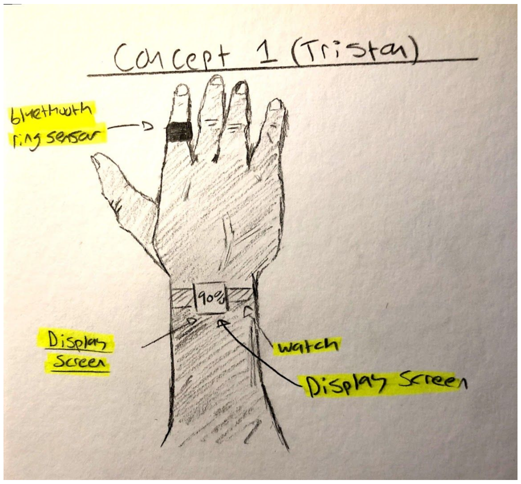
Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Discrete	**4**	**2**	**3**
Product Life	**3**	**3**	**3**
Cost	**4**	**3**	**4**
Notify EMS	**5**	**5**	**5**
Detection accuracy	**4**	**2**	**4**
Total:	**20**	**15**	**19**

Tristan's Concepts

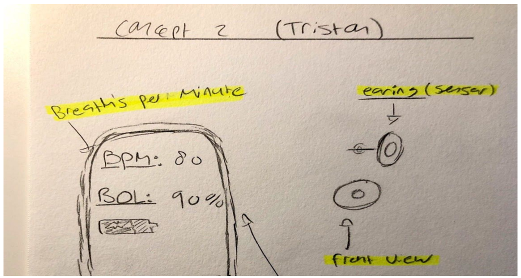
Concept 1: This concept is a bluetooth ring sensor that would connect to a portable display screen attached to a watch. The idea is that the discreet ring would have a BOL(blood oxidation level) sensor embedded inside it and it would constantly read your BOL will simultaneously sending the information to the portable watch to be read by the user.

Pros: Discreet and very portable

Cons: Very hard to make an would be expensive.



Concept 2: This concept would be designed to look like a



portable insulin pump. The large device would read the persons BPM while reading a signal from an exterior sensor which would read the person's BOL. This device would display this information, while also acting as the main body of concept. The users contacts, sensor sensitivity and battery life would all be controlled via this phone size device.

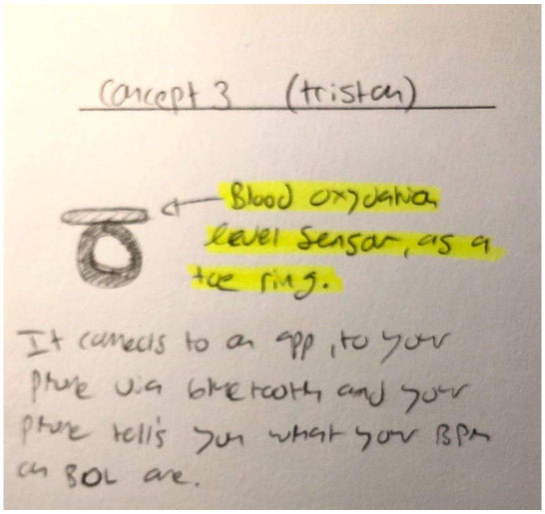
Pros: Effective and a one stop shop

Cons: Bulky and expensive.

Concept 3: This concept would be designed to be as cost effective and discreet as possible. The small sensor on the end of a ring which could be attached to a foot or hand, would be used to measure a person's BOL and send this information via bluetooth to the person's phone. This information would be displayed using a team create app which would also be used to contact EMS in the case of an overdose.

Pros: Cheap and effective

Cons: Time consuming to create an app, and could only calculate your BOL.


Concept 3 (tristan)
Blood oxydation level sensor, as a toe ring.
It conects to an app, to your phone via bluetooth and your phone tell's you what your BPM an BOL are.

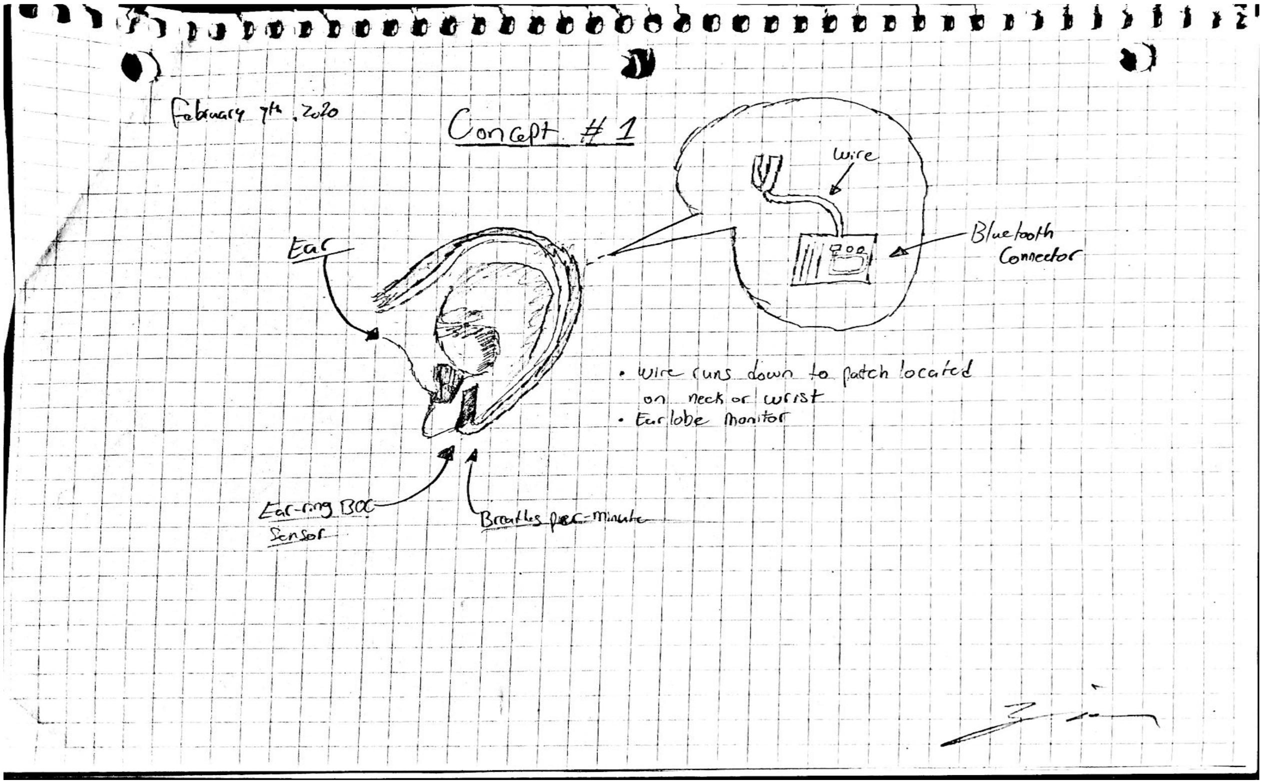
Evaluation of Tristan's Concepts

Criteria	Concept 1	Concept 2	Concept 3

Discrete	**4**	**2**	**5**
Product Life	**3**	**4**	**3**
Cost	**3**	**2**	**5**
Notify EMS	**4**	**4**	**4**
Detection accuracy	**4**	**4**	**4**
Total:	**17**	**16**	**21**

Zach's Concepts

Concept 1: Ear-lobe Monitor

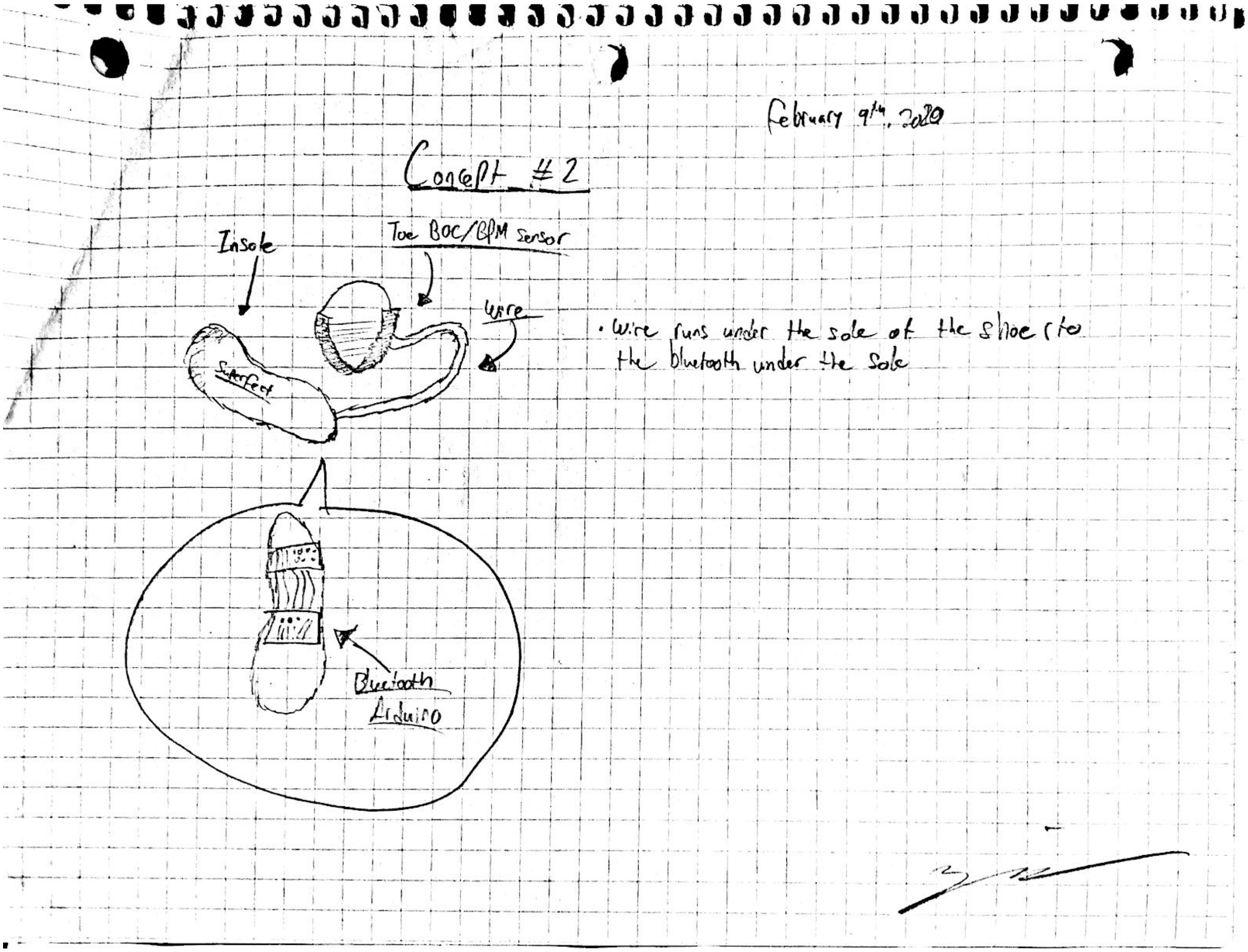


This idea uses a "clip-on" on attachment to measure blood oxygen levels and respiratory rates through the ear-lobe cartilage. To better manage feel and look, the wire will wrap around the outside of the ear, leading to a bluetooth device to connect through a mobile phone.

Pros: Discrete

Cons: Could easily fall/be ripped off

Concept 2: Toe-Insole Sensor

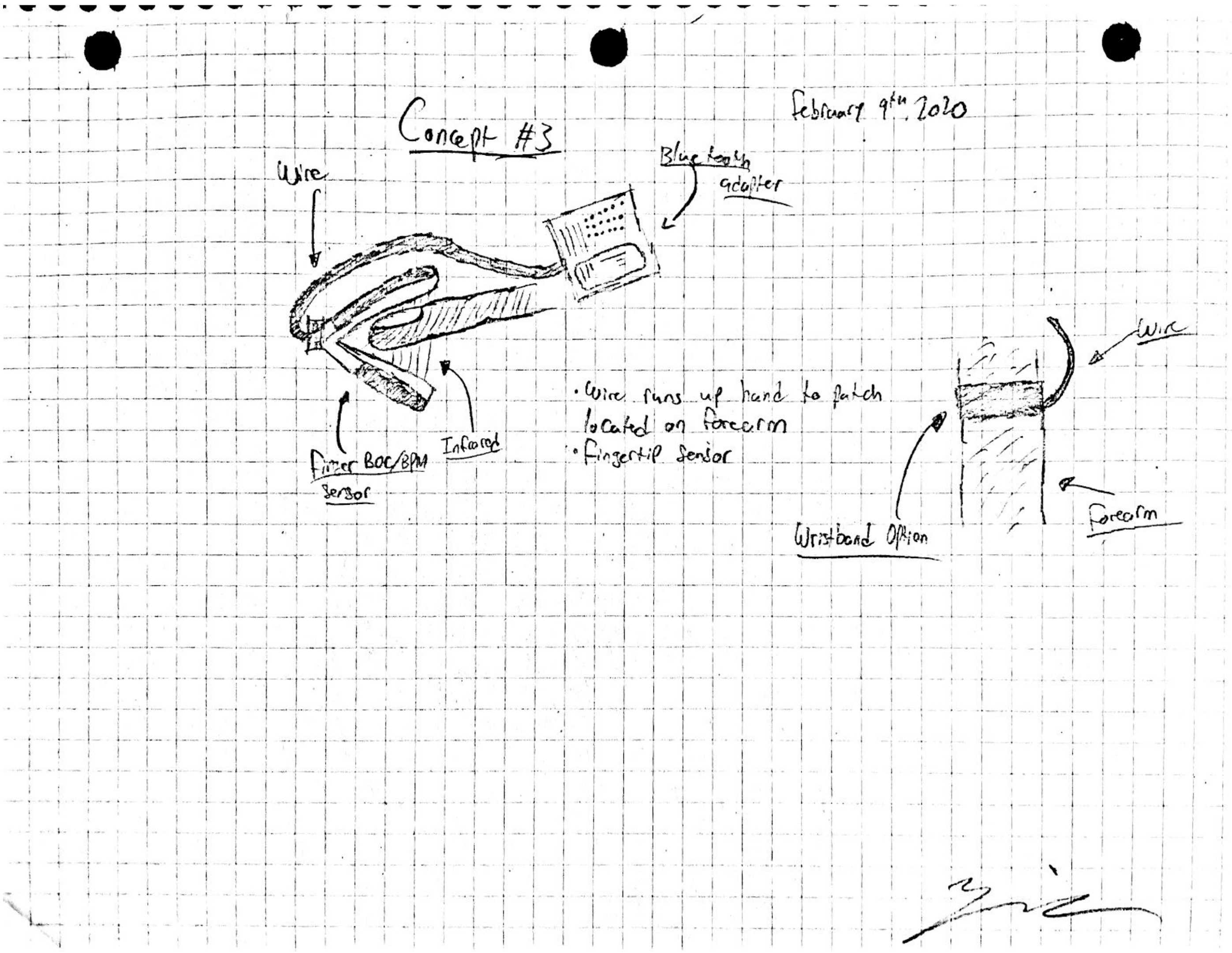


The toe-insole sensor monitors blood oxygen levels as well as breaths per minute through toe-cartilage. This concept is very discrete and has a high durability, since its location is in the protected area between the sole and the shoe.

Pros: Discrete, Safe from Damage

Cons: Could be vulnerable to water damage

Concept 3: Fingertip Monitor



This last concept utilizes a common fingertip sensor to monitor the user’s two main identification traits. It is linked to a forearm/bracelet bluetooth unit that can alert EMS and emergency contacts.

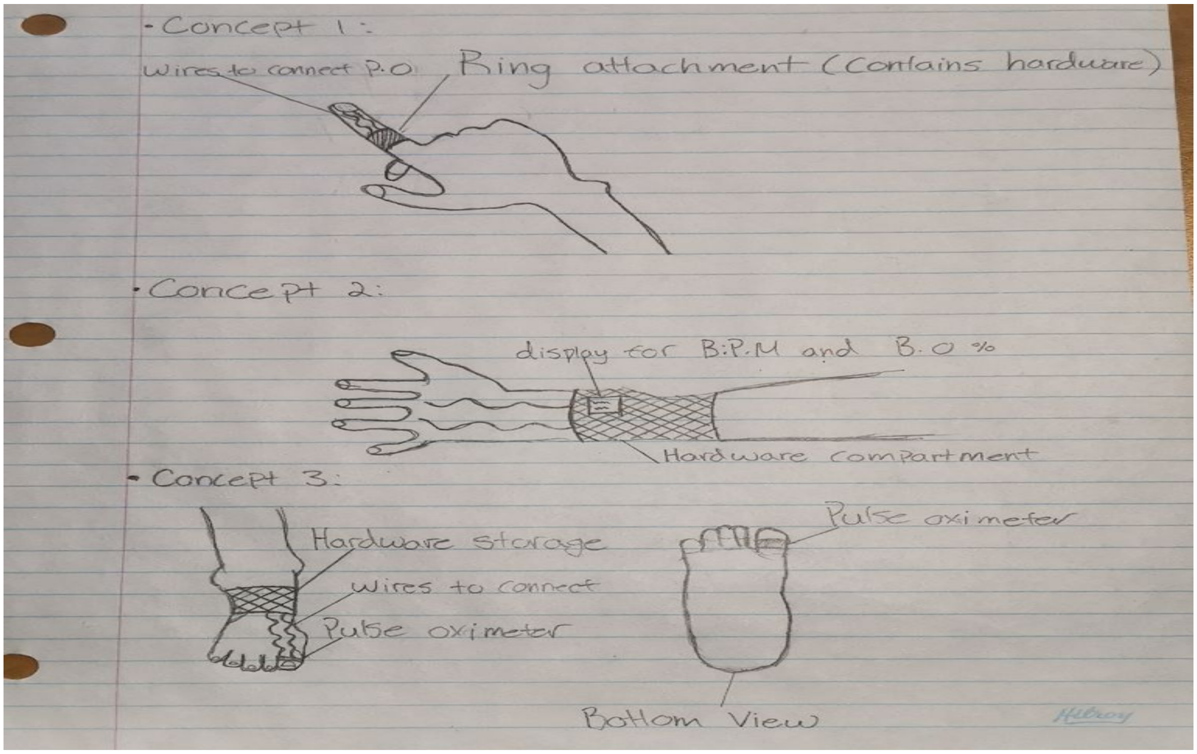
Pros: Cheap

Cons: Not discrete at all, Cannot use while doing activity

Evaluation of Zach’s Concepts

Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Discrete	**3**	**5**	**1**
Product Life	**3**	**4**	**2**
Cost	**2**	**2**	**4**
Notify EMS	**4**	**4**	**4**
Detection accuracy	**3**	**4**	**5**
Total:	**15**	**19**	**16**

Callum’s Concepts



Concept 1: Ring

This concept is using the already known finger scanner to track blood oxygen level and heart rate, and converting it into a ring. While still being able to monitor the required levels it will also be less invasive than a module at the tip of one's finger.

Pros: less invasive,
Cons: too small for hardware(smaller battery)

Concept 2: Bracelet

This concept utilizes the aspect of the finger module without the invasiveness of the module itself. This concept would utilize a bracelet function that would house all the needed hardware(Battery, Blue-tooth adapter, pulse oximeter) with a wire connecting the sensor to the finger allowing for more mobility. In addition to a display that shows the percent oxygen level as well as heart rate

Pros: less invasive
Cons: bulky bracelet, would need to be an adjustable strap

Concept 3: Toe scanner

As the pulse oximeter can be used on a toe this eliminates the issues that come with having the pulse oximeter on the tip of the finger as most of the consumers would like complete free range of motion with their hands, this concept allows this free range of motion with no restriction to finger/hand motion. The design is more or less the sensor on the big toe of the user with the main bulk hardware being attached to the ankle which would house the needed specifications such as bluetooth to contact services and the battery.

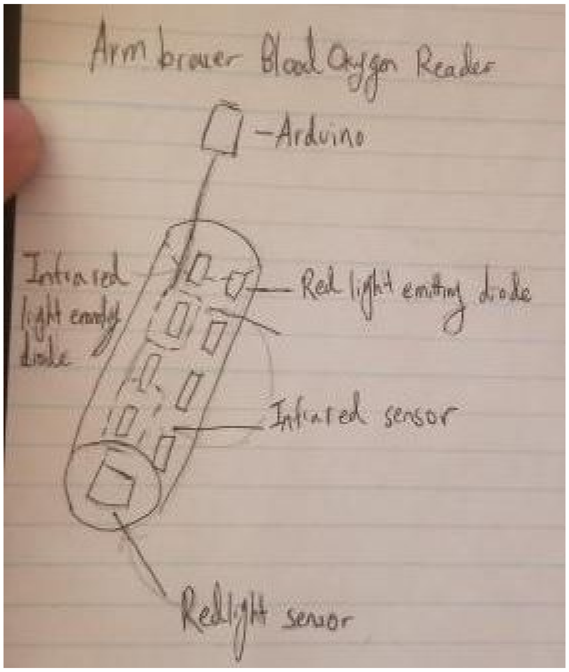
Pros: free range of motion
Cons: requires space unless done barefoot, must be done seated

Evaluation of Callum' Concepts

Criteria	Concept 1	Concept 2	Concept 3
Discrete	**4**	**3**	**5**
Product Life	**2**	**4**	**4**
Cost	**3**	**1**	**1**
Notify EMS	**5**	**4**	**4**
Detection accuracy	**3**	**4**	**4**
Total:	**17**	**17**	**18**

Tyler's Concepts

Concept 1: Arm Bracer style Blood Oxygen Reader

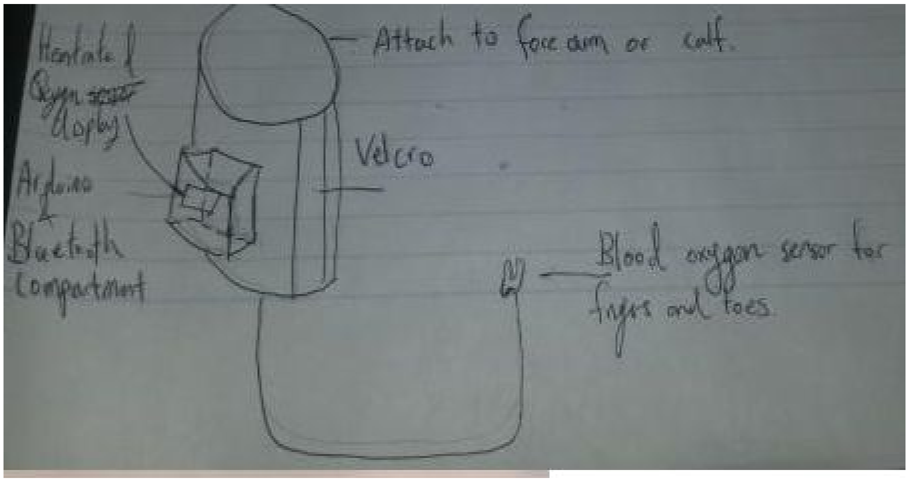


This design is designed to combat one of the biggest issues of every blood-oxygen monitor; in that the devices are usually intrusive and/or obstruct finger/ hand movement. With this device, the readings, display, and arduino/ bluetooth device will all be contained in a bracer housing that would be attached to the user's calves or forearm.

Pros: does not impair the user's hand/foot movement, very discrete.

Cons: The accuracy of the device might not be great, since the light penetrability through the arm/ leg is known to be difficult.

Concept 2: Forearm/calf with Finger/Toe Blood Oxygen Sensor

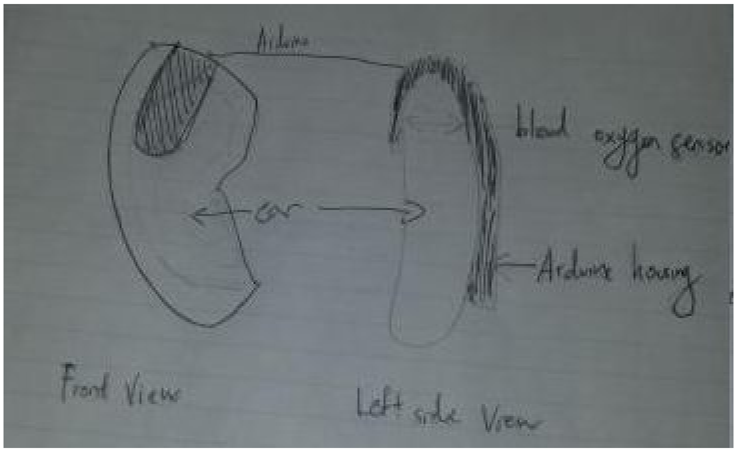


This design will use a standard blood and oxygen sensor, but the Arduino and Bluetooth devices will be contained on the Forearm/calf.

Pros: The simplicity of the concept will mean it will be easy and cheap to manufacture. This concept will allow the user to select which kind of sensor they want to use since different models of sensors will be compatible with the device.

Cons: since the sensors will be attached to the finger/toe, the device will interfere with user hand/feet accessibility.

Concept 3: Ear Clip



This concept will utilize the thin cartilage area where redlight and infrared light can pass through the skin easily. Ideally the bluetooth and arduino can be housed all in one piece behind the ear. This concept will allow the user full zero obstructions to their hands and other body areas, with the entire device being functional from behind the ear

Pros: Discrete, and non-intrusive to the user.

Cons: The weight and design of the device will be difficult to manufacture.

Since the device will be housed behind the ear, there will not be a detailed user interface on the device itself.

Evaluation of Tyler's Concepts

Criteria	**Concept 1**	**Concept 2**	**Concept 3**
Discrete	**5**	**1**	**4**
Product Life	**5**	**4**	**3**
Cost	**3**	**4**	**2**
Notify EMS	**5**	**5**	**5**
Detection accuracy	**2**	**5**	**5**
Total:	**20**	**19**	**19**

Evaluation of concepts

After reviewing each idea/concept given by our team members, we have selected 5 of the best concepts to further analyze . Using the same values found earlier, we created a new evaluation matrix only containing our highest scoring ideas. Some of the concepts found during individual brainstorming had things in common, but our top ideas were all different.

Selection Criteria	**Option 1 Adam's Concept #1**	**Option 2 Tristan's Concept #3**	**Option 3 Zach's Concept #2**	**Option 4 Callum's Concept #3**	**Option 5 Tyler's Concept #2**
Discrete	4	5	5	5	2
Product Life	3	3	4	4	3
Cost	4	5	2	1	4
Notify EMS	5	4	4	4	5
Detection accuracy	4	4	5	4	5
Total	20	21	20	18	19

Option 1 - Anklet Device (Adam)

For this concept, the blood oxygen sensor will be attached to the users toe, with the arduino compartment of the device attached to an anklet. These two sections are attached with one another via a wire. This concept also includes bluetooth, and the capability to notify EMS.

Option 2 -Ring sensor and app (Tristan)

This concept would be designed to be as cost effective and discreet as possible. The small sensor on the end of a ring or earring depending on customer needs would be used to measure a person's BOL. The sensor would then send this information via bluetooth to the person's phone. This information would be displayed using a team create app which would also be used to contact EMS in the case of an overdose. The one big downside to this concept would be to make the ring/ earring as discreet and effective as possible. This could be very difficult depending on arduinos part sizes. The second downside would be that creating the app would be very difficult and a long process but once the app would be done it would be very easy to distribute and use since most people already have mobile phones.

Option 3 - Toe-Insole Sensor (Zach)

The toe-insole sensor monitors blood oxygen levels as well as breaths per minute through toe-cartilage using a pulse oximeter. This concept is very durable as well as discrete. The main downfall is that there is no screen, making measurements and observations only through the mobile phone it is connected to. Furthermore, water damage could harm the device if the user says, steps in a puddle and soaks the monitor. Other than those two disadvantages, the device is secure and reliable. The main components of the device will be located beneath the insole, with a wire connecting it to the toe-ring sensor.

Option 4 - Toe scanner (Callum)

As the pulse oximeter can be used on a toe this eliminates the issue that comes with having the pulse oximeter on the tip of the finger as most of the consumers would like complete free range of motion with their hands, this concept allows this free range of motion with no restriction to finger/hand motion. The design is more or less the sensor on the big toe of the user with the main bulk hardware being attached to the ankle via a strap which would wrap around like a watch strap and would house the needed specifications such as bluetooth to contact services, the battery and the hardware for the blood oxygen sensor.

Option 5 - (Tyler)

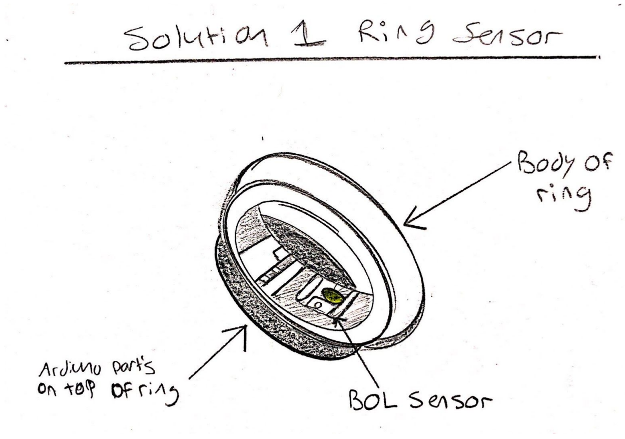
This concept is the most experimental because all oximeters currently available are only compatible for fingers and ears; where light can pass through easily. This concept relies on the idea that by generating a large amount of light through the numerous redlight and infrared light emitting diodes that measuring the blood oxygen level will be possible through the arms and legs. If this concept can be proven to be effective and accurate, it will revolutionize the way oximeters will be designed as there will no longer be a need to sacrifice the dexterity of our fingers/ feet in order to get a reading of the blood oxygen level. If this concept is proven to be viable, this one-part device will be able to discreetly read/monitor your blood oxygen level and heartbeat, while also containing the arduino/ bluetooth device. This will all be done while being concealed in a arm bracer.

Completion of Ideas

During the process of discussing the key features of each of our best concepts, the team as a whole came to a consensus allowing us to synthesize 2 functional solutions. We noticed an overlap of ideas with the toe/anklet concept, this will be the main concept we will be focusing on moving forward with our design process for the project. We will also be using common technology that has been used in a wide variety of applications giving us a large bank of information to work off. We felt the main focus of the project was to create a product that would actually be used by the users, understanding that the main focus is a sensor that is non invasive.

Solution 1 - Ring sensor + bluetooth app

This solution would involve a physical ring, the ring will contain a blood oxygen sensor and the bluetooth sensor. The main part of this solution takes place within an app that we are going to develop. The app will display all of the users



results from the blood oxygen sensor and perhaps the respiratory rate. Within the app the user will create an emergency contact from which the app will automatically call/notify EMS if the device detects an overdose (BOL below 90%). The idea behind the app would be the fact the user could easily adjust the sensitivity of the automatic contacting of EMS as well as who the secondary emergency contact would be.

Features integrated from brainstorming sessions:

- The ring will incorporate a blood oxygen sensor and a bluetooth sensor.
- The app will have the option to set up their emergency contact which will be notified when the device detects an overdose
- The app will have a clear display screen which will provide the user with his current results from the blood oxygen sensor as well as an optional BPM.

Possible downsides:

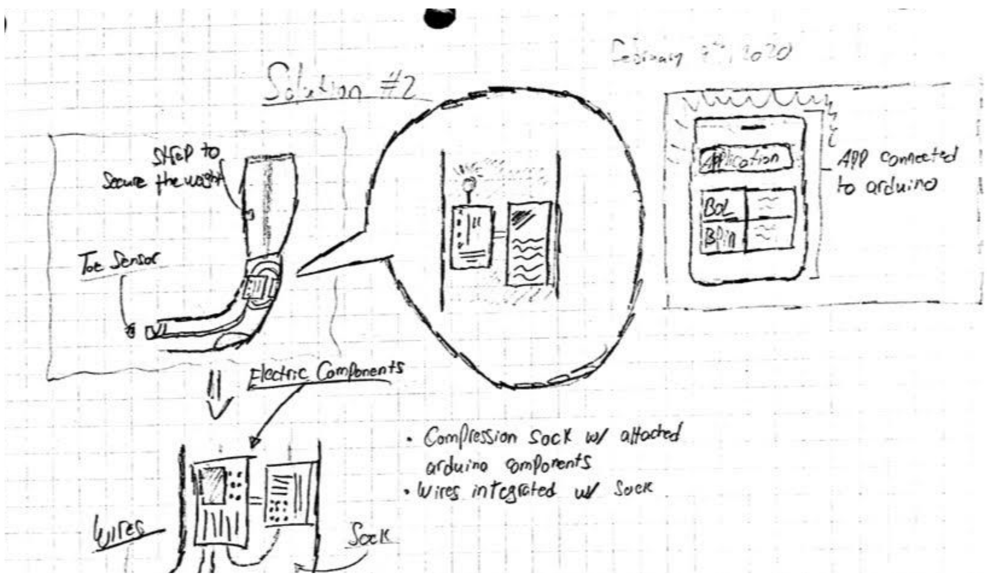
- If the user's phone dies. (then what)
- The arduino parts could be too big to incorporate them into a ring.

Things to think about:

- The size of the arduino parts and how it will affect the size of the ring.
- How difficult it will be to develop an app to our initial expectations.
- The difficulty to incorporate a blood oxygen sensor within the design of the ring.
- With all the arduino parts installed within a ring, the ring could possibly be very bulky and would then defeat the purpose of the discreteness of the device.

Solution 2 - Application-linked sock/toe monitor

This solution would have the arduino chip and all other hardware integrated to the foot/ankle compression sock. It will be connected to the toe


February [illegible] 2020
Solution #2
Strap to Secure the weight
Toe Sensor
Application
BoL
BPM
APP connected to arduino
Electric Components
• Compression Sock w/ attached arduino components
• Wires integrated w/ Sock
Wires
Sock

monitor with wires running down the side of the fabric. Furthermore, there will be a small display on the side of the sock, which will all be connected to an app that will be downloadable on most smartphones. When the user's blood oxygen levels get too low or if the respiratory rate falls under the set limit, an alert will be sent and emergency services will be called through the user's phone.

Features integrated from brainstorming sessions:

- By only including a sensor in the independant sock design, a small power bank would be sufficient to power the device for a maximum amount of time. Also, having minimal hardware on the sock reduces discomfort and manufacturing time.
- Having a thick and stretchy fabric allows for a "one size fits all" product design as well as allows the wires to be buried in the material to further protect the connections and keep the hardware discrete.

Possible downsides:

- Since the alert and call goes through the user's phone, the whole system is dependant on the phone being charged
- This system also requires the user to have usable mobile data, as well as reception when using the device
- The weight of the components compared to the flexibility of the sock leaves an opportunity for discomfort and twisting to occur when walking with the device

Things to think about:

- Designing an app (the foundation of our product design) may be more challenging than what we are planning for at the moment. Since the product's success depends on the performance of the app, it is the most important aspect of our chosen concept.
- Size and fit. The sock's thickness could cause a comfort problem depending on what type of shoe the user has. Finding an "ultra-slim" way to incorporate the wiring would be imperative to keeping comfort and indistinction.

Final Ranking

As stated in the introduction of this deliverable “A ranking system of 1-5 was used throughout this process, where 5 (ideal), 4 (good), 3 (manageable), 2 (had some problems problems), and 1 (was non-passable based on our needs).”

We are evaluating “discrete” based on how invasive the product would be with 5 being completely non invasive and 1 being completely invasive. We are evaluating “Product life” based on the durability of the product with 5 being very durable and 1 being nondurable. We are evaluating “Cost” as how inexpensive the product would be with 5 being cheap and 1 being expensive (based on our 100$ budget). We are evaluating “Notifying EMS” based on how quickly and effectively the product would be able to notify EMS with 5 being fast and effective and 1 being slow and inefficiently. We are evaluating “Detection accuracy” based on the magnitude of error that would be associated with sensor with 5 being a miniscule margin for error and 1 being a large margin for error.

Criteria	**Solution 1**	**Solution 2**
Discrete	4	5
Product Life	4	3
Cost	4	4
Notify EMS	5	5
Detection accuracy	3	4
Total:	20	21

Final Design

After carefully evaluating and comparing both solutions, we came to the conclusion that we will pursue solution 2: Application-linked sock/toe monitor. We believe that this solution is cost-effective, easy to use, and possible to accomplish with our given skill sets and time restrictions. This solution also fulfills the users needs set out in the problem statement. Such as, the discreteness of the device, the portability of the device, effectively measure blood saturation, the capability to notify EMS, all while being cost effective.

Next Step

With the Sock/Toe monitor concept being elected as our best design, this will conclude the ideate portion of this project and we will now move onto the next step; prototyping. To ensure that prototyping and construction of the product is efficient, every foreseeable problem will be noted and discussed by the team to ensure everyone is on the same page.

Upcoming Learning Objectives:

- How to code the arduino device.
- How to connect the sensor to the Arduino/Bluetooth device.
- What model of Blood-oxygen sensor is to be used.
- How the device will contact EMS/ and emergency contact.
- What kind of battery/ power source is going to be most efficient.
- What kind of material are going to be used to construct the sock.
- Where are we going to purchase the materials to construct the socks
- How are we going to implement the sensor into the sock without it being intrusive.

With each one of these objectives completed, it will allow our team to produce a more accurate estimate for the list of materials and time of completion of our first prototype. Moving forward, our next steps include doing the stated research in order to create the best solution to our problem in the given timespan, creating a bill of materials/estimating overall cost of the project including each prototype and testing. With all of these steps completed our group will be ready to present our completed project at the assigned design day in front of our designated customers.