Conceptual Design

Project Deliverable D

GNG1103
Team 13
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Contents

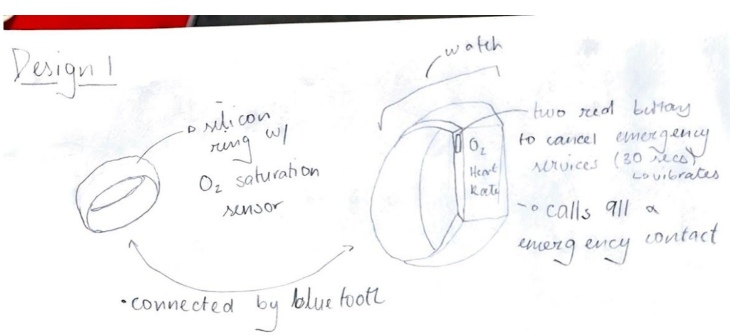
1.0 Introduction

In the previous deliverables, a problem statement was created which states the need for a non-intrusive, wearable device that monitors oxygen levels of an opioid user and detects overdoses. The device must be affordable, lightweight and compact; it must alert emergency responders of the location of the person affected. Based on the problem statement and general benchmarking; the team concluded that the ideal product must cost less than $100 CAD, weighing around 15g to 25g, be made from plastic and silicone, have a battery life of 24 hours or longer, be water resistant, and have an oxygen saturation monitor, heart rate monitor, and respiratory rate monitor.

Based on the information collected from benchmarking and the problem statement, each member was given the task of creating three conceptual designs using the interpreted needs, list of prioritized design criteria, and benchmarking from previous deliverables.

2.0 Conceptual Designs

2.1 Naomi's Designs



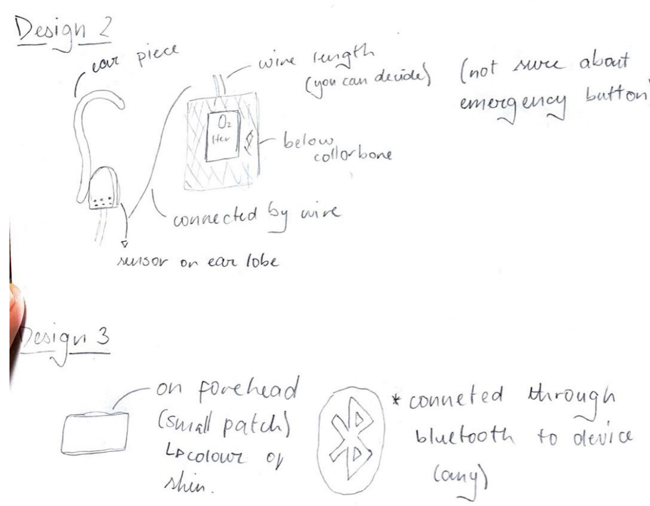


Figure 1

2.2 Sam's Designs

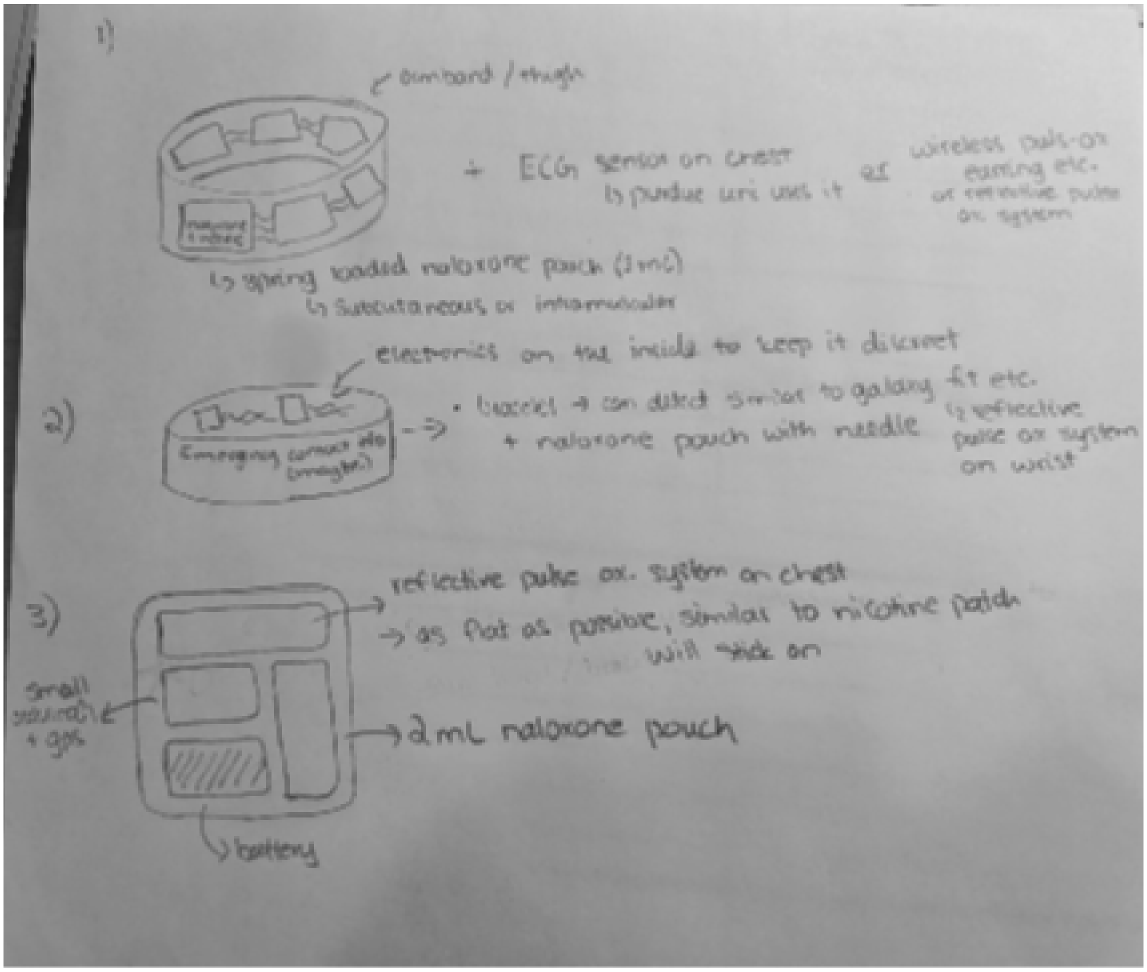


Figure 2

2.3 Liam's Designs

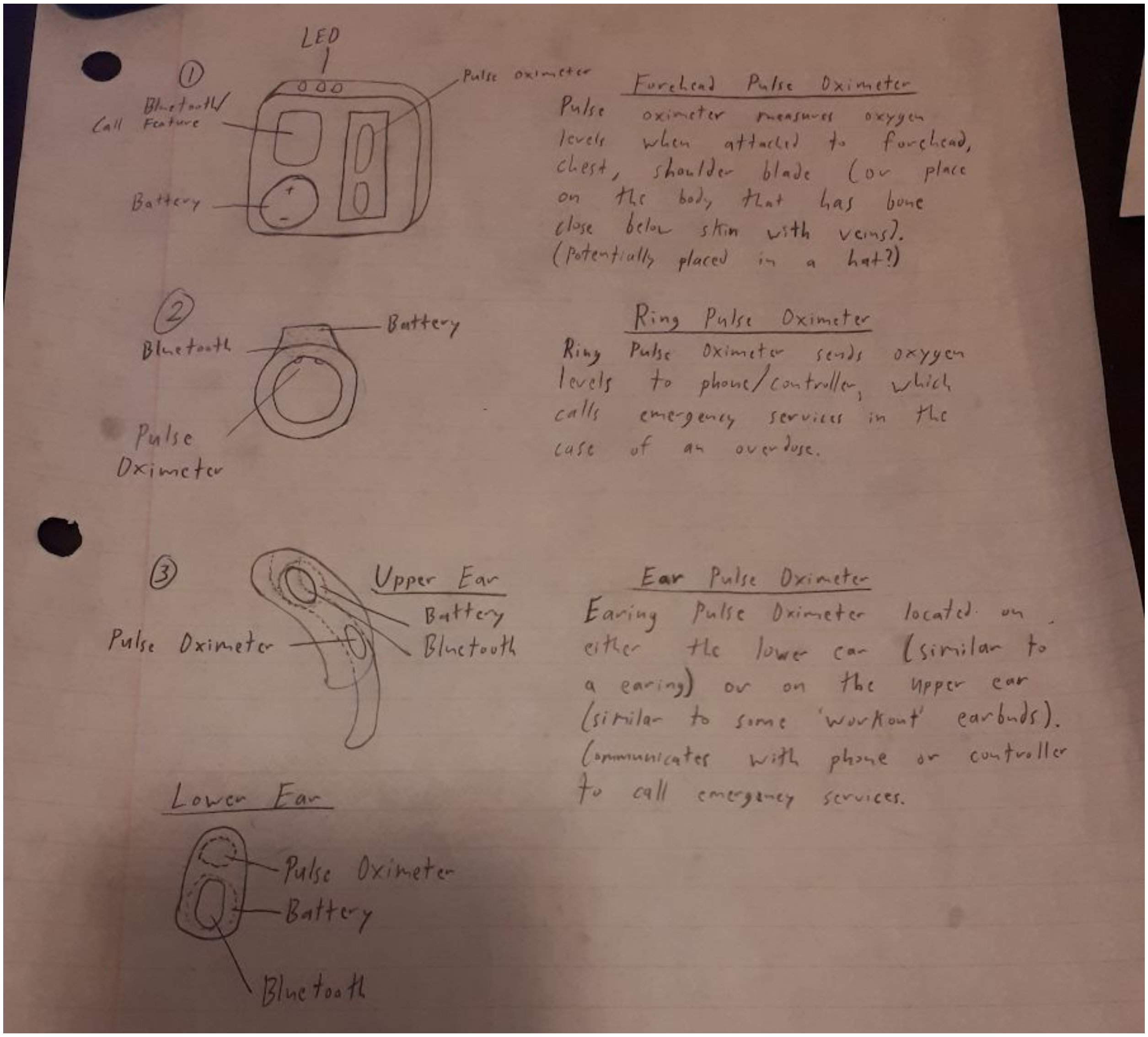


Figure 3

2.4 Mariyam's Designs

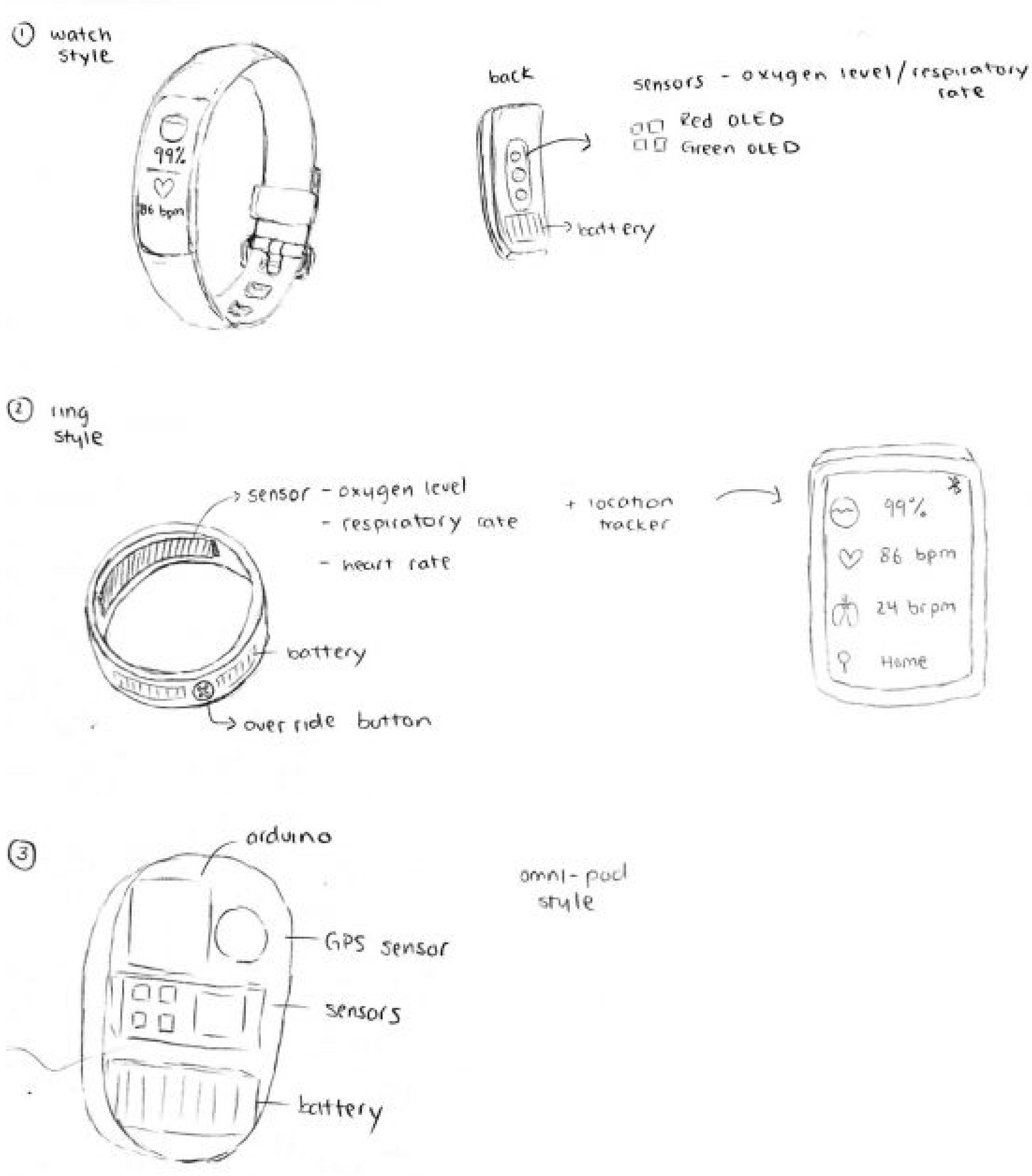


Figure 4

3.0 Analysis

Each member has created with three conceptual designs that satisfies one or more of the design criteria listed in previous deliverables. The goal of the separate designs is to produce various concepts that will be modified and combined into three fully functional solutions.

3.1 Naomi's Designs

Her designs are more focused on the various ways to collect Oxygen Saturation in the body as that is one of the most important criteria.

The first design is a watch and ring combo. The ring utilizes the easy collection of O2 saturation from the finger and it will be connected to a watch via bluetooth. The watch is going to be the main device. You will be able to view your oxygen levels and if there is a miscalculation in the oxygen percentage you can easily call off the emergency services. The watch and ring will both be discreet and look just like casual jewelry.

The second design is similar to a hearing aid. The O2 sensor will be connected to the users ear lobes and a wire will be connected to a small patch that can be hidden underneath clothes. The patch will have a small device that can keep track of a person's O2 levels and contact an emergency contact if the patient is experiencing an overdose.

The final design is the least discreet. It is similar to a bandaid; the user will be able to stick it on their forehead (it will be the same colour as the user's skin, so as to blend in, and it can be connected via bluetooth to any device. An app will be used to keep track of the users O2 levels and heart rate. It will be able to contact emergency services.

3.2 Sam's Designs

His designs are various methods to keep the system discreet while still meeting all requirements.

The first design consists of two parts, similar to the device currently being developed at Purdue University. Much like Purdue, the sensor will be either an electrocardiogram (ECG) or a more accurate pulse-oximetry system that will wirelessly connect to an arm/thigh band that can be discreetly worn while still allowing for all the required electronic components to fit into the system. These electronics are common in all three designs which include a rechargeable battery, arduino system, reflective pulse-ox system, gps capability, and a 1-2 mL naloxone pouch with a retractable spring loaded needle. The naloxone is important as it is most effective when administered within three minutes of an overdose detection, often before emergency services can respond. It will administer a small dose of naloxone subcutaneously so as to buy time before emergency services arrive. The reflective pulse-ox system allows for readings to be taken in more discreet areas such as the feet, forehead, and wrist; it does not require to be placed on a finger where it might interfere with everyday activities.

The second design is worn around the wrist as a bracelet, taking reflective pulse-ox readings from the wrist much like the Samsung Galaxy Fit. It features all components on the inside of the bracelet so as to keep the system discreet. Challenges of this design might include using electronics that are small enough to fit around the wrist comfortably.

The third design is a patch, similar to a nicotine patch or bandage. This design features very flat electronic components and will ideally be worn discreetly on the chest. Challenges of this design are using very flat components so that the device does not feel uncomfortable to wear or feel obtrusive.

3.3 Liam's Designs

His designs incorporate three concepts each of which monitor blood oxygen levels. All designs send a signal through bluetooth to a cell phone. If the pulse oximeter detects an overdose, the cell phone calls emergency services and uses onboard GPS to pinpoint the users location.

The first design is a patch that is attached to a place on the body that has thin veiny skin with bone just below it. Such locations include the forehead, chest, shoulder blade and shin.

The second design is a pulse oximeter ring that the user wears. Both designs are based on current technology used in hospitals.

The third design is a pulse oximeter that is attached to the ear. This can be incorporated in one of two ways. The first is a design that discreetly measures the users blood oxygen level while being attached to the upper part of the ear. This design was based on sports earbuds that wrap around the back of the ear to ensure a secure and discrete fit. The second design is a pulse oximeter similar to those used in hospitals that attaches to the lower ear like an earring.

3.4 Mariyam's Designs

Her designs consist of three concepts that each satisfy various requirements.

The first design is similar to the Samsung Galaxy Fit because it has the style of a watch. This device will have a non-interactive display which will showcase the oxygen level, heart rate, and respiratory rate. The sensors (which includes LED lights and a patch) will be located on the back of the screen so that the sensors can be in contact with the skin. The strap will be made from silicon and the display will be made from plastic. This allows the device to be comfortable to wear for long periods of time. The plastic display allows it to not shatter at impact when dropped or hit.

The second design is similar to the Lookee Ring Sleep Monitor as it is in the form of a ring. It also contains the same features as the first design except this also includes a location tracker. All the information stored on the ring will be displayed on a seperate device that is connected through bluetooth. One obstacle that may be encountered with the ring and watch is finding small enough components that will easily fit in the device.

The third design is similar to an omnipod used by diabetic patients. It is a device that is attached to the arm and when an overdose is detected, a certain amount of naloxone will be injected into the patient. This device will also have an override button in which the individual will have 10 seconds to press in case of a false alarm. All of this information will also be displayed on a separate monitor.

3.5 Three Fully Functional Solutions

After comparing all of the individual conceptual designs, three fully functional solutions were put together.

The first subsystem will be a watch style device much like the Galaxy Fit. This design is discrete and aesthetically pleasing to wear by anyone. The strap will be made from silicon which is a comfortable yet also relatively affordable material to work with. The display will be made from plastic so that in a case of impact, the screen would not shatter. Using these materials with minimum holes in the device will allow it to be water resistant so that it can be worn under various weather conditions. The oxygen level and heart rate will be measured using LED sensors, the respiratory rate will be measured using an ECG or PPG sensor. There will also be a GPS tracker in the device so that if an overdose is detected, authorities, relatives, or any emergency contact will be alerted of the situation. All the information will be displayed on the screen for better convenience. It will also have a rechargeable battery that will only need to be charged once everyday as its battery life would be up to 24 hours. The device will have a screen size of approximately 45.7mm*25.4mm, also weighing around 25g. This device will contain everything that is needed apart from an automatic naloxone receiver. An obstacle that might be faced down the road with this design is finding small enough components to fit within the device.

The second subsystem will be the patch design that allows for the device to be discreetly worn. The patch has an adhesive that is placed on the chest and can collect blood oxygen levels through reflective pulse-oximetry. The patch will feature very flat electronic components. It will work with an arduino system powered with a battery that lasts up to 24 hours. The device will also have gps capability that will notify emergency services of a person's location when an overdose is detected. A naloxone pouch will administer small doses of naloxone that can allow for emergency services to respond before it is too late. The device is only as durable as the adhesive and will be ideal for customers that use opioids for short periods of time such as post surgery prescriptions.

The third subsystem will be the earpiece which will be discreetly worn on the upper part of the ear. The earpiece will wrap around the upper part of the ear similar to a sport earbud or hear aid without going into the ear canal. The earpiece will measure the blood oxygen level of the user by shining the pulse oximeter light through the pinna (upper ear skin). The device will be powered by a small battery similar to that of a hearing aid. A bluetooth signal will connect to the user's smartphone app to send data on the user's blood oxygen level. The app will keep track of the user's blood oxygen levels and in the case of an overdose will call the proper emergency services.

4.0 Concept Generation

A set of preliminary concepts were selected for the opioid overdose detector using the problem statement, list of design criteria, benchmarking, list of target specifications, the conceptual designs, and the final three subsystems. These preliminary concepts include the watch design, the patch, and the earpiece. Team 13 has selected the watch design as the best option for further investigation and design. The patch is very thin and so it would be difficult to include all the necessary components inside of it. The earpiece design on the other hand would require an additional device to display the information which may not be suitable in this case.

From a previous deliverable, Table 1 reviews the target specifications of the device. Based on the highlighted specifications, a choice of materials for the strap and display will be selected.

	Design Specifications	**Relation (=, >, or <)**	**Value**	**Units**	**Verification Method**
	Functional Requirements				
1	Accurately measure oxygen level	>	90	%	Test
2	Measures heart rate	>	5.5	mHz	Test
3	Respiratory rate	=	12-25	brpm	Test
	Non-Functional Requirements				
1	Aesthetics/discreteness	=	Yes	N/A	Test
2	Product Life	>	1	year	Test
3	Battery Life	>	24	hours	Test
4	Water Resistant	=	Yes	N/A	Test
5	Reliability	=	Yes	N/A	Test
6	Durable	=	Yes	N/A	Materials/ Test
7	Comfortable	=	Yes	N/A	Materials/ Test
	Constraints				
1	Weight	<	25	grams	Measure

2	Cost	<	100	CAD	Calculate
3	Size	<	45.7 * 25.4	mm	Measure

Table 1

Properties	Values
Density	2.33g/cm^3
Elastic Limit	5.5 MPa
Shear Modulus	$0.0003*10^6$ psi
Young's Modulus	$0.001*10^6$ psi
Thermal Stability	−100°C to 250°C
Poisson's Ratio	0.49

Table 2 Properties of Silicon

Silicone has been selected as the material for the strap because it is comfortable on the skin, and has high & low-temperature resistance. Along with being ultralight and water resistance, silicon also has a diverse colour range which allows for stylish personal options.

Properties	Values
Density	1.32 Mg/m3
Elastic Limit	44.6 MPa
Hardness	132 MPa
Shear Modulus	1.474 GPa
Poisson's Ratio	0.3989
Young's Modulus	4.1 GPa
Melting Point	513 K

Breakdown Potential	23.6 MV/m

Table 3 Properties of Acetate

The display and any other part of the watch that requires plastic will be made from acetate, which is a type of bio-friendly plastic-like material. It is made from polymers found in nature. Acetate is a strong material with a deep gloss that can be cleaned easily. It is lightweight and comfortable to wear, which makes it ideal for watches.

	Design Title	**Pros**	**Cons**	**Feasibility (TELOS)**				
				Technical	**Economic**	**Legal**	**Operational**	**Scheduling**
1	Watch	-With adjustable strap it can be placed on anyone	-Difficult to fit all the necessary components	Yes	Yes	Maybe	Yes	Maybe
2	Patch	-Can be placed on multiple parts of the body -Discrete	-Unknown if it will work on places other than the forehead and chest -Body fat might be an issue	Yes	Yes	Maybe	Yes	Maybe
3	Earpiece	-Small -Relatively discrete	-Difficult to fit all the necessary components	Yes	Maybe	Maybe	Maybe	Maybe

Table 4

The TELOS Feasibility table allows for an easy method of determining the feasibility of a design. The Technical, Economic, Legal, Operational and Scheduling for each design are listed as Yes, Maybe or No. For example, if the technology for the design is available then a Yes will be listed under Technical for that design. If the technology might exist and/or we might be able to acquire the technology then it will be listed as Maybe. If the technology is not accessible, then the design be listed as not technically feasible. Any No's automatically voids the idea. In the case of a draw or for more accuracy, the pros and cons of each idea are listed to give a better perception of each design.

Selection Criteria	**Weight Factor**	**Design 1: Watch**		**Design 2: Patch**		**Design 3: Earpiece**	
Volume of device (Discretion)	0.25	*4*	**1**	*4.5*	**1.125**	*5*	**1.25**
Weight of the device	0.15	*4*	**0.6**	*4*	**0.6**	*5*	**0.75**
Time it takes the user to put on the device	0.15	*4.5*	**0.675**	*3.5*	**0.525**	*4*	**0.6**
Strength of parts	0.05	*4*	**0.2**	*4*	**0.2**	*3*	**0.15**
Material cost	0.15	*4*	**0.6**	*3*	**0.45**	*2*	**0.3**
Effectiveness	0.25	*4*	**1**	*4.5*	**1.125**	*4*	**1**
	Total score	**4.075**		**4.025**		**4.050**	

Table 5

The weighted matrix table is used to weigh the listed criteria and give a score for each design based on the selected criteria. The weight adds to 1.00 (100%) and each score can be 0 to 5. The italic score is the score of each criteria of each idea. The score is then multiplied by the weight factor to give the weighted score. The design with the highest total weighted score is the design most suited to solve our problem while taking into account the design criteria for our project.

5.0 Conclusion

Through our discussions we were able to narrow our product ideas to three designs. The first being a bracelet/watch, the second being a patch that can be placed on multiple locations of the body and the third being an earpiece. All designs measure the users blood oxygen levels using one of multiple pulse oximeter technologies. The watch and patch use similar technology to that used in forehead pulse oximeters. The earpiece would use a more simple pulse oximeter measurement typically found in finger and toe pulse oximeters. After mapping our designs on a TELOS table we were able to determine that our watch and patch idea were tied as the most feasible designs. Through careful consideration of the pros and cons we were able to determine the watch design to be the most feasible. Using a weighted matrix table we listed the main criteria of our design and the weight (importance) of each criteria. The most important design factors are effectiveness and discretion. After scoring the criteria for each idea (in italics), then applying the weight factor (in bold) we determined the total weighted score of each idea. The watch design narrowly overcame the competition to become our top choice as the design most suited to solve our problem while taking into account the design criteria for our project.

6.0 References

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