Scuba Diving Accessibility for the Physically Challenged

by

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Bachelor of Industrial Design

Faculty of Applied Sciences &Technology
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Abstract

Scuba diving is a strenuous recreational activity in which a person dives underwater to explore and observe the marine life and environment with the use of a Self-Contained Underwater Breathing Apparatus (SCUBA). The pieces of equipment that are used while going underwater can be heavy even with the presence of water to help with the buoyancy and can interfere with the diver's performance, experience, and even safety unless they go through a training for Scuba diving. The purpose of this thesis is to create a concept that addresses the issue of accessibility of mobility for disabled people regarding doing a recreational diving activity. A person with a disability has their movements hindered due to their condition and for the most part, relies on having someone by them to monitor and assist with moving underwater. To know more about the problem, research on current practices and trends on how diving with a person that is disabled is being done and what the difference are compared to a normal diver are investigated, and other aspects such as user demographic are researched to help narrow down to a more specific user. A search on current products and equipment are also investigated to see their usage, how helpful they are to the user, and how they may be improved upon to better serve a disabled person. By knowing who and what the user is, what the current trends and equipment are used, and the problems that are present for disabled diving, and by combining the data from those research together, it creates an idea and understanding that will help in making a concept product with the goal of improved accessibility for disabled diving. And so, finding a solution or a way to better a disabled person's experience underwater will help them not only with their time being underwater but also open Scuba diving for more of the disabled population and be more independent in their recreational dive.

Acknowledgements

In dedication for disabled divers around the world.

I would like to give my thanks and acknowledgement to the advisors, professors and to my fellow peers for the support, guidance, and knowledge that they have contributed during the development and research for the concept of increasing support and accessibility of scuba diving for the physically challenged and disabled especially during this trying times. And thus, I would like to thank the following individuals in their contributions on the thesis.

I would like to thank Catherine Chong and Sandro Zaccolo as my professors and thesis supervisors, and for all the guidance, input, opinion, and views on the work that I have done for this thesis project and in helping me in going to the right and proper direction towards my concept design. I would also like to give my thanks and regards to Sandy Robb in accepting to talk to me and be my advisor regarding insight and knowledge in the field of scuba diving and working with people that are disabled.

Another group that I wish to extend my thanks to are my peers and fellow classmate that were also busy with their own thesis project but did not hesitate in giving their own advice and opinion on the thesis project if asked for it. Your support, even with the current events, are a welcome gesture and is appreciated.

Lastly, I would like to thank my family for having my back during the project and the trying time that we are currently facing. Your patience and support are greatly appreciated especially in times of need and hopefully I have made you all proud.

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Figure 1 – Retrieved from https://www.squalodivers.com/tours/adventure-diver/

1 Problem Definition

1.1 Problem Definition

Scuba diving is a strenuous recreational activity in which a person dives underwater to explore and observe the marine life and environment with the use of a Self-Contained Underwater Breathing Apparatus (SCUBA). Scuba diving is a popular recreational activity that exist across the globe as long as there are a body of water nearby. The pieces of equipment that are used while going underwater can be heavy even with the presence of water to help with the buoyancy and can interfere with the diver's performance, experience, and even safety unless they go through a training course for Scuba diving. But even with proper training, a diver with some sort of disability will have a very different and difficult time diving due to their condition.

This thesis report will focus on how to better understand divers with disabilities by looking at current trends and procedures that are being done to help accommodate for those diving with a disability and looking into areas where any improvement can be achieved or by trying to solve existing issues by creating a concepts that will help to solve the problem. The main goal of this thesis project is to create a better accessibility for disabled people to go diving.

1.2 Rational Significance & Investigative Approach

Scuba diving is a recreational activity that lets a person travel and experience the underwater ecosystem and habitats. It is a fun activity for many that wishes to move freely underwater. But for people with disabilities, Scuba diving comes with problems and difficulties that affects the experience of a disabled diver. This thesis will help to investigate such problem and to create a possible solution to benefit those with disabilities going diving underwater.

To gain a better understanding of the topic of diving and of people with disabilities, research on relevant data regarding the activities of existing diving with disabilities and organizations that promotes and supports such activity will be investigated. By looking into their activities, information regarding their diving such as equipment used, procedures needed to learn before going into open waters and any difficulties that are present when working with someone that has a disability. Research on literature reviews regarding the topic will also be investigated to learn more about the activity and the focused user. This research for the thesis topic will ultimately help to answer questions that will then help to create a concept for the final design. Questions such as:

- What are the types of disabilities that are present during a dive? What will the user be specifically?
- How do these disabilities affect a person’s experience when diving?
- What is currently being done to accommodate for people with disabilities? Are there any special equipment that is meant solely to help people that are disabled?
- What and how can we tackle the problems that exist in scuba diving with a disability?

These are the few questions that needs to be answered to learn more of the problems, the profile of the target users, and to finding the concept design that will help disabled divers.

1.3 Background / History / Social Context

Scuba diving is a recreational activity that can be traced back to ancient times where people used to dive underwater at deep depths or when they used hollow reeds as a makeshift snorkel. Today in modern times, Scuba diving includes equipment's that helps divers to go underwater much deeper and much longer for a better experience of being underwater. But even with the advancements in technology and the inclusion of a training course for everyone to take that wishes to go scuba diving, many of the equipment are standardized to fit the largest percentile and many of the standards for scuba diving is focused on accommodating for a "normal" person which is a problem with people with disabilities.

Many of the equipment for scuba diving is designed based around a normal person's physical capabilities which can be a problem for many in the disabled community. A switch that is easily reachable for someone that has function limbs can be difficult for someone that has a missing limb.

Another challenge that many disabled people face when scuba diving is the decrease in mobility due to their conditions. A person that is disabled from their lower half due to a medical condition or a person that is missing certain limbs will have their mobility of moving forward and steering themselves underwater be negatively affected with their speed decreasing to half the amount a normal person can move underwater or by not be able to move to specific direction due to the inability of being able to use their limbs to steer. By addressing such challenges, a solution can be made to help people with disabilities to experience diving underwater like any other person without the remainders of their disability.

2 Research

Figure 2 - Knyazev, D. (2019, January 17). Craig Wood PADI AOWD diver with legs and arms amputated while diving in the Red Sea. [Digital image]. Retrieved 2020, from https://knyazevda.com/articles/one-thousand-thirty-seven-1037/2019-01-17

To begin the research on how diving with a disability will be tackled, the first steps will be to learn more about the possible users, their demographic, and any other possible specificity. The following information and data will showcase the research done to locate and learn more of who and what the target user is for the thesis topic of “How may we make diving more accessible for people with disabilities?”. Though it seems that it is obvious who the target user is, the research will help to create narrow down a more specific user which will help to focus what the concept product will be thought of for the thesis project.

The research will begin with a User Persona of a made-up person which will help to start off what kind of user will be research on in mind. The persona will be a starting point and help to constrict the research to a specific information and data search.

2.1 User Research

2.1.1 User Profile – Persona

Figure 3 – Retrieved from https://twitter.com/milesobrien/status/446770976794378241/photo/1

Name: Nate O'Brian

Age: 36

Occupation: 911 Dispatcher

Income: $43,000/ year

Education: Bachelor's Degree - Technology

Relationship Status: Married, 3 kids

Location: Los Angeles, California

Career/ Volunteer: Career

Years of Service: Did 5 Years of Military Service before being a Dispatcher

Social: Works with multiple co-workers while attending to emergency calls by people in need

Frequency of Activity: Works 8 hours, 5 days a week

Hobbies: Hiking, Swimming, Fitness

Profile

Nate O’Brian is a 36-year-old Caucasian male. He attended university to receive his bachelor’s degree in Technology. He took a detour in occupation when he joined the military and did 5 years of service for his country until an unfortunate situation happened to him. He now works as a 911 dispatch operator while earning a yearly salary of around $43,000.

Steve began his career a few years after the accident, working a steady job with adequate salary and is hoping for a raise to better fund his family.

User Behavior

Nate works diligently at his workplace as it reminds his of being in the military a little bit while working with his peers for a better and safer community. He has a good relationship with everyone at work and with his friends outside of work and will join them when they go out to do activities such as going out for dinner, drink, hiking on the weekends, etc. and also especially when he gets home to see his family. He tries not to let his disability get in the way and tries to live his life to the fullest whenever possible.

Nate and his Condition

Due to an unfortunate event that happened during a provision transport, he lost a limb which ended his service to the military early. Due to this event, he went back home to his family and was able to get a job at his local police station. There are times where pain will come randomly from his missing limb but for the most part he endured and try not to let it get in the way. Though he wishes that he still has his missing limb, he instead changed his lifestyle and embraced what it is to be as a person that is disabled.

2.1.2 User Observation = Current User Practice

Introduction

The purpose of this thesis is to investigate the topic of diving with a disability and so to do this, the first step will be to know more about the target user. To learn more about the current trends and the possible user or users that the thesis will be focusing on, gathering research data by using a number of methods will be utilized in hopes of learning more of the demographics and what kind of things to consider based on what and who the user is while looking into information such as sex, most common age group for those that goes scuba diving and the correlation with age group for specific disabilities, types of disabilities to consider, focusing on a more specific disability group to look into to help narrow down a more specific user and much more.

Methods

Multiple methods will be used and utilized in gathering the necessary data to form a user for the thesis topic. The methods that will be used are image searches to help with creating a preliminary finding of information regarding the users, a literature search to research a more informed data and information regarding the demographics of disabled people and scuba divers and finally an advisor search for either the user of someone that works with the user to learn more about what it is like to interact and work with people with disabilities.

2.1.2.1 Research Image Search Findings

A Google Image Search was performed to understand what typical firefighters look like. As firefighters wear equipment that covers their faces group photos were primarily used. The following search terms were used:

- “Scuba Diving”
- “Diving with a Disability”
- “Disabled Divers”
- “Recreational Diving for the Disabled”

Findings have been collected in a Table.

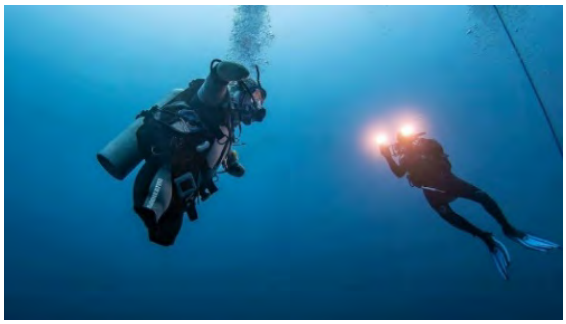
IMAGE	DEMOGRAPHIC INFORMATION
 *Figure 4 - Kalashnikoff, A. (2018, May 8). [An amputee diving while a person records him]. Retrieved from https://www.rbth.com/science-and-tech/328242-russian-diver-defies-disability*	Age: 30-40 Gender: predominantly male Culture: White Income: uncertain Educational background: College Career/ Volunteer: Mixed
 Knyazev, D. (2019, January 17). Craig Wood PADI AOWD diver with legs and arms amputated while diving in the Red Sea. [Digital image]. Retrieved 2020, from https://knyazevda.com/articles/one-thousand-thirty-seven-1037/2019-01-17	Age: 20-35 Gender: mixed, predominantly male Culture: White Income: uncertain Educational background: College Career/ Volunteer: Mixed
 Figure 5 - Flynn, S. (n.d.). Disabled scuba diving [Two guys helping a disabled driver with his equipment]. Retrieved from https://gogetfunding.com/disabled-scuba-diving/?show_desktop=1	Age: 28-45 Gender: mixed, predominantly male Culture: White Income: uncertain Educational background: College Career/ Volunteer: Mixed

Table 1 Image Research Table

2.1.2.2 Research – Literature Search for Demographic Data

A literature search was also performed on the Humber Library website and Google to find statistical data relevant to diving with disabilities. The following search terms were used:

- “Disabled diver Demographics”
- “Scuba Diving Data”
- “Diver Survey”
- “Scuba Diver Age, Gender, Education, etc.”
- “Disabled people Age, Gender, Education, etc.”
- “Stats on people with Disabilities”

Findings

Findings have been summarized below according to the relevant categories:

Gender; Age; Race and Ethnicity; Income and Education.

Attribute	Size of Market	Freshwater Scuba Divers & Snorkelers	Did Not Go Freshwater Scuba Diving or Snorkeling[1]	Pleasure Travelers	Index[2]
		556,454	17,883,055	18,439,508	100
Gender	Male	62.2%	48.4%	48.8%	127
	Female	37.8%	51.6%	51.2%	74

Figure 6 - Gender Distribution. [Image] (2007) Retrieved from http://www.mtc.gov.on.ca/en/research/travel_activities/CDN_TAMS_2006_Scuba_Diving_Snorkeling_Oct2007.pdf

Gender. Finding information regarding to the gender distribution of disabled divers is difficult to find because of how little specific information there are available about people with disabilities going scuba diving.

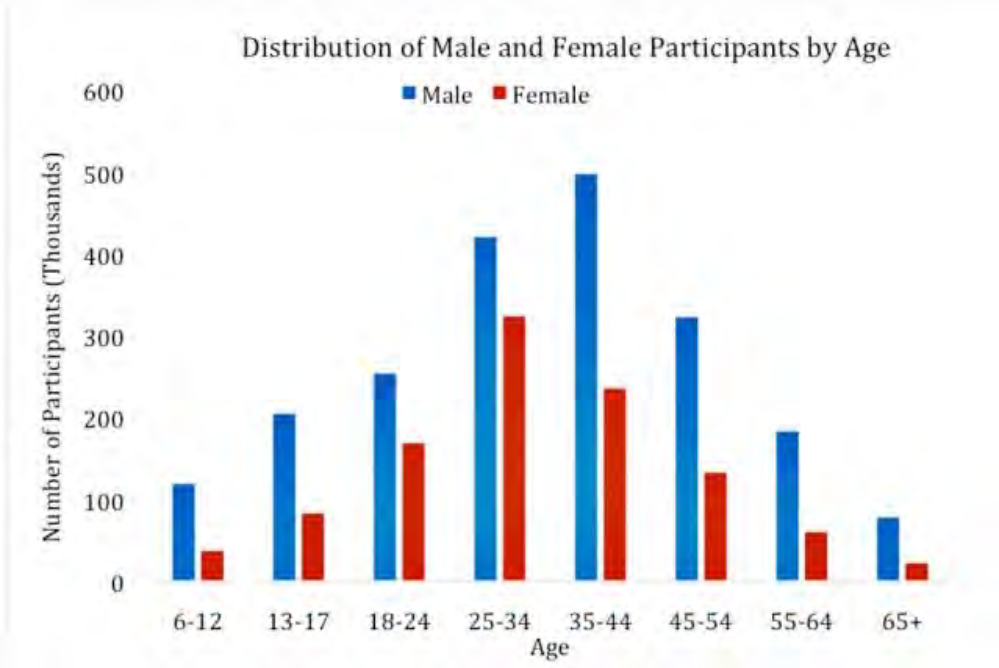


Figure 7 - Distribution of Male and Female Participants by Age. [Image] (2015) Retrieved from https://thedivelab.dan.org/2016/01/14/participation-in-recreational-scuba-diving/

Age. Similar to gender distribution, information regarding to age of disabled divers is very little, thus to help with the research, information finding is taken from the percentage of disabled individual's age and the age of divers, which is then compared to see any correlation between them.

Table 1
Canadian population aged 15 years and over, by age group and disability status, 2017

Age group	Total Population	Persons without disabilities	Persons with disabilities	Prevalence of disability
	number			percent
Total - aged 15 years and over	**28,008,860**	**21,762,230**	**6,246,640**	**22.3**
15 to 24 years	4,155,440	3,609,040	546,410	13.1
25 to 64 years	**18,636,250**	**14,908,330**	**3,727,920**	**20.0**
25 to 44 years	8,940,410	7,572,150	1,368,270	15.3
45 to 64 years	9,695,840	7,336,190	2,359,650	24.3
65 years and over	**5,217,160**	**3,244,860**	**1,972,310**	**37.8**
65 to 74 years	3,241,250	2,204,670	1,036,580	32.0
75 years and over	1,975,920	1,040,190	935,730	47.4

Source: Statistics Canada, Canadian Survey on Disability, 2017.

Figure 8 - Canadian population aged 15 years and over, by age group and disability status, 2017. [Image] (2017) Retrieved from https://www150.statcan.gc.ca/n1/pub/89-654-x/89-654-x2018002-eng.htm

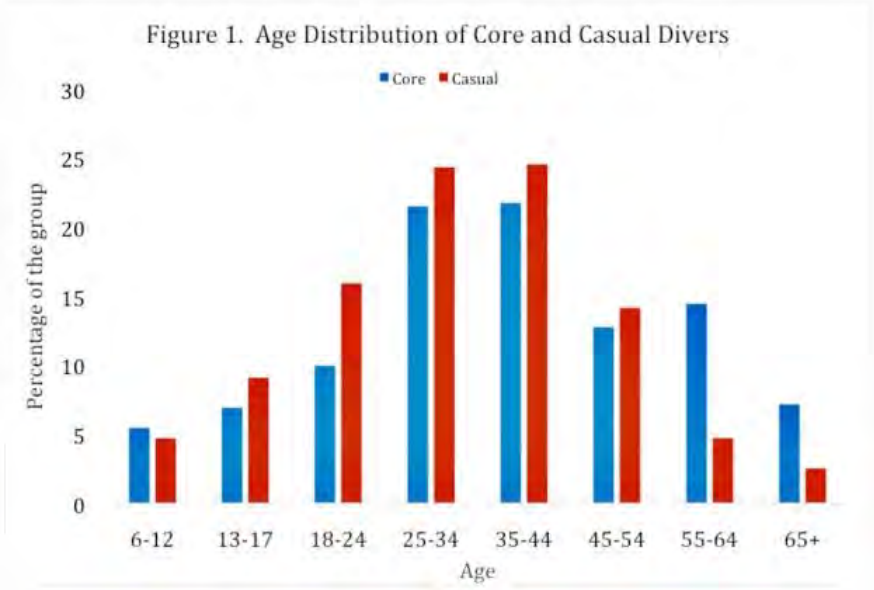


Figure 9 - Age Distribution of Core and Casual Divers. [Image] (2015) Retrieved from https://thedivelab.dan.org/2016/01/14/participation-in-recreational-scuba-diving/

Race and Ethnicity. Again, as seen with the images the predominant ethnicity among firefighters is shown in demographics as being White (Caucasian) which make up just over 80% of firefighters. With Black (African American) being the second most prominent Ethnicity.

Figure 10 - Adults with Disabilities: Ethnicity and Race. [Image] (2017) Retrieved from https://www.cdc.gov/ncbddd/disabilityandhealth/materials/infographic-disabilities-ethnicity-race.html

Education. The education of employed people with disabilities can reach all the way to a university level. The education level of those going scuba diving is also similar, reaching to a university level of education.

Table 8
Employment of Canadian population aged 25 to 64 years, by educational attainment, disability status, severity and sex, 2016

Education	Persons without disabilities		Persons with disabilities			
			Milder		More severe	
	Women	Men	Women	Men	Women	Men
	percent					
High school or less	65.8	79.2	54.4	67.0	28.8	32.3
Trade/college/CEGEP	80.3	86.2	79.0	79.5	47.7	49.0
University	81.6	86.7	79.1	83.9	58.2	50.0

Source: Statistics Canada, Canadian Survey on Disability, 2017.

Figure 11 - Employment of Canadian population aged 25 to 64 years, by education attainment, disability status, severity and sex, 2016. [Image] (2016) Retrieved from https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-respond

Attribute	Size of Market	Freshwater Scuba Divers & Snorkelers	Did Not Go Freshwater Scuba Diving or Snorkeling[1]	Pleasure Travelers	Index[2]
		556,454	17,883,055	18,439,508	100
Education	High school or less	24.6%	36.6%	36.2%	68
	Some post-secondary	12.7%	11.1%	11.2%	113
	Post-secondary diploma/certificate	25.1%	21.8%	21.9%	115
	University degree	37.7%	30.5%	30.7%	123

Figure 12 - Education. [Image] (2007) Retrieved from http://www.mtc.gov.on.ca/en/research/travel_activities/CDN_TAMS_2006_Scuba_Diving_Snorkeling_Oct2007.pdf

Income. Based on the information below, the income of people with disabilities is much lower compared to people without disabilities. The income can also drop even lower if the person's disability is much more severe.

Table 11
Median after-tax personal income of Canadian population aged 25 years and over, by disability status, severity, age group and sex, 2015

Disability status	Aged 25 to 64 years		Aged 65 years and over	
	Women	Men	Women	Men
	dollars			
Persons without disabilities	34,460	44,410	23,200	34,340
Persons with disabilities				
Milder	30,080	39,710	22,980	31,550
More severe	17,520	20,230	19,520	27,560

Source: Statistics Canada, Canadian Survey on Disability, 2017.

Figure 13 - Median after-tax personal income of Canadian population aged 25 years and over, by disability status, severity, age group and sex, 2015. [Image] (2015) Retrieved from https://www150.statcan.gc.ca/n1/pub/89-654-x/89-654-x2018002-eng.htm

Discussion on Findings

Based on the images above we get a general overview of disabled people and divers and some correlation of information between them. From the images, it can be observed that people that dives with a disability may appear to be between the ages of approximately 20 to early 40.It appears that based from the image people that dive with a disability seems to be of Caucasian background while the most common ethnicity for disabled people based on the infographic are blacks and whites. When it comes to the income of disabled people, it may range from around $17,000 to $40,000 which may also vary depending on the severity of the person's disability. The education level of disabled people reaches from at least a high school level to all the way to university level. With these statistical data, it helps to create a preliminary image of a disabled person that may go scuba diving for a recreational activity.

Demographics of Disabled Scuba Diver (Speculations)	
Age	30s, Early 40s
Gender	Mostly Male
Ethnicity	White & Black
Income	$40k - $80k
Education	May reach University Level

Primary User	Divers with Disabilities
Secondary User	Normal Divers
Tertiary User	Diving Instructors / Trainers

User Behaviour

A literature search was conducted to discover a disabled person's traits relating to user behavior. For this search Google and the Humber Library website were used to extract relevant information. The following search terms were used:

- "Social activity of disabled diver"
- "Movement and mobility of diving while disabled"
- "Pain and hardships of people with disabilities"
- "Common disability while diving"

Findings

Findings have been summarized below according to the relevant categories: Frequency of types of disability and pain levels; Group or Solitary Social Activity; Motivation and lifestyle; Income Level; Personality and cognitive aspects.

Disability Types and Pain Levels

There are multiple types of disabilities with each having their own severity levels. Depending on the disability, it may affect the diving experience.

Table 1
Prevalence of disability by type, among adults aged 15 years and older, Canada, 2012

Disability type	Population	Percentage
Total disability	**3,775,900**	**13.7**
Pain-related	2,664,200	9.7
Flexibility	2,078,000	7.6
Mobility	1,971,800	7.2
Mental health-related	1,059,600	3.9
Dexterity	953,100	3.5
Hearing	874,600	3.2
Seeing	756,300	2.8
Memory	628,200	2.3
Learning	622,300	2.3
Developmental	160,500	0.6
Unknown	79,500	0.3

Note: Individuals may have more than one type of disability; therefore, the sum of all individual disability types is greater than the number of "total disabilities".
Source: Statistics Canada, Canadian Survey on Disability, 2012.

Figure 14 - Prevalence of disability by type, among adults aged 15 years and older, Canada, 2012. [Image] (2017) Retrieved from https://www150.statcan.gc.ca/n1/pub/89-654-x/89-654-x2016004-eng.htm

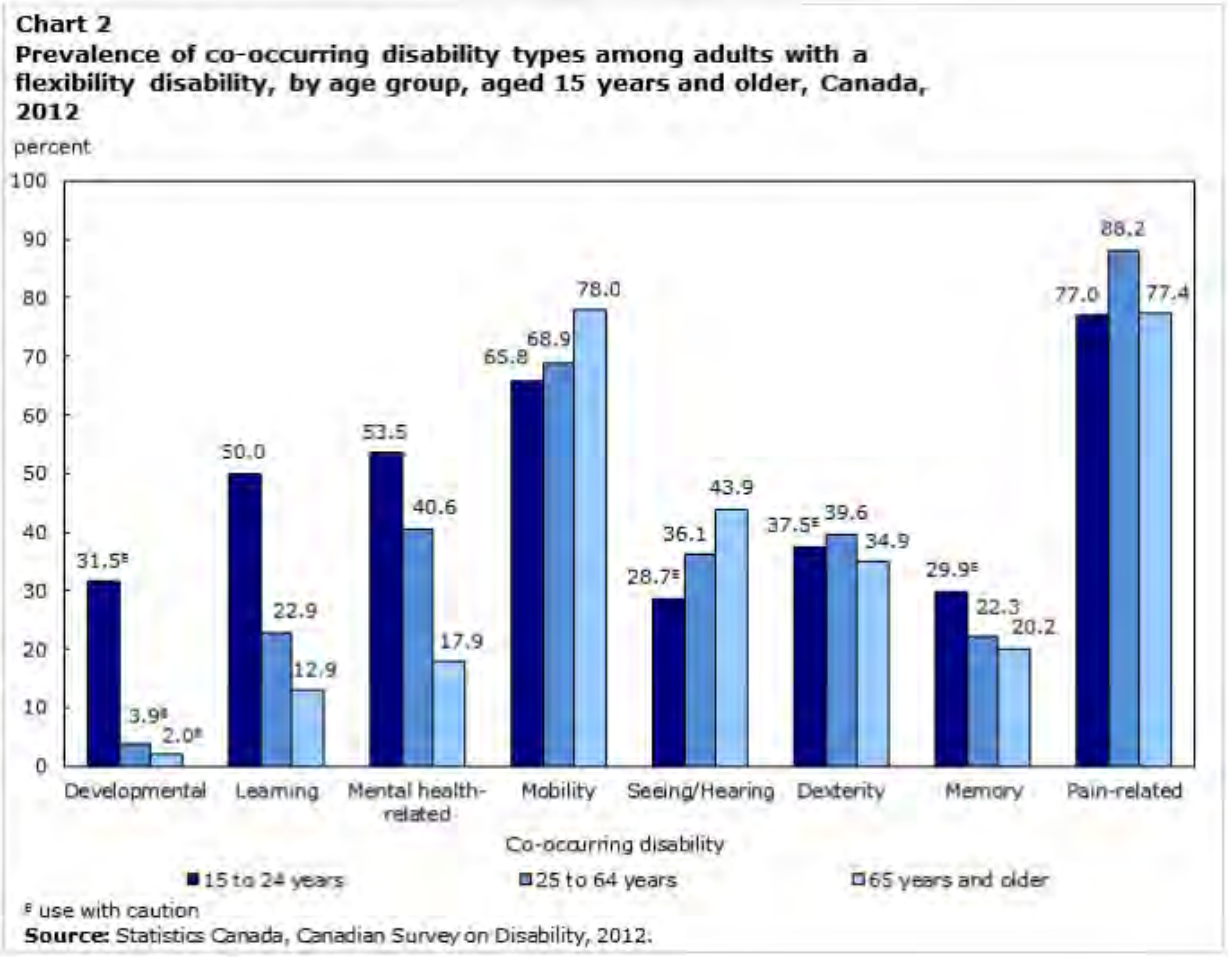


Figure 15 - Prevalence of co-occurring disability types among adults with a flexibility disability, by age group, aged 15 years and older, Canada, 2012 [Image] (2012) Retrieved from https://www150.statcan.gc.ca/n1/pub/89-654-x/89-654-x2016004-eng.htm

The table above shows information regarding the type of disabilities that are possible for someone to have with some having multiple disabilities at the same time. The two highest frequency of disability in the graph is mobility and pain-related disabilities, which can have a large effect and can be a hinder during a scuba dive activity. It would be best to focus more on people with mobility issues as they will be the biggest subject matter to be looking into when making scuba diving more accessible for disabled people.

Social

Normally, scuba diving is a recreational activity that one can do with multiple groups of people without the help of anyone or any supervision if proper training is received. If someone is diving without any prior training, then they are limited to shallower waters and/or with an instructor to supervise them for safety concerns, but when it comes to a disabled person, they will need to be constantly monitored and looked after due to their disability. Though they may enjoy being able to go diving, they would be more delighted being able to do it themselves.

Income Level

Scuba diving is one of the few recreational activities that is strenuous and is more costly compared to other activities due to the required equipment and training needed to do a dive. Disabled people's income is much lower than an average person's salary due to their disability which limits their work activity depending on what the disability is and how severe it is. But they can still afford to go scuba diving once in a while and one of the main reasons as to why that is, is because they have the ability of being able to move freely underwater which give them a sense of joy and fulfillment.

User Behavior Conclusion

The variable found in this aspect of understanding the user had to do with the physical limitations of their physical disabilities (problems of mobility or other disability limitations) rather than income levels, or they job description.

User Profile Summary

User	Description
Primary	Divers with Disabilities
Secondary	Normal Divers
Tertiary	Diving Instructors / Trainers

Primary User Profile

Demographics		**User Behavior**		**Personality**		**Cognitive Aspects**	
Age	20-50	Social	Social but disability gets in the way	Independence	↓	Technical Skill	↓
Gender	Predominantly Male	Activity	Varies Depending on aspects such as type of disability	Self-Efficacy	↓	Pre-Requisite Knowledge	↑
Ethnicity	Caucasian	Social	Low to Mid - Social	Changeability	↑		
Income	($17,000 to $39,000)	Level of Focus	Mid	Support from Love ones	↑		
Education	Minimum High School Diploma			Dependency On others	↑		

Table 2 Primary User Profile

Conclusions

The variables found while doing this helps to have an awareness of understanding what a person with disability goes through normal life. Depending on the type of disability and severity, one might need to be constantly looked after which can lowered not only their social life but also contribute to psychological stress of not being able to do things themselves. Scuba diving allows them to have that sense of freedom thanks to being able to move freely underwater but finding a way to make them more independent by finding a solution for their limited mobility with help greatly in a better experience.

2.1.2.3 Research - Interview

Introduction

A search for an advisor that deals or works on the topic of making diving more accessible for people with disabilities was also conducted to know more of the actual work experience and any relevant data and information they know from the work they have done in the field.

Thesis Topic: *How can we make diving more accessible for people with disabilities?*

***Objective of the user observation**:*
To determine the main pain points of the user while diving underwater with a disability.

User (individual or group):

- Diver and/or instructors
- Disabled individuals
- Late 20s to early 40s
- At least a high school diploma

The group or individual that is the focus of your inquiry (e.g., early senior with mobility issues) … can be more detailed (e.g., specific age group, sex, income, education)

User Background:
The person being interviewed is a diving instructor name Sandy Robb and she instructed for people that wants to go on a diving trip. She has also worked with people that have disabilities ranging from mobility to cognitive issues.

Method:

Interview

- Friday November 13, 2020, 2:00pm
- Driven by the analysis method- the Empathy Map.
- Interview Questions
- Zoom Meeting

Recording Techniques Used

- Video recording
- Transcription app (Otter)

Results:

Transcript of the Interview with the advisor

Analysis:

The Empathy Map
The Empathy Map insights into generates insights into Pains,
and possible solutions which make the task easier, more productive, or more enjoyable?

Questions for the Empathy Mapping

Interview with the user.
Specific questions that can be asked to give a more complete picture (for each of the main 7 questions).

1. WHO are we empathizing with?

- *Can you tell me about yourself and your background?*
- *Can you tell me about your relationship to the activity of diving? (How do you feel about doing this task?)*
- *Can you tell me about the people your working with?*
- *Tell me about how you got started doing this?*

2. What do they NEED TO DO?

- *What are you doing during the dive?*
- *What motivates when you decide to do this task?*
- *What or where do you get your **inspiration for doing this**?*

3. What do they SEE?

- *Describe the work environment and important visual cues while doing this task (if any).*

4. What do they SAY?

- *What instructions do you give others related to any part of this activity (if any)?*
- *What is going on in your head as you are doing this task? (what you say to yourself while doing this task)*
- *What type of social conversation takes place when doing any of the related tasks involved (if any)?*

5. What do they DO?

- *Are there any steps for this task that you had to prepare for in advance?*
- *What is the equipment? Are there any equipment specifically for the disabled?*
- *Please go through the sequence of activities involved, as if you were instructing a diver.*

6. What do they HEAR?

- *Do you remember any comments people have made about you doing your task?*

7. What do they think and feel about…

A. GAINS: *goals achieved; experiences enjoyed*

- *What were your goals in doing these tasks and were they achieved?*
- *What if anything was enjoyable about doing this? Why?*
- *At the end of the day, how do you feel about the outcome? Why?*
- *Can you recall a time doing this task that was really enjoyable?*

B. PAINS: *fears, frustrations, anxieties*

- *Is there anything you find difficult about diving with a disabled? Why?*
- *Regarding your goals doing this task, which were **not achieved**? Why?*
- *What gave you the most grief, or frustration doing this?*

"What other thoughts and feelings might motivate their behavior?"

- *Anything that would make **easier** if doing this again?*
- *Is there anything that would make the experience **more enjoyable** for you?*

Result

Transcript

“Shown below is a sample of the transcript taken from the interview in regard to the thesis topic of diving with a disability.

The transcription was generated from …… *voice recording / transcription app Otter.*”

1. WHO are we empathizing with?

So the first question, you kind of started already, but so can you tell me about more of yourself in the background?

Oh, yes. diving with people with disabilities. Yeah. Yeah. And I guess I guess I've covered that we weren't recording at the time. Yeah. So yes, it starts many years ago. And also I have taught that there is an organization out there, just so you know, that it's called HSA, it's a handicap scuba Association, all of the teaching I have done with the divers with disabilities, I have taught them through PADI, through my being an instructor with PADI. And when I started the teaching people with disabilities how to dive, PADI didn't have the special course that they do now. So what I was doing is if the person had the ability, maybe they do the steps differently than we did in our regular course. But as long as they could perform the requirements, what PADI needed, you know, the requirements that PADI needed in order to pass, I gave them a full PADI certification. And the only one I was unable to do that with was the blind student who I worked with, for the simple reason that he could not act as a buddy, if his buddy was in trouble, because he couldn't see what to do, he wouldn't necessarily know where the shore was to be able to get them to shore, that sort of thing. So he couldn't get certified as a patty, a full pad with a full Patty certification, because he wasn't able to fill all the requirements. So it's not whether they could fill the required or how they filled requirements is whether they could do them. And with modifications. He was my only exception.

can you tell me about your relationships, the activities, so you do so? diving?

What got me diving is years and years and years ago, I saw these people just walk along the beach, walk along the shoreline disappear under the water in bubbles and said, Oh, my God, this, this looks so amazing. And so then I was on vacation in Jamaica. And there was this big sign at the property next door that said, learn to scuba dive. And I said to my friend, Lucy, I said, you know, someday I'm going to try that. She said, Why wait for some day. And that was 40 years ago, and I'm still diving. And as I mentioned earlier, before, we had the recording on, it was working with people with disabilities, in the filming of this documentary, documentary, it's a horrible documentary, and it's really poorly done. But it gave me an opening and an opportunity into, I guess, working with people with disabilities, and looking at how we had to adapt in order to make it fun for them. So to me, it was a real challenge. But more than anything, it was a learning experience. Because it's not like regular teaching where I could say to someone, okay, here's how you do it. What I'd have to what I learned to do is say, this is how this is what you have to be able to accomplish, this is how I would do it. Now let's work and find a way for you to do it. So it just became a whole different perspective for me, and I really, really love it.

can you tell me about the people you were working with? In this case, people that are disabled. Could you tell me more about some of their life story? If you ever heard from them?

Well, the one, one lady I taught Andrea. She has little appendages for arms. So she has maybe a couple of fingers and her arms are very, very small. And so she, it's only because he some equipment, Maris makes a BCD that has some of its controls in a different place. And it's only because of this BCD that she was able to get her full certification. But she is she does everything. I mean, this girl is far more active than I am. She's just absolutely amazing. And one thing I learned from working any of the people that I worked with, is they are, they don't look at themselves as being special or different. They just, they're just people like everyone else, and they do what they want to do. And they can laugh at themselves. And more than you could ever imagine I spent more time laughing I thought it would all be so serious and that I spent more time laughing, nearly choking to death on the water sometimes because we had so much fun. And because when things went wrong, instead of treating it like it was a disaster, they'd laugh it off. Because this wasn't working best we learn a new way to do it. Mark who's blind has been blind since the age of 10. And an interesting story and he again is he doesn't see himself as having a disability he just can't see. And what was funny is one night we were at the pool and he has a guide dog. And he didn't we didn't properly leash the guide dog to the to the lifeguard station. And so we went jumping into the water and his dog jumped in after him wanted to rescue him. But the people that I have taught are another fellow I taught, he walked with cadence to or he walked with crutches. And he would just chuck his crutches by the side of the lake, and then kind of slide his way into the water on his bum. And away he'd go It was just the, the people that I have taught have, most of them have lived with a disability all their lives. So, they're used to doing things a little bit different in coping. And to them, it was no big deal. And when you consider if you get to the side of the water in a wheelchair, and you get underwater, and you're totally weightless, you weigh nothing. And you can move like a fish and just not be attached to anything like a chair or a cane or crutches or anything else. It For Me scuba diving is such an incredible feeling. I can't even imagine what an amazing feeling of liberation, it must be for them. Right? It's a great feeling. Being able to move.

2. What do they NEED TO DO?

When you go diving with someone, what is your task when you are underwater with them? What do you make sure is happening or not happening?

Well, to get certified as a diver, there are a whole bunch of, I guess, tasks that you have to be able to do. So, there it starts above water is how do you assemble your equipment, right, as a diver, you have to be able to assemble your own equipment. So it's learning to assemble the equipment, so that it's safe to use, then then the first step is getting into the water and just putting the regulator in their mouth and breathing. Can they do they have? You know, did they have sufficient strength in their job or the regulator in their mouth? And are they comfortable and showing them how to work the controls on the equipment so that they can get underwater, and then when I get them under water, I would take them exactly the same as I would take any other student, but paying attention to whether they could use their legs, for instance, if they can't use their legs, there are special gloves that are almost like frog things on your hands so that they you can move your fingers but they take the place of Finn's so they work with any adaptations that we have in equipment. And I just make sure that I'm with them all the time and have the signals I know what signals we're using and they know what signals so if they're comfortable if they're not comfortable if they're ready to proceed or not. And
at first I would take them in shallow water the same as I would any other student and make problem if they were nervous. Take them by the hand or the arm or piece of equipment if I had to hold it for them, and just swim around slowly till they got comfortable, and then gradually work into the skills. Right? Okay. Of course with a person, depending on the type of disability they have may not go as fast as a course, that I would teach someone who was full, fully able bodied, because it may take a little bit longer for them to learn how to adapt to moving in the water or to using the equipment. So I couldn't say they probably wouldn't learn, or I wouldn't be able to do a weekend course and have them ready to do their open water. It's probably a lot longer period. Right? Yeah.

What motivates us to pretty much kept on doing the tasks when working with the disabled, because it's, it's made me learn, right? It's taught me so much. It's open doors to an area that I wasn't familiar with. And
who knows, now that I'm getting older, I may have limitations at some point in time and what I can do physically, and just seeing how other people meet those physical challenges is a real eye opener for me.
And it taught me to listen and observe more, rather than rather than showing and telling. It taught me to make it a really interactive experience that both of us learned from it, they learn how to do something they didn't know before. And I learned how to deal with a situation I had never dealt with before. Right? learning experience. Yeah, really.
It was sort of like me going to school.

3. What do they SEE?

Can you try to describe the work environment, and any important visual cues that you see, while you're working with disabled people.

that's, that's a bit of a tough one each, I guess each person has a different disability, each person that I've worked with, like an even if they had the same sort of disability, they may not have adapted to it the same way. Right. So it's, it's a matter of, well, for instance, with someone who is blind, you, I had to learn a whole new set of signals, because normally we use him signals to show which way you know which way we're going to stop to check our equipment. Well, none of those worked with him. So I had to, we had to, I had to figure out what signs he used in order to communicate with me and I had to learn them so I could communicate back with him.
As far as adapting to the environment, or just fires the work or the scuba environment. Again, it's not like working in an office building or a factory or anything else where you have a very predictable place and experience. Because you know, yourself growing up by the ocean, it can be many different things on many different days. So it means being able to, I guess, be alert to everything that's happening. If it's really wavy, for example, if the waves are really high, and the person is using crutches to get into the wall or to the edge of the water. Maybe that may not be a down day, we could go diving, or we may have to find a different way to get into the water. If we're not diving from a boat. The work environment as far as a boat, depending on the person's abilities, or disability, getting them into the water can be a challenge. Like I said the lady who had no muscular control because of having polio as a young person, we would two of us would pick her up and we just heaver off the side of the boat. Once she was in the water. She had enough motion in her hands and arms that she could handle her equipment and she was fine. The fellow the fellow who had one leg amputated at the hip. What was the challenge for us there was putting weights on them. As you know when you're diving, you have to wear weights and if you're too heavily weighted, you just sink to the bottom and you have a hard time getting up. If you're not heavy enough you can't get underwater. Well because he had one leg missing. He kept on tilting over to the one side. So it took us a long time to finish. figured out the placement of the weights. So he too could be stable in the water. Okay, so I guess every case is different and sort of had to be adapted as we went along.

4. What do they SAY?

If you were to do a dive right now, explain some extra instructions that you tell your divers? Can you tell me what just goes through your head when you are diving with the disabled people?

Well, I would, every, every set of instructions depends. For example, if we were on the with we were on the surface, I would have to explain to people how to put their equipment together and why it's necessary to. To put it they would have already spent some time in the classroom. So to take a scuba course, you have the component with the classroom. And then you have the pool session where you learn in confined water
to do the basic skills, and then you move on to open water. So each one comes with its own set of instructions. So depending on where what part we're doing in the classroom, I would anyone who was in the room who had disabilities would be able to watch the video and see the demonstrations that I did with equip the equipment the same as if I was in the, you know, as anyone else in the classroom. Unless of course they were blind and then I'd then I would actually have them sitting up front and have them when I put equipment on or put it together have them actually feeling the equipment so they could understand what I was talking about. Then when we get to the pool, then it's then it's a matter of actually being in the water and learning First of all, to breathe comfortably to get comfortable breathing, how to let the air in and out of your BCD so you can either stay on the surface or so you can sink how to propel yourself underwater how to position your body so that your most streamline for swimming. I always let people know that they should. They should always consider their inner fish. Don't you don't see

fish standing up? Well, the odd one does, but most fish don't stand up right like this. In the water. Most fish swim laying down and flat and they don't put much movement into it. So I always ask people to bring out their inner fish. Right.

Can you, if you could, recall some social conversations you had with your divers, if you had any. Maybe while they were putting on the gear or any other time where you ever had a conversation with them.

Well, I remember Andrea, the girl with a very small the under formed arms and that. And so normally I would stand up and put my BCD over the tank and everything and then tighten down the strap. Well, to get the strap tight enough so that it doesn't fall off your back. Take some takes a bit of strength. So she would simply sit down on the deck of the pool and wrap her legs, lift her legs up in the air and wrap them tight around the top of the tank. And I remember her looking at me and saying Betcha you can't do that. She's absolutely right. I couldn't. And also, with her because she had very slender shoulders and slender upper body like she had incredible strength in her legs and that and use them for a lot of things. But because her shoulders were so under formed and so were her arms, she didn't have the upper body strength to hold herself upright.in the water when we were on the surface underwater it was fine because your equipment pushes you into a facedown position the way you swim. But on the surface, she would try to hold herself up right but because she didn't have the upper body strength, her equipment kept on pushing her face first into the water. And I can just remember her laughing so loud spitting up water because she was trying so hard to find a way that she could stay on the surface. And, and still not go planting face first in the water. So I can remember we just howling with laughter as she's spitting up water and everything we've seen We finally figured out a way, simply learn to take most of the air out of her BCD and lay on her back. So she was laying on it. And then she didn't need the strength to hold herself upright. And oh, god, so we're just there were so many. My blind student Mark had said to me, okay, you've been guiding this first time I took him in the pool. He said, Okay, you've been guiding me around the pool and you haven't let me hit. You know, you haven't made me hit into any edges of the pool headfirst or anything else. Now, let me guide you around. I said, No, I don't think so. So, there was just we had a lot of fun with it.

5. What do they DO?

What equipment did you have to use to go diving? And for the disabled people, is there any specific equipment that they had to use?

Okay, well, to dive, for the most part, even diving in warm water, you would wear a wetsuit, depending on the temperature of the water, it might be just a shorty wetsuit, or it might be a full wetsuit.
Up here in Ontario, you possibly even want to dive in and probably want to dive in a dry suit because it's very cold, and have all the pieces of equipment that our a challenge. By far, the wetsuit is the most of a challenge. Mm hmm. For the simple reason that a person who has a physical disability, often that body part isn't straight, and normally formed, like the average person. So when I think of the fellow who had MS, who was who was a diver, and kept on diving afterwards, the biggest challenge was getting him into a wetsuit. How do you when a person's body is hunched like this? How do you take them and stretch them into this single piece of neoprene that's made to fit somebody who's standing up, right, it just is almost impossible. And what I was thinking would make so much sense is if there was some sort of a shop that did customization on wetsuits for people depending on what their disability was. Because Velcro works incredibly well underwater. So if you had someone who was like had no use of their legs, why couldn't you have a suit that was totally slid up the middle with Velcro on the legs, the person could lay down on the deck, somebody could slap their legs closed with the Velcro, and instead of struggling to push and pull and work to get them into a suit, they could just simply lay there have the suit wrapped around them, almost like a super bandage shouldn't go diving. It's not the underwater part that's difficult, it's the getting them into the water. Right. Then another thing is the tank, your tank is very heavy. And if you don't have say a lot of upper body strength, to handle or to hold that tank, while you're out of the water, it's couldn't weigh I know 20 kilos. So yeah, it's heavy. So it's finding a way to get the person into the water so that the way the water can support the tank. But on the surface or on a boat, it can be really difficult when you are using the tank. Another piece of equipment is the BCD. So it's the buoyancy control jacket that attaches to the tank and then you wear it like a jacket. So that lets you control where you are in the water by letting air in and you know, if you're on the surface, you fill it up with air. So it acts like a life jacket. And when you're underwater, you take the air out of it because you want to be able to get down to the bottom. Those are fairly standard in design. But there is one make that this girl Andrea, that if she if this one make a marrows Mrs. BCD hadn't been wasn't out there, she would not have been able to get full certification, because her arms were not long enough to reach the controls on one of these vests normally, but this vest had a little side pocket just under just sort of it would be sort of around the upper rib cage that her arm was long enough that she could push on the button that would let air into the BCD and everything. So it's a totally different design than everything else that's out there, but it's because that one company made a modification and why I don't know that but she was able to get a full certification. Another thing we teach people in scuba diving is to that you always have Your equipment the same way. And it's mainly a safety thing is that if you are struggling in the water or you're having a problem, I don't want to have to go underwater where I can't talk to you figure out if you're left handed or right handed. So if you have a right handed or left handed equipment set up. If you wear your equipment exactly the same way, as I wear my equipment, if you need help, I know what to do, if you've got some sort of a makeshift setup of your equipment. If you need help, someone may not be able to help you. But however, some of the people who have disabilities may have the piece of equipment, say that's normally operated with the left hand, they may not have their left hand working, so they may need it adapted for the right side. And again, this might this girl Andrea, we had normally your regulator, always the part you breathe, always comes over your right shoulder. Well, with her, we had to hook it up. So it came over her left shoulder because she didn't have the strength in her neck to hold it. If it came over the other side, so we had to adapt the way she wore the equipment. Mm hmm. So those are so basically it, you wear the wetsuit, you wear fins, you wear a mask, so you can see, you have to be able to clear your mask, you have your regulator, you have your tank, and you have your BCD and your weight belt, and hopefully you don't forget any of the pieces at home or you sit on the boat.

6. What do they HEAR?

Have others commented on your task or job of working with disabled people for a diving activity?

Hmm. Yeah. Back then, back then what I had always worked with people saying is that when you're diving within another diver that's not familiar with you, you need to make sure that you explain to them how your setup works. So that if you do run into any trouble, they can help you. Because they can't just assume that it's set up exactly the same way as everybody else. Again, not all people that come in with a disability are the same and that you have to accommodate for each one depending on what their situation is.

7. What do they think and feel about…

A. GAINS: *goals achieved; experiences enjoyed*

Tell me about your goals for doing such task, and do you believe you have achieved those goals?

That that's a really tough one, because I'm one of these people who has done an awful lot of things in my life. And you can see by the white hair, I wasn't born yesterday, I have done a lot of things. And so many things I have fallen into my life in my life have been by accident. Like by accidental exposure, many of the jobs I just happened to be in the right place at the right time that someone was looking for someone and gave me a chance in diving. Like I said, it was just seeing somebody go into the water. This is long before diving was really popular. And just thinking wow, you can breathe underwater. This is amazing. And I never set out to be a scuba instructor. I just knew that I love to dive and I want to spend the rest of my life diving. And part of the reason I liked it is because it was different. Not everybody did it. Part of it because it took me to places that I never expected to go. Part of it is because as a diver you become very environmentally friendly. And I was very conscious of the environment anyhow, having growing up, grown up in a small town, the environment meant a lot to me. And so helping to preserve the environmental mental on. So I never had the goal of becoming an instructor. But I joined a scuba club and started dating a fellow there who was go who was who had just become an instructor and spent so much time helping with the classes, that he just insisted that both my friend and I went and became instructors. So we just did because it was going to help out our club. It wasn't that we wanted to make a living as scuba instructors. Both of us were employed in paying jobs, or well paying jobs. And so we were just diving for the fun of it. And then like I said when I when I got to be the dive master when they were making this documentary, I wasn't as interested in the filming of the documentary as I was it just Hey, there was a whole chance to learn a bunch of new things here that I didn't know anything about. And that's really what got me interested in working with diverse with disabilities. And then I spent quite a long time either teaching or diving, but not necessarily with people with disabilities. So I never got any kind of a special certification to work with them. I just like I did, I contacted the HSA. But didn't. I was already teaching people who had disabilities, they just kind of came to my class and I just worked with them and learn from them. And from each person, I learned more. So did I meet my goals? Absolutely, because I didn't really set any. But I just, I enjoyed it so much. And if it hadn't been I probably in spite of my age, and if it hadn't been for COVID coming along, and basically shutting down teaching facilities and everything else. This year, I'd probably still be teaching, but I figured From now on, I'm just gonna dive.

At the end of the day of doing a dive, can you tell me how you feel after doing your task. were you satisfied? Do you feel like you did your job at the end of the day? What are your thoughts?

Absolutely, to me diving is…I can't do meditation, because I'm too active to hyperactive, and I want to be on the go all the time. But to me diving is meditation, it's just, it's an environment that is so different than the one we normally live in, to be able to take someone who, especially someone who has limited movement, and to take them into an environment where they have, where they can move around without anything physical, like a wheelchair, or crutches or anything, where they can just move around and let the water carry them where they want to go, where they can see things where they can stop and watch fish behavior and watch all these underwater creatures living their life in such an incredible manner and things that we don't even think of unless we're into diving, and then have them come up to the surface and grins so wide that you think their faces going to split in half. Because it's been such an amazing experience for them. To me, that just makes it all worthwhile. Mm hmm. And even my, my stepdaughter when I taught her to dive as well, and she learned to dive when she was just a kid. And she was diving here in Ontario, where the waters brown and cold and nothing and everything else. And we took her on a trip to St. Kitts in the St. Kitts and Nevis. And the first dive that she did when she came up from her dive. And this is a girl that's really got a laid back temperament. She doesn't get excited. She just takes everything as it is. And there she came up from the dive and she could not sit on the dive boat. She was like she was just she was just absolutely beside herself. Because it was like we had gone diving in a fishbowl at every kind of fish. It was like they all came out to welcome her. And every kind of fish you can imagine was there. And the experience was so overwhelming for her. She was just buzzing like a bee in the hive. And just seeing that it I can still I can still grin today just remembering that expression, and how she reacted when she had been diving in warm water for the first time. So it's just every dive. It's so satisfying. Sometimes you see amazing things. Sometimes you see not very much. Sometimes you think see things, photograph things that are smaller than your fingernail. And then when you blow the image up on the screen, and you think oh my god says I didn't, I couldn't see that they look like that. And then other times you're diving with whale sharks, and they're 10 times your length. It's just every experience is different. And it did. And each one is just remarkable. And, and because you dive with a buddy, you're always sharing it with someone too. And when you're diving with someone who wouldn't have that type of experience normally because of some disability, and they're even more entranced by it than I am that that just makes it all worthwhile.

I know you said you didn't really set up any goals, but can you think of anything like for example a task or any activities that you weren't able to achieve? Something you set your mind upon, but you did not achieve it exactly the way you want it to.

Hmm. Not so much with instructing but I, I used to have I used to be claustrophobic I had a fear of small spaces. And I know a lot of people I have taught to dive have said that they're claustrophobic or they think they'll be claustrophobic so they wouldn't try diving. But I've, they have found with time, my time and patience that they really aren't. But I remember doing some cave diving. And for someone who's claustrophobic and going through a space where you have to take your tank off and shove it through underwater, and then follow it through and wedge your body through places that you don't really fit. That was that was a super challenge for me to do. Like, mind you I got over my claustrophobia. But on the other hand, it made me realize that that's not what I was super comfortable doing. And I had done it, I had accomplished it. I sure as hell wasn't going to teach anybody else to do it. And it wasn't some that there is so many aspects to diving. I didn't need that one. It was one of those. Okay, I've checked the box off once. That's good enough for me. Oh, yeah. I've also been diving in Iceland. The water in Iceland is clearer than anywhere else in the world. And if you couldn't see a person's bubbles, you would not know that you were underwater, you lay on your back. And this is in the summer, and you look up and you can see the chunks of ice floating on the surface above you. And Iceland is where your the tectonic plates of North America and Europe join underwater. So you can actually touch two continents separate normally separated by water at the same time underwater. So it's a pretty amazing, just that alone is an amazing experience. I've been I've been to all seven continents visiting, but they didn't let me dive when I was in Antarctica. So that's the only continent I haven't been diving on.

Was there a reason for that?

Yeah, because we were on a cruise boat, and they didn't have the equipment for, or the or the insurance to cover passengers diving in Antarctica. Other than that, I would like to go underwater and pull the pull on the penguin's legs.

B. PAINS: *fears, frustrations, anxieties*

can you tell me what you think is the most difficult or frustrating thing when diving with someone that is disabled?

I found it isn't frustrating for me. And I'm not a normally patient person when I'm on the surface. But when I work with students, I really do have an awful lot of patients. And when I work with people with physical disabilities, I have even greater patients. So, I know it isn't. It, I don't think it's as frustrating for me as it is for them, where they want to maybe just go running into the water and jump in. And they can't do that. Or they may have to take extra time to prepare their equipment to make sure that they could wear it safely, that someone else is sitting there waiting to get into the water. And they've got to go through these extra steps to make sure that they'll still be able to do the dive. Or hearing somebody from Mark who's blind hearing somebody to describe what they saw. And because you can't go down and pet a fish or anything, you can't you have to rely on what someone's telling you and I just can't imagine what that must be like. Mm hmm. I've also taught people who are deaf and that's quite interesting, because of course many of them speak sign language. So, we use limited hand signals underwater to indicate yes uncomfortable no I'm not let's go up let's go down direction and that your instructions are very limited where they can carry on full blown arguments underwater. It's quite interesting to see a couple just down there just you can tell they're having one heck of an argument and you have no clue what they're saying. And that was that was a bit of a that was just One thing I'm thinking of is that as an instructor, that was a challenge for me, because I'm used to when I'm teaching in the classroom, I'm used to everybody watching me, because I'm the one with the information. I'm the one that's showing the slides. I'm the one that's demonstrating the equipment and everything. Well, because I had to have someone who was translating sign language or pardon me into sign language for them. So, the person was standing with me and translating into sign language for the for my deaf class. They weren't watching me at all. They were watching the translator. And I, and I was not sure whether she was saying what I needed her to say, whether they were watching me enough that they still got all these actions that I was doing with the equipment that they understood. So, for me, that was probably one of the bigger challenges is just not having ever worked with someone with I had a full class, I think I had eight of them. And not having worked with someone before, that was acting as an interpreter in sign language. And that was that was challenged because I couldn't tell whether they were getting it. But when they wrote their exam, and when they were in the water, I could see they got it. It was just in class I had to challenge.

can you think of anything that would kind of make the experience more enjoyable? for people with disabilities? Yeah, any ideas?

Yeah, I think I touched on it. Initially, what I was talking about the wetsuits is, is having a company that made equipment that wasn't horrendously expensive, especially wetsuits, that made the equipment, simple, and easy to get in and out of, because of all things that they need the most help with. It's the wetsuit. And also, the ability to make minor changes in their equipment, in the way they were there, their equipment.
So that it didn't have to be specially adapted that you didn't have to get into wrenches and hook hoses up backwards and things like that, that it was just you just like, now you can you can choose something that's left hand or right hand controlled or something like that. Why not have that ability with scuba equipment? At least, that when you buy it in the shop, you'd have the option of saying, okay, I want it hooked up this way. I've often wondered firemen where their tanks upside down. They wear it with a valve on the bottom, and they bring the hose up between their legs. I've often wondered why scuba, we have ours on the back with the hoses sticking out where they could get caught on anything. To me, it's a standard way to do it. We've always been taught that's the way you wear your equipment as a scuba diver. But firefighters are going into confined areas and areas they've got to get in and out of really quickly. So why don't we wear our tanks like they do. Because even for people with disabilities, it might be easier on them physically controlling the hostess that way than the way they are. So it's, it's I guess like anything else. Scuba diving equipment has in some ways evolved, but not as much as in other sports. So maybe we need to take another look at it. Get a whole panel of people with various physical challenges and say, okay, that our divers, get them together and say, with a manufacturer and say what would work for you? What would make it easier now that you know what to do? Because you're a diver? How could you do it easier? I just don't see why. Why we haven't done that yet. It's still like it you most of the equipment is it's improved. But it's still a lot like it used to be.

I guess it is because of the idea of they are accommodating for more of the larger population size.

Yeah. And it's unfortunate, but it is they're always they're always niche markets for people other than the bigger market. So I'm just thinking that divers with disabilities could become a really huge market with a little bit more adaptive equipment. Like it doesn't necessarily have to be adapted out of the box. But if there was a way that they could easily get it adapted to their needs, if it would bring a bigger market, and it would certainly bring an amazing experience to a lot of people that may not try it now. Right? I hope yeah, hopefully in the future do start moving from in that market. Just to include more people than just your average person. Yeah. Well, I have a slightly different topic, I have a friend who has gone into her making her own, she has her own wetsuit company. And most scuba equipment is made for people who are a standard height, and a standard width and a standard body size. And she makes scuba equipment for women. And she has all sized kinds of sizes like up to plus, plus, plus, to accommodate all sorts of female figures that don't fit into this standard wetsuit.
So, if Eddie was one was able to adapt a wetsuit to for a disabled diver, she'd be able to do it, it's just making limited numbers is also more costly, right? But she has done it with wetsuits for women, because most wet suits are designed by guys running companies that these are guys that were diving back in the 60s when women did not dive very much.

Interview Questioning Concluded

2.1.3 User Observation – Activity Mapping

Below shows the procedure of how a person will have to go through when going scuba diving. A person with a disability will also go through the same process, though they will have some difficulties in doing some of the procedures as their disability will make some tasks be more difficult compared to a normal person performing the same task. Scuba diving requires a lot of preparation before a person can go into the water. A person will need to first go through a medical check to ensure that they are healthy enough to go underwater as being able to breath properly is one of the foremost things that a person should be capable of doing when going underwater.

Below is a list of activities that is done for scuba diving:

- Medical examination to see whether one is fit to dive
- Learning what equipment are used during scuba diving and how they operate
- Learning to put on the gear properly, checking on their condition and whether they in working condition
- Training within the confines of a pool with the diving gear equipped so that the user that get a feel on what it is like diving with them on
- Travelling to the location
- Putting the training into action by putting on the equipment on site of the dive
- Doing a real dive in open waters and experiencing the marine environment and wildlife

USER JOURNEY MAP

	Preparation 1	Preparation 2	Preparation 3	Preparation 4	Task 1	Task 2	Goal	Completion
User Goals	Medical Check-up	Explanation of what each equipment are and how they work	Explanation of how to put on equipment	Training on how to move underwater at a pool	Traveling to diving site	Equipment is worn and is ready to dive	Going Diving	Getting back on the boat and travelling back home
User Actions	Medical Questionnaires	Learning what equipment is needed to go underwater	Learning the how each equipment work	Learning the how to move undewater	Divers and instructors travel to the designated area by boat	Wearing Equipment based on the training	Experiencing diving underwater	Taking Off equipment
	Doctor's notes		Knowing how to put on equipment and the order they go on	Knowing the safety procedures and precautions		doing safety checks before diving	Explore and take photos	Returning to shore
User Thoughts	Am I healthy enough to go diving?	What do each equipment do?	How hard is it to put on?	Am I able to complete this training?	I'm close to being able to dive!	Is my equipment on securely?	I feel weightless and I can move freely!	When will I be able to return?
	Will my disability stop me from diving?			Will I pass?	How far is it?	Have I checked all safety precautions?		
Storyboard / Photos								
User Experience								
+ ☺							☺	
☺				☺	☺			
Neutral 😐		😐	😐			😐		
☹	☹							
- 😠								😠
Problems/Challenges	Ensuring that there are no health problems	Remembering what each equipment are	Remembering how to put on equipment	Making sure the participant is safe while training	Bad Weather	Missing Equipment	Equipment Failure/ Damaged	Difficulty in taking off wet and heavy equipment
	Ensuring disability doesn't stop the activity		Making sure that the equipment is in working order		Rough Waters		strong currents	
Ideas / Take-aways	Medical Examination	Create a checklist of some sort	Remembering the steps	Instructors need to keep a close watch	Watch the news and do research before leaving	Create a checklist of each equipment	Communication signals and safety equipments	Help from others, redesign of some equipments

Figure 16 - User Journey Map

2.1.4 Human Factors – Research of Existing Products

Below is a list of a few existing products that is used for underwater mobility:

Product	Product Description from the sellers
Torpedo 3500 Dive Propulsion Vehicle (DPV) 	The Torpedo DPV (Dive Propulsion Vehicle) is designed to provide divers with greater mobility and less air consumption giving them more bottom time (within tables) and far greater range. Scuba divers pursue their sport to experience the fun and excitement of the underwater world. A DPV can enhance this experience by providing a greater mobility and extended time while using less effort. The Torpedo 3500 has been developed specifically with ease in operation and maneuverability. Engineered hydro dynamically with precision balance, Torpedo's unique design was specifically developed to keep the Torpedo 3500's operation and maintenance easy and simple. Every DPV is factory tested to a Depth of 170' (52 meters) to ensure that all design specifications have been achieved.
APOLLO AV 2 EVOLUTION SCOOTER 	The **Apollo AV 2 Evolution Scooter** features a 3-speed prop with a top speed of 2 and half mph. Apollo manufactured the original AV 1 underwater vehicle for over 20 years. It has been recognized as one of the most reliable diver propulsion vehicles in the world. We are very proud to introduce the next generation in Underwater Propulsion vehicles. Built for serious underwater explorers. The Apollo AV 2 Evolution Scooter is depth rated to 230 feet (tested to 300 feet) and can run up to 120 minutes. That's right! More than triple the average burn time of the original AV1. With the new Li-Ion Battery You can go out 4.5 miles and with a cruise time of 120 minutes. With all that time to burn you can get distracted. The Apollo AV 2 Evolution Scooter battery life indicator is very useful tool.
Jerry Rat Underwater Scooter 	ABOUT THIS Underwater Scooter: The Sea Scooter flying the world's first bionic marine vehicle which helps you fly in the water, circling, rotating, fast descending and ascending in the water. Cruise on the surface, capture stunning videos, rescue and retrieve while diving and snorkeling. Perfect device for underwater emergency rescue.
SAV-7 EVO3 	For underwater explorers, the most reliable diver propulsion vehicle just got better with the next generation TUSA SAV-7 EVO3. This new underwater vehicle features an innovative and patented Hands-Free Riding Saddle, quick and smooth-responding Variable Speed Control, and a high performance and long-lasting Lithium-Ion Battery with an L.E.D Battery Life Indicator.

Table 3 Research on Existing Product

2.1.5 Safety and Health

Safety and health associated are important and crucial elements regarding scuba diving. Though scuba diving is a recreational activity, proper training is required before even considering going into open water and proper supervision from professional are required for new and unexperienced divers. Some elements to consider regarding the health and safety of those going scuba diving are as follow:

- Making sure equipment are operational and are working are intended
- Making sure water temperature are in favourable conditions
- Consideration for the ecosystem and wildlife
- Looking at depth levels and not going too deep
- Making sure there is enough supply of oxygen in the tank

Health and safety during scuba diving are important and vital aspects of the activity as any problem that may occur can have significant effects and may even lead to a life-or-death situation.

Current procedures and practices in scuba diving take health and safety in a very serious manner, more so if the person involved is physically disabled as it factors into health and safety. Any problem with the weather, equipment, diving condition, and health may cancel the dive which goes to show that there is no taking chances in safety regarding scuba diving.

2.2 Product Research

Figure 17 - Retrieved from https://weedersdigest.com/sublue-whiteshark-mix-underwater-scooter/

2.2.1 Benchmarking – Benefits and Features

To learn more about the existing products and the benefits and features that they give and contribute to a scuba diving, an internet search is conducted on exist and available products that are sold commercially. Some of the products will be chosen to perform an investigation of what each product sells to their target audience of divers and underwater swimmers. The benefits and features of each products will be highlighted, and a spreadsheet will be used to list each ones of the benefits and features and the frequency of how often they are told at the products promotional piece.

Product #1

Torpedo 3500 Dive Propulsion Vehicle (DPV)

https://www.leisurepro.com/p-tor35/torpedo-3500-dive-propulsion-vehicle-dpv

Promotional Piece *(Highlight the Benefit)*

The Torpedo DPV (Dive Propulsion Vehicle) is designed to provide divers with greater mobility and less air consumption giving them more bottom time (within tables) and far greater range. Scuba divers pursue their sport to experience the fun and excitement of the underwater world. A DPV can enhance this experience by providing a greater mobility and extended time while using less effort. The Torpedo 3500 has been developed specifically with ease in operation and maneuverability. Engineered hydro dynamically with precision balance, Torpedo's unique design was specifically developed to keep the Torpedo 3500's operation and maintenance easy and simple. Every DPV is factory tested to a Depth of 170' (52 meters) to ensure that all design specifications have been achieved.

The Main Seal for the battery compartment has an O-ring seal for optimum protection against leakage. This type of sealing is easy to maintain. In normal use, the Torpedo 3500 is slightly negative -2.5 lbs. (-1.3 kg) when underwater. This allows a diver to set the unit down on the bottom to make equipment adjustments, take pictures, etc. For the snorkeler who wants his/her unit to be more buoyant, floatation devices are available. A magnetic reed switch, which can only be magnetically activated, has been designed for both safety and dependability. A magnet, conveniently inserted in a hook and loop palm strap, activates the switch.

The DPV is constructed from Gel coated BI axial fiberglass, ABS and powder coated aluminum. By utilizing computer aided design the Torpedo 3500 enhances the free flow of water through the shrouded propeller to maximize efficiency of the motor thrust. The Torpedo 3500 can be positioned upright for ease of opening and closing the unit to access the battery, as well as minimizing floor space during storage. The handles are designed for optimum function. Their location along the centerline of thrust and buoyancy provides minimal operation effort and arm fatigue while in use. This design also allows the user to carry the Torpedo DPV with ease while out of the water. The common 7/8" (2.22 cm) handle diameter allows for numerous accessory attachments to better adapt this unit to the individual's needs.

The DPV is powered by a sealed mercury marine/motor guide aluminum housing trolling motor. The battery is a 32 AH absorbed electrolyte sealed lead acid style that measures (W x H x L) 5.13" x 6" x 7.63", and weight 26 lbs. (11.8 kg). The unit comes complete with a fully automatic 6-amp output charger that will recharge a fully discharged battery in 3 to 4 hours. Charger is designed for an electrical input of 120 VAC 60 HZ. The Torpedo 3500 DPV weighs 50 lbs. (22.68 kg) on land, provides a speed of 3.5 mph (5.6 kph) with a run time of 45 minutes. The DPV with battery measures (H x Dia. x W) 35" x 10" x 12" (88.9 cm 25.4 cm x 30.48 cm) and comes with an owner's manual.

Features *(Highlight the Features)*

- Torpedo 3500 Dive Propulsion Vehicle (DPV)
- Designed to Provide Divers w/Greater Mobility and Less Air Consumption
- More Bottom Time (BT) and Far Greater Range
- DPV: Enhance Experience by Providing Greater Mobility, Extended (BT), Using Less Effort
- Developed Specifically w/Ease in Operation and Maneuverability
- Engineered Hydro Dynamically w/Precision Balance
- Design Specifically Developed to keep Operation/Maintenance Easy and Simple
- Depth Rating: 170' (52 meters)
- Battery Compartment: O-Ring Seal for Optimum Protection
- Seal is Easy to Maintain
- Buoyancy: -2.5 lbs. (-1.3 kg)
- Switch: Magnetic Reed Design, hook and loop Palm Strap, w/Magnet Activates Switch
- Housing Construction: Gel Coated BI Axial Fiberglass, ABS and Powder Coated Aluminum
- **Utilizing Computer Aided Design:**
  Enhances Free Flow of Water Thru-Shrouded Propeller
  Maximize Efficiency of Motor Thrust
- Storage: Positioned Upright for Ease of Opening/Closing, Minimizing Floor Space
- **Hand Rail Design:**
  Provides Easy Transport
  Provide Optimum Function
  Minimal Operation Effort and Arm Fatigue
  (2.22 cm) Diameter Allows for Numerous Accessory Attachments
- Propulsion: Sealed Mercury Marine/Motor Guide Aluminum Housing Trolling Motor
- Power: 32 AH Absorbed Electrolyte Sealed Lead Acid Battery
- Run Time: 45 Minutes
- Includes: Fully Automatic 6 Amp Output Charger
- Recharge Fully Discharged Battery in 3 to 4 Hours
- Electrical Input: 120 VAC 60 HZ
- Weight: 50 lbs. (22.68 kg)
- Speed: 3.5 MPH (5.6 KPH)
- Dimensions: (H x Dia. x W) 35" x 10" x 12" (88.9 cm 25.4 cm x 30.48 cm)
- Owner's Manual

7/8"

Figure 18 - Retrieved from https://www.leisurepro.com/p-tor35/torpedo-3500-dive-propulsion-vehicle-dpv

Product #2

APOLLO AV 2 EVOLUTION SCOOTER

https://www.scubatoys.com/products/571-apollo-av-2-evolution-scooter/

Promotional Piece *(Highlight the Benefit)*

The **Apollo AV 2 Evolution Scooter** features a 3-speed prop with a top speed of 2 and half mph.

Apollo manufactured the original AV 1 underwater vehicle for over 20 years. It has been recognized as one of the most reliable diver propulsion vehicles in the world. We are very proud to introduce the next generation in Underwater Propulsion vehicles.

Built for serious underwater explorers. The **Apollo AV 2 Evolution Scooter** is depth rated to 230 feet (tested to 300 feet) and can run up to 120 minutes. That's right! More than triple the average burn time of the original AV1. With the new Li-Ion Battery You can go out 4.5 miles and with a cruise time of 120 minutes. With all that time to burn you can get distracted. The **Apollo AV 2 Evolution Scooter** battery life indicator is very useful tool.

The **Apollo AV 2 Evolution Scooter** offers complete control of speed is now at your fingertips. Travel at up to 2.6 miles per hour. Our new variable speed trigger works with the Hands-Free Riding saddle (included) for smooth acceleration from full stop to top speed. Riding hands free give you freedom to explore new sites and new diving styles. Twist and turn like a dolphin, soar like a manta ray or make use of the tow bars to take along a coupe friends and extra gear.

Features *(Highlight the Features)*

- 2.6 mph top speed
- 40 lbs thrust
- up to 100 minute run time
- Speed: 0 - 2.6 mph
- Depth rated: 230 feet
- Average cruising range in open water: 4.5 miles (LiFePO4)
- Continuous cruise time in open water: 120 minutes (LiFePO4)
- Speed control: Progressive acceleration system at trigger with use of saddle,
- 3-speed pitch propellor and with Optional SHU, single hand operation
- Motor: 262W Aluminum DC brushless
- Decelerator: Reduction planet gear
- Thermal switch protection - auto shut off if overheating occurs
- Heat radiation: Aluminum gear case and plate
- Normal capacity: 10 - 20Ah (DC24V)
- Material: shock resistant ABS resin body
- Outer Dimensions: 28.5 x 13.5"
- Surface weight with battery: Li-Ion 45 lbs.
- Submerged weight with battery: Li-Ion 0.5 lbs.
- Apollo Battery Set (Optional): NEW 20A LiFePO4 & Charger
- Also compatible with 13A/24V Lead Acid & 20A/24V NiMH
- NATO/National Stock Number 4220-66-158-6194 (AV2E Black)

Figure 19 - Retrieved from https://www.scubatoys.com/products/571-apollo-av-2-evolution-scooter/

Product #3

Jerry Rat Underwater Scooter

https://www.amazon.com/Jerry-Rat-Underwater-Rotational-Compatible/dp/B07DXD9K45

Promotional Piece *(Highlight the Benefit)*

ABOUT THIS Underwater Scooter: The Sea Scooter flying the world's first bionic marine vehicle which helps you fly in the water, circling, rotating, fast descending and ascending in the water. Cruise on the surface, capture stunning videos, rescue and retrieve while diving and snorkeling. Perfect device for underwater emergency rescue.

SPEED & DEPTH INFO: The Underwater Scooter 100-minute running time can take you anywhere till a 3.7 Miles (6 KM) cruising range. It has the capability to go with a speed of up to 5.6 Miles (9 KM) per hr. Safe diving depth of 0-16 feet but dives up to 66 ft. depth. 3 level rotational speed control with Low, Medium, High speed along with a Progressive Acceleration System that has the ability to change your speed while in motion.

SUPERIOR SAFETY FEATURES: Positive buoyancy will lead it back to the surface if you lose control of the device. Auto shut off magnetic switch security system-if something goes wrong. Intelligent controlled motor with a perfect horizontal experience. CE & UL Approved, and more.

√ADDITIONAL FEATURES: Powerful thrust can carry up to 40 lbs allowing you to carry four adults at once. Includes a portable backpack for storage and traveling. Powered by a RECHARGEABLE Li-Ion Battery that's Ultra quiet and eco-friendly, will not pollute the water and will make sure that no marine life is spewed.

COMPATIBLE CAMERA MOUNT: Have extraordinary fun while recording your next adventure in the big blue. Our underwater sea scooter is equipped with a universal interface which connects to any waterproof camera.

Features *(Highlight the Features)*

VARIOUS PROTECTION FEATURES:

- POSITIVE BUOYANCE will lead it back to the surface if you lose control of the device.
- AUTO SHUT OFF MAGNETIC SWITCH SECURITYSYSTEM-if something gets stuck inside or goes wrong, the motor will shut off automatically.
- INTELLIGENT CONTROLLED MOTOR with a perfect horizontal experience.
- LOW SONIC SIGNATURE makes sure that no marine life is spewed.
- Will warn you with any mechanical failures.
- Ultra quiet and eco-friendly, will not pollute the water.
- The rear screen will protect your hands from the propeller.
- WATERPROOF CONSTRUCTION and Impact resistant with heavy duty rubber hull protection to prevent accidental flooding.
- CE & UL Approved.

Figure 20 - Retrieved from https://www.amazon.com/Jerry-Rat-Underwater-Rotational-Compatible/dp/B07DXD9K45

ROBUST FEATURES:

- PROGRESSIVE ACCELERATION SYSTEM with 3level rotational speed options that has the ability to change your speed while in motion.
- POWERFUL THRUST can carry up to 40 lbs allowing you to carry 4 adults at once.
- Powered by a RECHARGEABLE Li-Ion Battery that's Eco-Friendly and safe.
- LED BATTERY INDICATOR will update the driver about the remaining battery life.
- Portable carry on backpack.

CAMERA MOUNT FATURE:

Underwater Scooter with Action Camera Mount. Enjoy your water fun while capturing everything underwater to share with friends and family.

SPECIFICATIONS:

- Battery Running Time: 50-100 minutes.
- Speed of up to 5.6 Miles (9 KM) per hr.
- Safe diving depth of 0-16 ft.

- Dives up to 66 ft.
- Weight: 14 kg (30.8 lbs

Product #4

SAV-7 EVO3

https://tusa.com/us-en/TUSA/DPV:Scooter/SAV-7_EVO3

Promotional Piece *(Highlight the Benefit)*

For underwater explorers, the most reliable diver propulsion vehicle just got better with the next generation **TUSA SAV-7 EVO3**. This new underwater vehicle features an innovative and patented **Hands-Free Riding Saddle**, quick and smooth-responding **Variable Speed Control**, and a high performance and long-lasting **Lithium-Ion Battery** with an **L.E.D Battery Life Indicator**.

The SAV-7EVO3 has been updated with an improved energy compliant small battery charger. All other specifications remain the same.
With the newly designed rotational speed adjustment function and hands-free riding style, the TUSA SAV-7 EVO3 decreases fatigue, reduces air consumption, and allows a diver to go further and faster in a variety of conditions while extending their time in underwater.

The upgraded Variable Speed Control is at your fingertips for a greater diving experience while giving you complete control of speed.

Transportation options like the fold-out wings on both sides of the saddle allows additional divers to tag along.

Features *(Highlight the Features)*

- **Speed**: 0 - 2.8 mph / 4.5 km
- **Depth Rating**: 230 feet / 70 m
- **Dim. (L x W)**: 28.4" x 13.4" / 720mm x 340mm
- **Surface Weight w/ Battery**: 45 lbs / 20.4 kg
- **Submerged Weight w/ Battery**: 1.1 lbs / 0.5 kg
- **Range in Open Water**: 5.9 miles / 9,400m
- **Battery Type**: Lithium-Ion
- **Speed Adjuster**: Rotational Speed Control with Variable Pitch-Type Propeller (3-Step)
- **Safety Device**: Sensation Current Shut-Down Device, Water Leakage Sensor, and Water-Cooling Motor Deployment

Figure 21 - Retreived from https://tusa.com/us-en/TUSA/DPV:Scooter/SAV-7_EVO3

*Gather up **Benefits** and place in a column in Excel (left-hand column below)*

BENEFITS	Sort #1	Sort #2
From Promotional Material	DATA [On Menu Bar] →	Groups like categories
greater mobility	average crusing range	*Mobility* 14
less air consumption	complete control	average crusing range
greater range	continuous cruise time	continuous cruise time
greater mobility	decrease fatigue	Fast
extended time	ease	faster
less effort	ease	go further
ease of operation	ease of operation	greater mobility
maneuverability	ease of operation	greater mobility
easy and simply	easy and simply	greater Mobility
protection	easy and simply maintenance	greater range
safety and dependability	eco-friendly	greater range
maximize efficiency	eco-friendly	high performance
ease	eco-friendly	maneuverability
ease	efficiency	maneuverability
greater Mobility	extended time	quick
greater range	extraordinary fun	
ease of operation	Fast	*efficiency & Safety* 12
maneuverability	faster	efficiency
easy and simply maintenance	fun experience	extended time
efficiency	go further	less air consumption
reliable	greater diving experience	maximize efficiency
smooth acceleration	greater mobility	positive bouyancy
progressive	greater mobility	protect
useful	greater Mobility	protection
complete control	greater range	reduce air consumption
continuous cruise time	greater range	reliable
average crusing range	high performance	reliable
Fast	innovative	safe
positive bouyancy	less air consumption	safety and dependability
ultra quiet	less effort	
eco-friendly	maneuverability	*ease* 7
extraordinary fun	maneuverability	ease
fun experience	maximize efficiency	ease
ultra quiet	positive bouyancy	ease of operation
eco-friendly	progressive	ease of operation
protect	protect	easy and simply
eco-friendly	protection	easy and simply maintenance
safe	quick	less effort
reliable	reduce air consumption	
innovative	reliable	*Quality* 5
quick	reliable	complete control
smooth	safe	smooth
high performance	safety and dependability	smooth acceleration
decrease fatigue	smooth	ultra quiet
reduce air consumption	smooth acceleration	ultra quiet
go further	ultra quiet	
faster	ultra quiet	*Others* 6
greater diving experience	useful	extraordinary fun
		fun experience
		greater diving experience
		innovative
		progressive
		useful

Figure 22 - Benefits Excel

*Gather up **Features** and place in a column in Excel (left-hand column below)*

FEATURES		Sort #1	Sort #2
From Promotional Material	Re-order: NOUN first	DATA [On Menu Bar] →	Group like categories
o-ring seal	seal: o-ring seal	attachment: action camera mount	**Battery 8**
floatation device	buoyancy: floatation device	battery: electrolyte sealed battery	battery: electrolyte sealed battery
magnetic reed switch	switch: magnetic reed switch	battery: electrolyte sealed lead acid battery	battery: electrolyte sealed lead acid battery
fiberglass,ABS,powder coated AL	body: fiberglass,ABS,powder coated AL	battery: li-ion battery	battery: li-ion battery
shrouded propeller	propeller: shrouded propeller	battery: li-ion battery	battery: li-ion battery
trolling motor	motor: trolling motor	battery: li-ion battery	battery: li-ion battery
electrolyte sealed battery	battery: electrolyte sealed battery	battery: li-ion battery	battery: li-ion battery
o-ring seal	seal: o-ring seal	battery: lithium-ion battery	battery: lithium-ion battery
magnetic reed switch design	switch: magnetic reed switch design	battery: lithium-ion battery	battery: lithium-ion battery
gel coated bi axial fiberglass	body: gel coated bi axial fiberglass	body: ABS	
ABS	body: ABS	body: aluminum gear case and plate	**Control 8**
powder coated aluminum	body: powder coated aluminum	body: fiberglass,ABS,powder coated AL	controller: progessive acceleration system
shrouded propeller	propeller: shrouded propeller	body: gel coated bi axial fiberglass	controller: progessive acceleration system
trolling motor	motor: trolling motor	body: powder coated aluminum	controller: rotational speed adjustment function
electrolyte sealed lead acid battery	battery: electrolyte sealed lead acid battery	body: shock resistant ABS resin body	controller: rotational speed control
3-speed propeller	propeller: 3-speed propeller	body: waterproof construction	controller: rotational speed control
li-ion battery	battery: li-ion battery	buoyancy: floatation device	controller: variable speed control
battery life indicator	HUD: battery life indicator	buoyancy: positive buoyancy	controlller: variable speed control
variable speed trigger	controlller: variable speed trigger	controller: progessive acceleration system	controlller: variable speed trigger
hands-free riding saddle	saddle: hands-free riding saddle	controller: progessive acceleration system	
pitch propellor	propeller: pitch propellor	controller: rotational speed adjustment function	**Body: 7**
262W motor	motor: 262W motor	controller: rotational speed control	body: ABS
thermal switch protection	switch: thermal switch protection	controller: rotational speed control	body: aluminum gear case and plate
aluminum gear case and plate	body: aluminum gear case and plate	controller: variable speed control	body: fiberglass,ABS,powder coated AL
shock resistant ABS resin body	body: shock resistant ABS resin body	controlller: variable speed control	body: gel coated bi axial fiberglass
li-ion battery	battery: li-ion battery	controlller: variable speed trigger	body: powder coated aluminum
progessive acceleration system	controller: progessive acceleration system	handles: hands-free riding style	body: shock resistant ABS resin body
rotational speed control	controller: rotational speed control	HUD: battery life indicator	body: waterproof construction
security system	security: security system	HUD: led battery indicator	
powerful thruster	propeller: powerful thruster	HUD: LED battery life indicator	**Propeller 7**
portable backpack	storage: portable backpack	motor: 262W motor	propeller: 3-speed propeller
li-ion battery	battery: li-ion battery	motor: intelligent controled motor	propeller: pitch propellor
positive buoyancy	buoyancy: positive buoyancy	motor: trolling motor	propeller: powerful thruster
magnetic switch security system	security: magnetic switch security system	motor: trolling motor	propeller: powerful thruster
intelligent controled motor	motor: intelligent controled motor	motor: water-cooling motor deployment	propeller: shrouded propeller
low sonic signature	waves: low sonic signature	propeller: 3-speed propeller	propeller: shrouded propeller
waterproof construction	body: waterproof construction	propeller: pitch propellor	propeller: variable pitch-type propeller
progessive acceleration system	controller: progessive acceleration system	propeller: powerful thruster	
powerful thruster	propeller: powerful thruster	propeller: powerful thruster	**Motor 5**
li-ion battery	battery: li-ion battery	propeller: shrouded propeller	motor: 262W motor
led battery indicator	HUD: led battery indicator	propeller: shrouded propeller	motor: intelligent controled motor
action camera mount	attachment: action camera mount	propeller: variable pitch-type propeller	motor: trolling motor
hands-free riding saddle	saddle: hands-free riding saddle	saddle: hands-free riding saddle	motor: trolling motor
variable speed control	controlller: variable speed control	saddle: hands-free riding saddle	motor: water-cooling motor deployment
lithium-ion battery	battery: lithium-ion battery	seal: o-ring seal	
LED battery life indicator	HUD: LED battery life indicator	seal: o-ring seal	**Security 4**
rotational speed adjustment function	controller: rotational speed adjustment function	security: magnetic switch security system	security: magnetic switch security system
hands-free riding style	handles: hands-free riding style	security: security system	security: security system
variable speed control	controller: variable speed control	security: sensor	security: sensor
lithium-ion battery	battery: lithium-ion battery	security: shut-down device	security: shut-down device
rotational speed control	controller: rotational speed control	storage: portable backpack	
variable pitch-type propeller	propeller: variable pitch-type propeller	switch: magnetic reed switch	**Others 15**
shut-down device	security: shut-down device	switch: magnetic reed switch design	attachment: action camera mount
sensor	security: sensor	switch: thermal switch protection	buoyancy: floatation device
water-cooling motor deployment	motor: water-cooling motor deployment	waves: low sonic signature	buoyancy: positive buoyancy
			HUD: battery life indicator
			HUD: led battery indicator
			HUD: LED battery life indicator
			saddle: hands-free riding saddle
			saddle: hands-free riding saddle
			saddle: hands-free riding saddle
			seal: o-ring seal
			storage: portable backpack
			switch: magnetic reed switch
			switch: magnetic reed switch design
			switch: thermal switch protection
			waves: low sonic signature

Figure 23 - Features Excel

Benefits Table

Table 4 Benefits Table

Key Benefits of Comparable Products	
Keyword	***Frequency***
Mobility	11
Efficiency & Safety	9
Ease	7
Quality	6
Others	4

Features Table

Table 5 Features Table

Key Features of Comparable Products	
Keyword	***Frequency***
Battery	11
Controls	9
Body	7
Propeller	6
Motor	4
Security	4
Others	15

2.2.2 Benchmarking – Functionality

From the research done on the benefits and features of the four products, the main functionality that the four products share and focus on is the mobility of each the products. Being able to achieve mobility and replacing the divers swimming motion to ease their movement underwater is one of the main purposes for each of the products. To achieve this, the inclusion of a propeller and motor on the products is a definite feature to have the benefits of a good mobility.

2.2.3 Benchmarking – Aesthetics and Semantic Profile

Based on the previous products that were researched on and reviews there is two distinct aesthetic still that is common for underwater scooters. The first distinct aesthetic is the use of soft curved shapes which is present in the Torpedo and the Jerry Rat. The shape has soft and almost organic curves which seems to glide easily in water. The second distinct aesthetic is a more rugged, sharp line, and more focused on functionality than looks aesthetic that is present in the Apollo AV 2 and SAV-7. Both craft have very similar if not almost the same look and the styling design seems to focus more on the functionality of the motor than the hydrodynamics of the scooters.

Both distinct styles have something to offer regarding contributing to the aesthetics of the concept. The best way to deal with such aesthetics is to take a style that works from both distinct aesthetic and finding a way to combine it onto the concept so it is both stylish and functional.

2.2.4 Benchmarking – Materials and Manufacturing

To help with learning more of the sustainability of the concept product, a couple of current existing products are chosen as a benchmark for the project. Four underwater scooter each from different manufactures are researched on what materials and used and advertised from their sites. All four underwater scooters have parts and materials that they each highlight as a benefit and feature for their product. They also have parts that share similar or close to being the same functions as a requirement for an underwater scooter. The parts that all four shares are as follows:

- A motor to propel the scooter underwater
- A battery power source to power store and power the motor

- A propeller that interacts with the water to move forwards
- A controller for the user to interact and control the scooter
- The needed electronics for the scooter to work which can include the controls, security, power delivery, etc.
- An outer body that incases all the parts

Addition parts from the product concept includes an internal oxygen tank and a buoyancy regulator. These parts are investigated when considering the types of materials and manufacturing processes that will used or be considered for the construction of the concept product.

2.2.5 Benchmarking – Sustainability

To learn about the sustainability of the benchmark products, Martin-Belz's six characteristics that defines a sustainable product will be used to help analyzed the sustainability of the benchmarking products. The benchmark products try to deliver their customers the satisfactions they want by creating an advertisement and promotional piece that caters to the needs and wants of the customers such as reliability and performance. For the Dual focus characteristics, the products are focused on the social aspect of diving but there are little mentions of the products being eco-friendly with only one of the products mention eco-friendly and its assurance of not polluting the water and environment. The Life cycle orientation is not easy to determine based on the promotional piece and advertising alone but based on the materials used to create and is being advertised by the product there are some consideration for what and why the product is chosen. Improvements are present for the products particularly when compared to early iterations of underwater scooters. And finally, there are many competing offers from consumers as there is always something that they wish a product has or improve upon which means a benchmark is always available.

3 Analysis

3.1 Analysis – Needs

Most people, with some training, can enjoy being able to go free diving and swimming underwater. But Scuba diving takes such activity into the next level by allowing a person to be able to go deeper underwater and be underwater for a longer period with the help of specialized equipment such as snorkeling mask, oxygen task, flippers and so forth. Scuba diving enhances the activity of underwater diving by prolonging and increase the experience of being underwater.

Unfortunately, such activity is not experienced the same with people with disabilities because of previously said reasons such as the hindering of the person disabilities to have a good experience compared to an abled body person. Though a person with disability may be more mobile underwater than they are on land, things such as their mobility is very different compared to the mobility of a normal person. It is also unfortunate that most scuba equipment present in the market are not fitted for people with disabilities so finding a concept that benefits a disabled person's experience and accessibility underwater is the goal and purpose of this project.

3.1.1 Needs/Benefits not Met by Current Products

Specialized and specific equipment are needed to go scuba diving. The equipment needed includes diving mask, snorkel, wetsuit or dry suit, scuba gloves, fins, scuba oxygen tank, regulator, depth gauge and compass, dive computer, and a buoyancy compensator. There is more optional equipment that a diver can included in their list, but the previous listed equipment are the minimum essentials needed to be able to go underwater. Each of the listed equipment are tasked to do a specific objective to enable a person to go scuba diving.

Each equipment's objectives are explained in the table below:

Table 6 Diving Equipment List

Diving Equipment	Purpose
Diving Mask and snorkel	Allows a person to be able to see underwater by creating an air space in front of a person's eyes. Though some professionals do not wear diving mask, most if not all beginners require it to see underwater.
Wetsuit / Dry suit	A suit that is made of neoprene that protects and warms the body. A wetsuit differs from a dry suit in that a wetsuit locks a thin layer of water around the body and is used more on a warmer water while a dry suit keeps the diver completely dry and is loosely fit compared to a wetsuit, incubates the diving to keep them warm, and is used mostly in colder waters.
Scuba Gloves	Works similarly to how a wetsuit works but are for the diver's hands. They keep the diver's hand warm and protects them from injuries.
Fins	Fins are one of the most essential equipment in diving it that they are focused on helping with a diver's mobility underwater. They lessen the strains of moving underwater by decreasing the energy needed to move underwater.
Scuba Oxygen Tank	A vital equipment of being able to breath underwater. The scuba oxygen tanks, as the name suggest, it stores large volumes of oxygen that allows a diver to breath underwater.
Regulator	The regulator is what allows a person to breath underwater by allocating the air from the scuba tank to the person's mouth.
Depth Gauge and Compass	The depth gauge specifies the current and maximum depth a person reached during a dive which allows a person to end a dive before their air supply depletes while a compass helps to navigate a diver underwater.
Dive Computer	The dive computer monitors a diver's duration, depth, and safety while underwater and can also tracks the amount of remaining air.
Buoyancy Compensator	A buoyancy compensator is what allows a person to keep them from floating up to the surface or sinking to the bottom of the sea by controlling the buoyancy of a diver.

Each of the listed equipment works together to allow a person to dive underwater with ease and safety but not all the equipment is designed to accommodate for people with disabilities. Even with water acting as a medium to help carry the weight of the equipment, the combined weight can still be heavy and hinder the movements of someone that is disabled. Other problems that are associated with the equipment are the wetsuit/dry suit and the fins. Some disabled divers have difficulties with putting on the standard wetsuit/dry suit as their disabilities makes it hard to equip them. A person that are disabled at the lower half of their body will not be able to use and utilize fins for mobility thus they need to rely on their hands to propel themselves forwards which can be extreme straining compared to using legs for movement.

A diver needs are met by relying on the equipment that are available to them but some of the equipment cannot do the task they were design for due to a person disability, then finding an alternative is a must to be able to help the diver underwater.

3.1.2 Latent Needs

Table 7 Latent Needs

Latent Needs	Benefit Statement
Function	Works to reach the goal of assisting and monitoring the person's dive duration
Experience	Not interfering with the person's diving experience and letting them take in the environment and marine life

Ease	Straight forward usage with easy-to-understand controls and functionalities, knowing without any second thoughts
Mobility	Traversing underwater with ease and directionality and substituting a person's energy usage with an external force
Comfort	Increase or create a new amount of comfort for diver while underwater by doing things such as decreasing weight, less body motion, etc.

3.1.3 Categorization of needs

From the research conducted on user observation and the product benchmarking analysis, the needs for divers with disabilities have been categorized into needs, latent needs, and wants based on the importance of each needs to the design and functionality of the concept and solution for the problem topic. By using Maslow's "Hierarchy of Human Needs", a table is generated to illustrate and summarize each need and the categories they lie in.

Need	Benefit Statement	Relationship with Benefit
Needs		
Accessibility	Should be able to let people with disabilities to use the product with no issues	Strong
Mobility	Replaces the energy consumption from the user to allow mobility with a difference source of energy	Strong
Experience	A diver's diving experience should not be hindered in any way as enjoying the experience is one of the main goals of scuba diving	Strong
Latent Needs		
Comfort	A diver should be in a comfortable position to be able to fully experience and enjoy the underwater environment	Strong
Ease	Any interactions and usage should be easy to understand even for new users.	Strong
Function	Helps in assistance of user goal for Scuba diving.	Strong
Hydrodynamics	A product intended for underwater use that is mobility based should take hydrodynamics into consideration to move with ease underwater	Moderate
Wildlife Consideration	Marine wildlife should be considered to make sure no harm is done	Moderate
Wants		
Cost Effective	Affordable enough for Scuba diving but can focus more of being rented than owning.	Moderate
Aesthetics	The aesthetics is influenced with hydrodynamic shapes	Moderate

Table 8 Categorization of Needs

3.1.4 Needs of Analysis Diagram

Desirability

Scuba diving is a fun recreational activity that lets people experience and interact with the underwater environment and the marine wildlife. The objective of this thesis is to satisfy the desirability of experiencing the underwater world for the physically challenged and disabled portion of divers. Finding a solution to help then focus more on the experience of scuba diving without worrying about their problem getting in the way is what this project is trying to understand and solve.

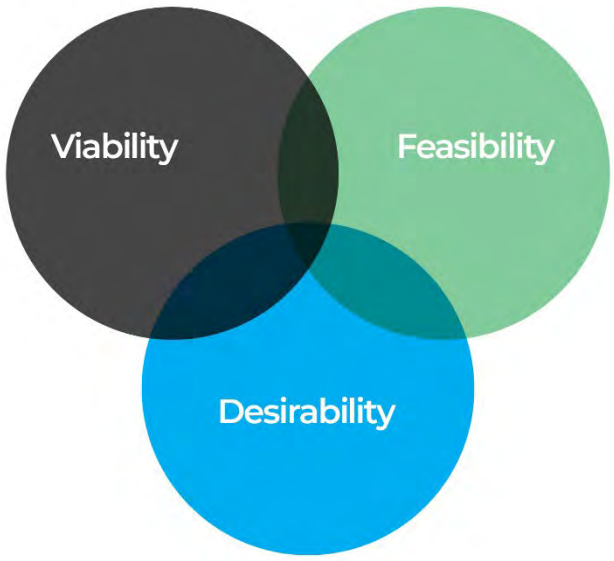


Figure 24 - Needs of Analysis Diagram

Viability

There are currently new products out in the market that caters itself in helping people move underwater. Looking into such products and how they work and are designed may give some thoughts and insight of figuring out a solution that would benefit the physically challenged divers.

Feasibility

Looking at current existing technology and being developed innovative technology, is it possible to utilized and work with such technologies to create a concept product that may focus and accommodate divers that are disabled and physically challenged. Doing research on current trends of technologies can create an innovation in products that will support the target audience and future endeavours.

3.2 Analysis - Usability

3.2.1 Activity – Workflow Mapping

USER JOURNEY MAP

	Preparation 1	Preparation 2	Preparation 3	Preparation 4	Task 1	Task 2	Goal	Completion
User Goals	Medical Check-up	Explanation of what each equipment are and how they work	Explanation of how to put on equipment	Training on how to move underwater at a pool	Traveling to diving site	Equipment is worn and is ready to dive	Going Diving	Getting back on the boat and travelling back home
User Actions	Medical Questionnaires	Learning what equipment is needed to go underwater	Learning the how each equipment work	Learning the how to move undewater	Divers and instructors travel to the designated area by boat	Wearing Equipment based on the training	Experiencing diving underwater	Taking Off equipment
	Doctor's notes		Knowing how to put on equipment and the order they go on	Knowing the safety procedures and precautions		doing safety checks before diving	Explore and take photos	Returning to shore
User Thoughts	Am I healthy enough to go diving?	What do each equipment do?	How hard is it to put on?	Am I able to complete this training?	I'm close to being able to dive!	Is my equipment on securely?	I feel weightless and I can move freely!	When will I be able to return?
	Will my disability stop me from diving?			Will I pass?	How far is it?	Have I checked all safety precautions?		
Storyboard / Photos								
User Experience								
+							☺	
Neutral		☺	☺	☺	☺	☺		
-	☹							☹
Problems/Challenges	Ensuring that there are no health problems	Remembering what each equipment are	Remembering how to put on equipment	Making sure the participant is safe while training	Bad Weather	Missing Equipment	Equipment Failure/ Damaged	Difficulty in taking off wet and heavy equipment
	Ensuring disability doesn't stop the activity		Making sure that the equipment is in working order		Rough Waters		strong currents	
Ideas / Take-aways	Medical Examination	Create a checklist of some sort	Remembering the steps	Instructors need to keep a close watch	Watch the news and do research before leaving	Create a checklist of each equipment	Communication signals and safety equipments	Help from others, redesign of some equipments

Figure 25 - User Journey Map

Activity 1	Steps/Process	Base User Experience	Potential Improvement
Preparation for Scuba Diving	-learning what each equipment are and how the work -training in putting on equipment and learning in a pool	-studying equipment usage -learning to use equipment in pool to get ready for actual dive	-combining some of the equipment to be multi-use

The first couple of activities of going scuba diving for the first time requires potential divers to learn all the basics and necessities of scuba diving, whether it be equipment of proper diving etiquette.

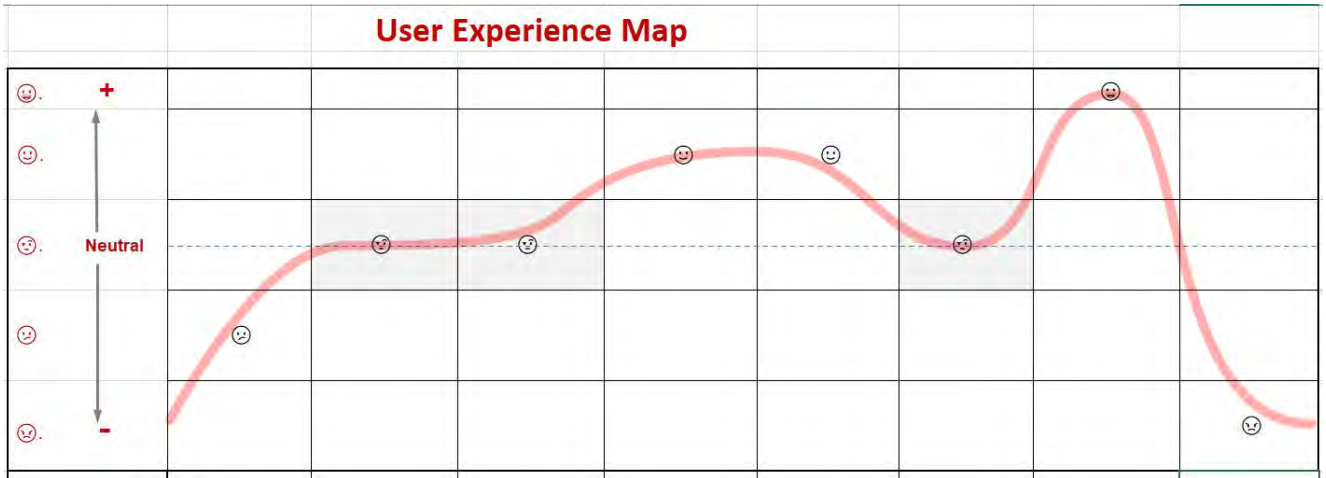
Activity 2	Steps/Process	Base User Experience	Potential Improvement
Task – Going Scuba Diving	-going to designated area -putting on equipment -performing actual scuba diving	-users are putting the knowledge to use -experiencing the scuba diving environment	-making equipment easier to put on -increase the experience of scuba divers

The second portion of scuba diving is taking all the knowledge that the potential divers have learn and putting it to the test by performing scuba diving is open waters. The divers will need to know all the proper procedures, protocols, and safety as they are exposed to the open waters.

Table 9 Activity Workflow Mapping

3.2.2 Activity – Experience Mapping

The user experience map helps to illustrates the collected data of the users experience of pain and desires in each task. Such data analysis is useful in that it shows a benchmark of a user's average experience during each task that they do, and it illustrates their level of satisfaction that they experience. Having a visual representation of their experience helps to identify areas where satisfaction can be increased.



	Preparation 1	Preparation 2	Preparation 3	Preparation 4	Task 1	Task 2	Goal	Completion
User Goals	Medical Check-up	Explanation of what each equipment are and how they work	Explanation of how to put on equipment	Training on how to move underwater at a pool	Traveling to diving site	Equipment is worn and is ready to dive	Going Diving	Getting back on the boat and travelling back home
Problems/Challenges	Ensuring that there are no health problems	Remembering what each equipment are	Remembering how to put on equipment	Making sure the participant is safe while training	Bad Weather	Missing Equipment	Equipment Failure/ Damaged	Difficulty in taking off wet and heavy equipment
	Ensuring disability doesn't stop the activity		Making sure that the equipment is in working order		Rough Waters		strong currents	
Ideas / Take-aways	Medical Examination	Create a checklist of some sort	Remembering the steps	Instructors need to keep a close watch	Watch the news and do research before leaving	Create a checklist of each equipment	Communication signals and safety equipments	Help from others, redesign of some equipments

Figure 26 - User Experience Map

The graph shows the user having a neutral satisfaction for most of the preparation section of the user experience map. Having to do a medical check-up can be a hassle for some people but is a necessary step in being able to go scuba diving. Learning and getting to know the equipment and how to equip and use each one shows a moderately neutral response in user satisfaction, but the satisfaction increases when the user starts to train and practice at a pool with the equipment on. After learning and being qualified to go scuba diving, the user's satisfaction level drops a little in the part where they must put on the equipment. This can be a bigger hassle for users with disabilities getting in the way of

putting on the equipment. The user experience peaks when the users are finally able to go underwater and enjoy the underwater scenes and wildlife. After the peak, the experience drops down as the activity comes to an end. Finding a way to level some of the lower regions of the user experience map by minimizing the pain and enhancing the lower areas will benefit the value of the design concept.

3.3 Human Factors / Ergonomics

The recreational activity of Scuba diving is a popular activity that many people attend if they wish to explore and experience all the things that the underwater world has to offer, whether it be the many marine life that exists underwater or the large ecosystem such as vast oceans, beautiful coral reefs, and many more. Overtime Scuba diving has become more accessible to many people with the advancement of technology and an increase in safety and procedures. But even with all such advancements and safety precautions, there are still certain groups of people that are not fully supported. Scuba diving though is open for people that are disabled, it does not fully support people with disabilities as many of the equipment and procedures are standardized to fit an average person without disabilities taken into consideration which is why an ergonomic study is being done. The ergonomic report plans to demonstrate how a user will interact with the product and how the body may fit into it. Learning this will help to better design and create the product to fully support a disabled person underwater. It also helps to know how the product should be designed with regards to a person's disabilities.

LITERATURE REVIEW

Ergonomics/human factors is an important aspect when it comes to creating a product. This is because ergonomics is one of the focus when creating a product as it is, in simple terms, the usage of

the measurement of the human body and relating that information into creating a product that best fits the human dimension so that it is functional and comfortable during an interaction. Without the use of ergonomics, the product will come out being an awkward fit during usage or not being useful at all as the product is not comfortable. A product that is not designed based on the human factor will interfere with not the usage of the product but also its functionality since the user will be having trouble interacting with a product with incorrect or none-existing ergonomics.

When looking into the ergonomic study of a person with a disability, their disability will for sure be a definite factor to consider when creating a product. In this report, the ergonomics will focus on a user that is disabled from the waist down thus it is important to consider both functioning and non-function limbs and other body parts. It is also good to consider the strength of the user as many individuals with disability also include a weaker dexterity and thus the ergonomics also needs to factor in their strength. The ergonomics of the product will also need to factor in the fact that the activity is done underwater thus a medium of water will also affect the design of the product's ergonomics and human factors.

METHODOLOGY

To learn the ergonomic fit and interact of the product and the user, an ergonomic evaluation and analysis is done by creating an ergonomic buck that helps simulate the usage and interaction with the following considerations:

Objectives

This evaluation aims to learn about the full-bodied human interaction and ergonomic design and challenges of an underwater Jet-propelled Scooter that will help with a disabled person's mobility underwater. Though the aforementioned term is "full-bodied", the thesis criteria for the report focuses

mostly on evaluating the interaction of only three major body part areas relevant to the full-bodied human interaction design of the product. This report will help to outline the necessary information and assessment by gathering relevant data and evaluating the ergonomics, human factor, challenges, and interaction of the three major body part areas.

Decisions to be made

The following interactions that is relevant to the three main body part areas were observed and investigated to know the experience of the user and learning challenges and how it may be solved:

- Getting on the Jet-propelled Scooter (Sitting on the scooter)
- Positioning and strapping onto the scooter (Leaning on the scooter for support and securing themselves)
- Interacting with the controls (Holding onto the controls)
- Visibility during movement (Easy to look around)

Description of Users Targeted by Product

The targeted user demographic are divers that have a physical disability that may interfere with their experience of going diving. Unfortunately, it would be too difficult, to the point of being impossible, to accommodate for most types of disability and thus the targeted user is focused more on to those that are disabled from the waist down but still has function of their upper body. This will help to narrow due the target user to a more specific group of disabled divers which are people that have their mobility underwater limited due to their lower half being disabled. Other description that helps to describe the target user based on previous research are as followed:

- Both types of sex and all gender that wished to go Scuba diving
- The age ranges mostly from around their early 20s to late 60s

- Level of education of most divers being above high school level
- Income of person with disabilities averaging from around 17,000 to around 40,000 depending on severity of disability

Evaluation Process

By creating a 1:1 full scale ergonomic buck of the scooter, an evaluation can be done by observing the following criteria:

- Observing how the user gets on and off the product
- Observing how the user position and secure themselves onto the product
- Observing how the user interact with the controls and how they position their arms
- Observing locations and how a user with disability can be secured
- Documenting the scooter and its design (Size of length and width, position of controllers, etc.)
- Identifying human dimensions that may affect the usage and design of product
- Identifying troubled areas and possible solutions

Description of User Observation Environment Used in this Study

To further help with the study, an observation of the user and environment of where and how the activity is done is conducted to learn of the current actions and procedures being done. Due to current events happening right now, a physical observation will be difficult thus an alternative of finding a video that demonstrates the activity is instead observed.

Location and Timeframe

Date of Observation(s): January 04, 2021

Location of Observation(s): YouTube Video (https://www.youtube.com/watch?v=ZK3TMoGYnfA)

RESULTS

1)Ergonomic Diagrams

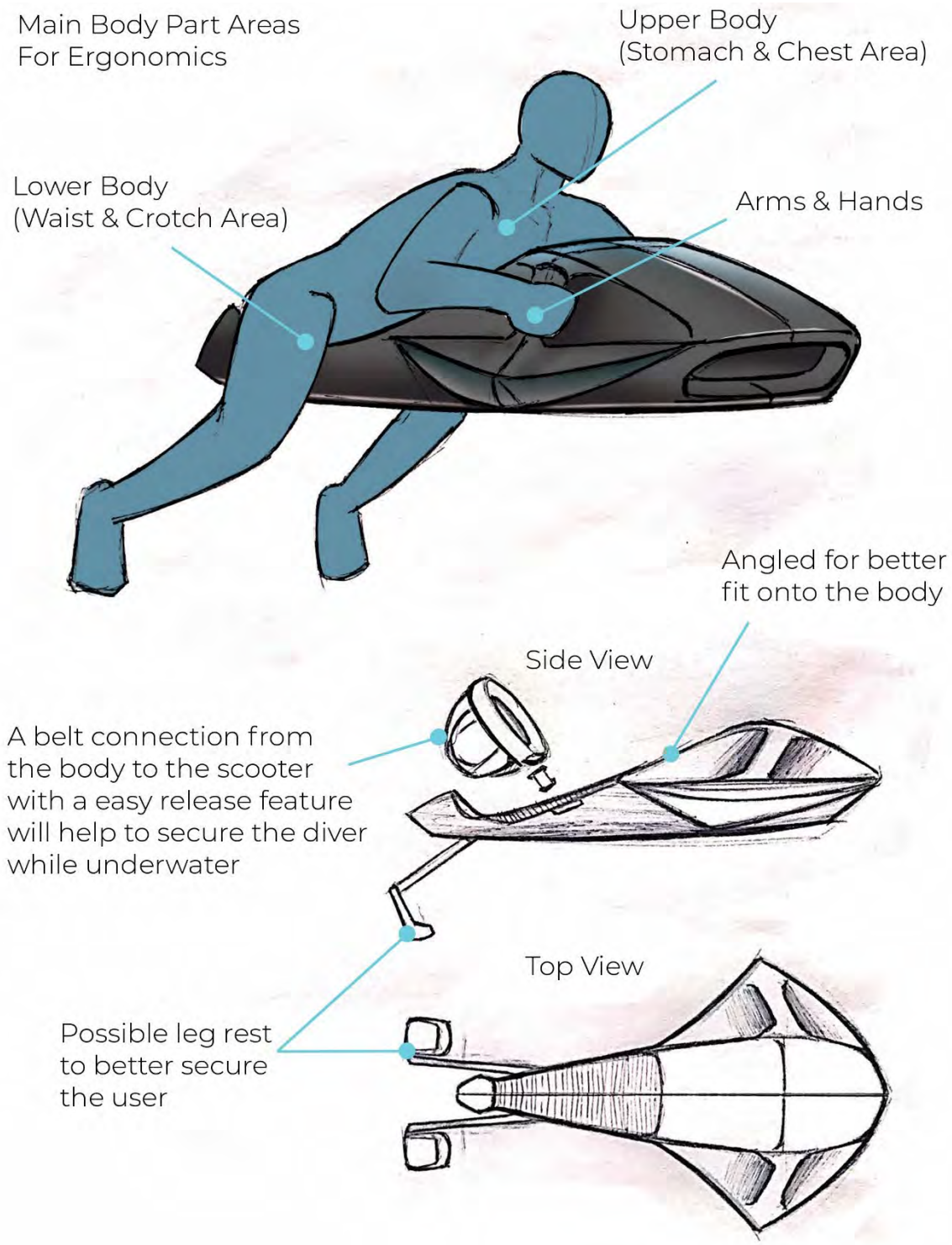


Figure 27 - Preliminary Ergonomic Study

Ergonomic Study of 5th and 95th Percentile

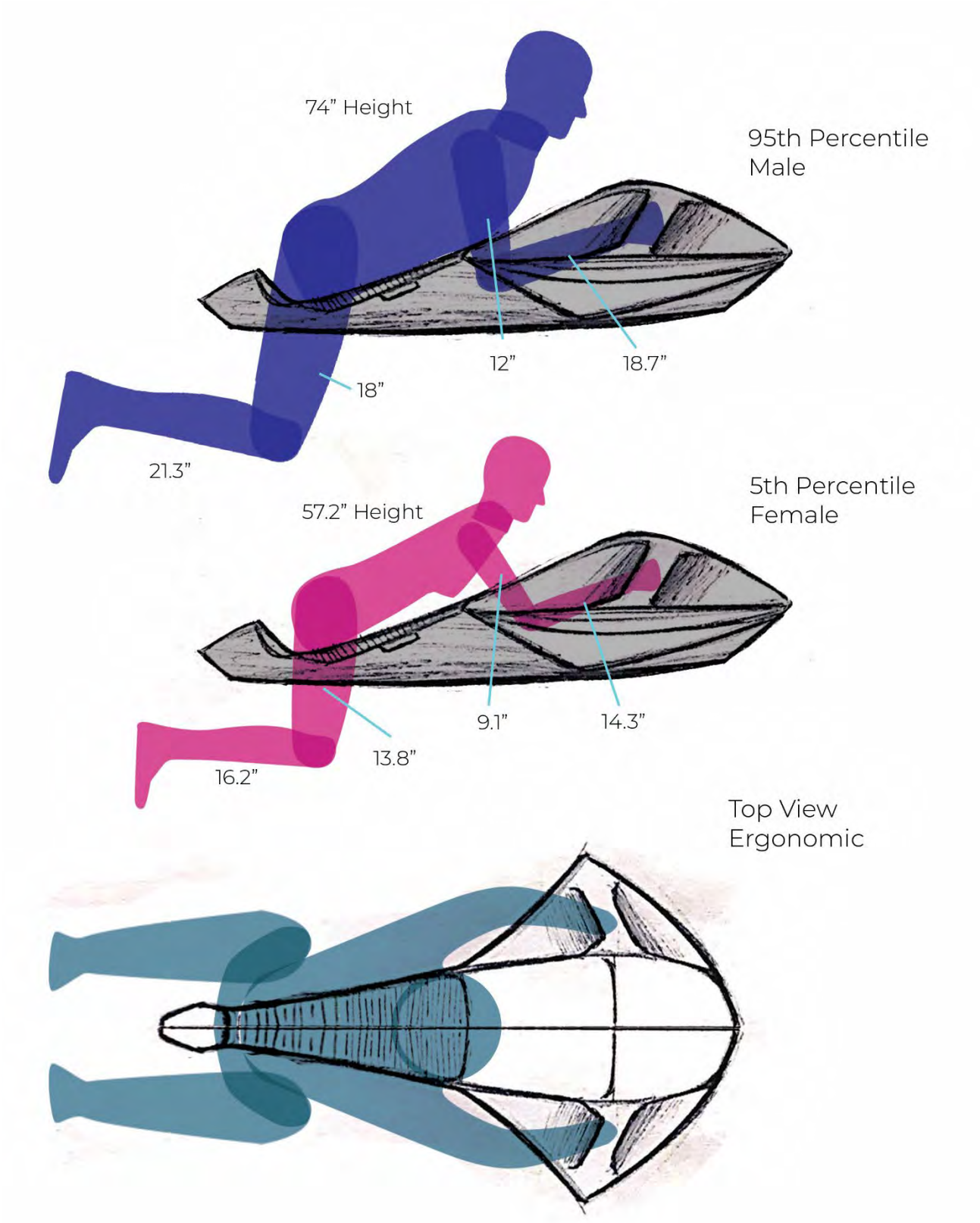


Figure 28 - Ergonomic 5th and 95th Percentile Study

2)Buck Model Photographs

Figure 29 - Buck Physical Model Study

ANALYSIS

After drawing and creating a rough buck model for the scooter design, an observation and analysis is done to learn about the interaction of the product model on the three main body parts, with consideration of both a 5th percentile and 95th percentile anthropometric human scale diagrams and measurements. An observation of a person getting on and interaction with the buck model helps to see the ergonomic physically and helps to better understand the ergonomics compares to simply relying on drawings and measurements on sheets and drawings. The three main body parts to consider for the jet-propelled scooter are the Arms and hands that holds onto the craft and interacts with the control, the main body consisting of the chest and stomach that lays on the craft and is support by it, and the last main body part being the lower body consisting mostly the waist and crotch area that is also supported by the craft. With the interacting between these body parts and the product, it will help to learn more about the interaction of the current design, what problems are present that is not fully optimized to support the target user and finding solutions on how these problems can be solved.

To start off, the first main body part that interacts with the product regarding the ergonomics of the design are the arms and hands. The arms interact with the scooter by holding onto the handle during its movement and is the first step of getting onto the scooter, which is by grabbing onto the scooter's handles and pulling themselves and the craft together. The arms and hands are also the body parts that oversee the controls of the scooter's movement and is the main support as the arms have the most freedom of movement with it being the main "tools" that humans possess. Though it may not have the most surface area that interacts with the scooter compared to the other two body parts, it is the most supportive as you can grab with the arms and hands than the other main body parts.

The second body part is the upper body, more specifically the lower chest and stomach. This body part has the most contact with the product regarding the surface area and such interaction also

means that this is where most of the body weight is being supported with the scooter. To better support the ergonomics on the upper body, it is better to have the scooter on angle for a more comfortable seating. The buck has an incline angle included onto the design, but it is good to consider adding even more angle for better comfort and fit but not to the point of sitting, as being in a sitting position will interfere with the hydrodynamics and movement underwater. Though the interaction with the upper body would suggest that this area will need the most support, it should be taken into consideration that water becomes a medium that will interfere with the weight of a person compared to their normal weight above the surface. This will also help to consider things such as material usage.

The final body part area for consideration regarding the ergonomics of the product is the waist and crotch area of the lower body. This area is an important body part to consider as this the area in which the disability of the target user is located and thus it is important to consider that disability of the lower body whether that be something such as an amputation, lose of control on the lower half, etc. Currently only a lip feature is securing the lower body to the scooter but there are some solutions that can be considered for securing the lower half. One solution is to add a leg rest, like a stirrup for a horse where the legs can rest on to, to secure and support the legs. Another feature to consider is by using a belt connection in which a user puts on a belt strap that goes on their waist and crotch area and can connect onto the scooter with an easy secure and release clip, like a seatbelt on a car or plane.

With these finding and consideration, it will help to further the design of the product closer to the final rendition and by taking into consideration not only the disability of the user, but also their size and percentile, it will allow to create a more accommodating product specialize more on helping divers with disabilities.

LIMITATIONS AND CONCLUSION

The finding in the report suggest that the three main body part areas are the arms and hands, the upper body consisting of the chest and stomach area, and the lower body parts consisting of the waist and the crotch area. Based on these areas the important information that were gathered that affects the design of the product are as followed:

- The distance of the handle and whether it is near enough to be reach by lower percentile groups but far enough that it is comfortable for the higher percentile group
- The angle of the scooter body in which the upper body rest and being angled enough for a comfortable ride without interfering with hydrodynamic of the scooter. This also affects the head position since having an angle that is not close to being horizontal will be more ergonomic and comfortable to the user
- The lower body area being supported by the scooter especially for the fact that it is the area in which the target user's disability is located

Some Ergonomic Issues That Are Still Not Yet Resolved

Based on the design from the buck, the angle on the body will need to have some more adjustment for a better head position with more comfort and less strain on the neck. The width of the back of the scooter will also need to be adjusted as the width of the buck is too thick is does not fit the lower area properly. There is also the consideration for adding more support for the lower half by looking into solutions such as adding a leg rest like a stirrup or a belt holding attaching the body onto the scooter. With all of these in mind, it will help to create a product that will fit the ergonomic needs of a disabled diver during their activity.

3.4 Aesthetics & Semantic Profile

Considering that the environment that the concept will be used in, the underwater environment, the aesthetics of the concept needs to consider that it is moving through a medium of water. Another consideration is how the user will use and fit themselves unto the underwater scooter thus the shape of the scooter needs to be smooth enough so that it can easily move and glide in water but also shaped so that it can accommodate for a person on it.

Such needs and expectations can only lead to a slim scooter design that can have some level of creative expression but without sacrificing functionality. A good way to start with the scooter's shape and aesthetics is by looking into underwater wildlife such as dolphins, sharks, whales, fish, etc. Research and observation of their body shape and composition will help to determine what the shape of the final concept will be.

Using nature as an inspiration for the aesthetics and design of the concept is a great way of starting off with shaping the concept especially since many of the design today are inspired and/or derived from nature itself and this is not only because of the looks but also because of its functionality. Designs shaped from nature works because nature is designed to work and survive but also be aesthetically pleasing which is why using nature as the first step is a great idea.

3.5 Sustainability – Safety, Health and Environment

3.5.1 Safety

Safety is a big factor when it comes to being underwater as any mistake whether it be big or small done underwater can become a life or dearth situation in an instant. A diver needs to undergo a training session before being able to even go underwater as it is a very different environment than what anyone knows. The safety risk when Scuba diving is taken into consideration seriously at all time, but

that safety consideration increases when a disability is added into the equation. A person with a disability has a limitation to them that a normal person does not have thus their reaction regarding an issue with safety will also be limited due to their disability thus safety is a large factor when Scuba diving with a disabled person and thus when taking into considerations of things to think about when creating and designing the concept product, all risk and dangers should be minimalized to as much as possible for the safety of the target user such as securing the user into the scooter with their disability in mind.

3.5.2 Health

As previously mentioned, the targeted user is a disabled user that is exposed to the elements of the underwater environment. The target user is also a person with a disability thus when regarding health, the first thing to note of is the disability of the target user. Ensuring that the health of the user during the dive is a primary consideration and can be achieve that the user is comfortable all the thing while in use of the scooter with the ergonomics study taking care of such issue. Other health considerations are the health of the marine wildlife. The scooter should not interfere with their lifestyle and should consider things such as making sure that the scooter does not harm any wildlife in any way for example poisoning or physical collision. Things such as pollution whether it be noise or physical pollution should be reduced to a minimum or to zero.

3.5.3 Environment

The environment presents a large portion of how the design of the scooter ends up being as the scooter is designed to be able to move underwater and so the design of the scooter is designed to be sleek and hydrodynamic. The environment also helps to figure out not only the design but also the sustainability of the scooter. Considerations such as using light materials to prevent the scooter from

sinking while underwater is one consideration for the sustainability aspect of the scooter design. Other things to also consider the type of battery that is used as some lithium-Ion battery is an eco-friendlier solution compared to other battery types. Other environmental aspect to consider is the gathering of raw materials and the product disposal and minimizing any damages to the environment on material gathering and minimizing waste of disposal close to zero by doing things such as recycling.

Considerations into the welfare of both user and wildlife, environmental impacts, and will help to develop not only the final design but also the sustainability of the product by having these points and consideration be reflected on concept design.

3.6 Feasibility & Viability

Based upon currently existing product and the scale of how large and how much materials will be used in creating a concept, there is feasibility and viability in creating a product for the proposed solution in the problem at hand.

As indicated from the needs and benefits and the sustainability sections of the report, the intended materials that will be used for the construction of the concept will be focused on being sustainable while also considering that it will constantly be exposed to water, as the concept is an underwater scooter. Recyclable plastic with a protective coating to water wear is considered for the outer shell body of the scooter. The scooter is electric-powered and uses jet propulsion for a fast and efficient movement underwater. Manufacturing will consist of methods and practices that are used in vehicle production, with plastic molding for the body and any plastic parts. All of this is done with sustainability in mind to help protect the environment from waste of product and destruction from raw material gathering.

3.7 Design Brief

The purpose of a design brief is to make sure that the design of the concept follows a certain and specific set of points in accordance with the research done beforehand. This makes it so that the concept ideation and development is in the right track which in this case is focusing on creating a concept that will help the accessibility and mobility of physically challenged and disabled individuals during scuba diving.

Thesis Design Brief

Safety	Scuba diving is a popular recreational activity but there are important and serious safety regulation in place when diving since the users will be in a different environment that requires specialized gears for people to stay into for long periods of time. The safety of divers will be of use in developing a concept.
Ergonomics	Ergonomics will play an important role in help design the concept for the thesis project especially about the fact that the concept is being designed to accommodate for physically disabled individuals.
Aesthetics	As previously stated, the environment of which this activity is done in is underwater, which will affect how the concept will be designed and shaped as it needs to move effectively and smoothly underwater
Technology	The scooter will be equipped with a combination of current and innovative technologies such as a jet propulsion system used in speedboats for mobility and is designed to be electric.
Sustainability	The materials used for the body will be recycled plastic and the other components that will make the scooter more sustainable are electric powered, silent operation so not to disturb the wildlife, and efficient operation which saves power consumption

Table 10 Design Brief

4 Design Development

4.1 Idea Generation

4.1.1 Aesthetics Approach

As previously mentioned on the aesthetics section of the product benchmarking section, the aesthetic idea for the concept should be designed and styled so that it can move and glide underwater smoothly. To do this, the best styling option to the body would be a hydrodynamic shape in which the water can flow through the surface with ease. A great source of inspiration for the design would be from nature itself, as most of the marine wildlife that exist today are shaped by nature to be hydrodynamic with little drag or interference while moving in water. Some organic animal shapes to consider are of those of sharks and fishes, but especially from dolphins are whales since they are mammals, and they are shaped to be more horizontally planar because their biological make-up of having a backbone that makes them swim up and down instead of side to side.

4.1.2 Mind Mapping

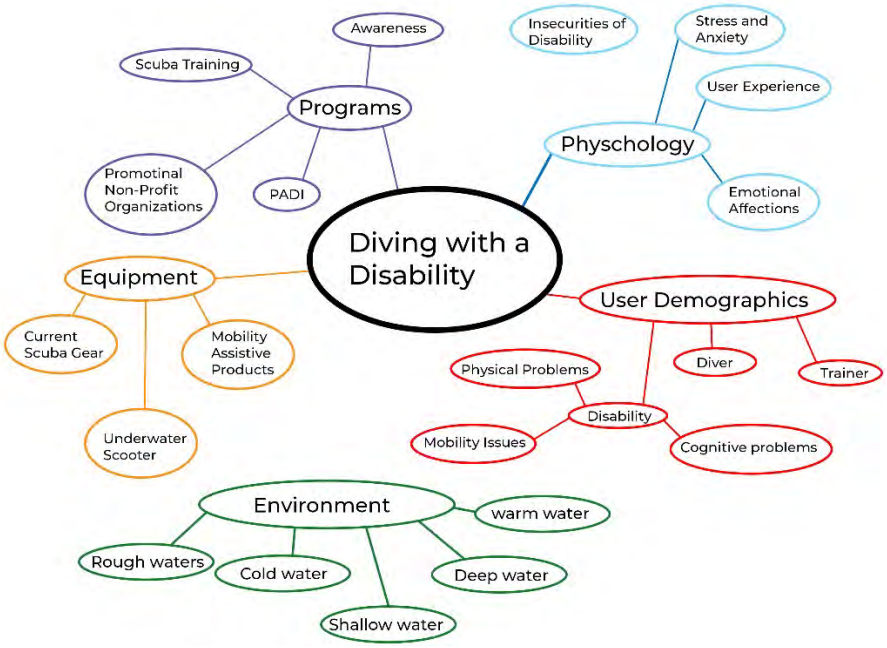


Figure 30 - Mind Map

4.1.3 Ideation Sketches

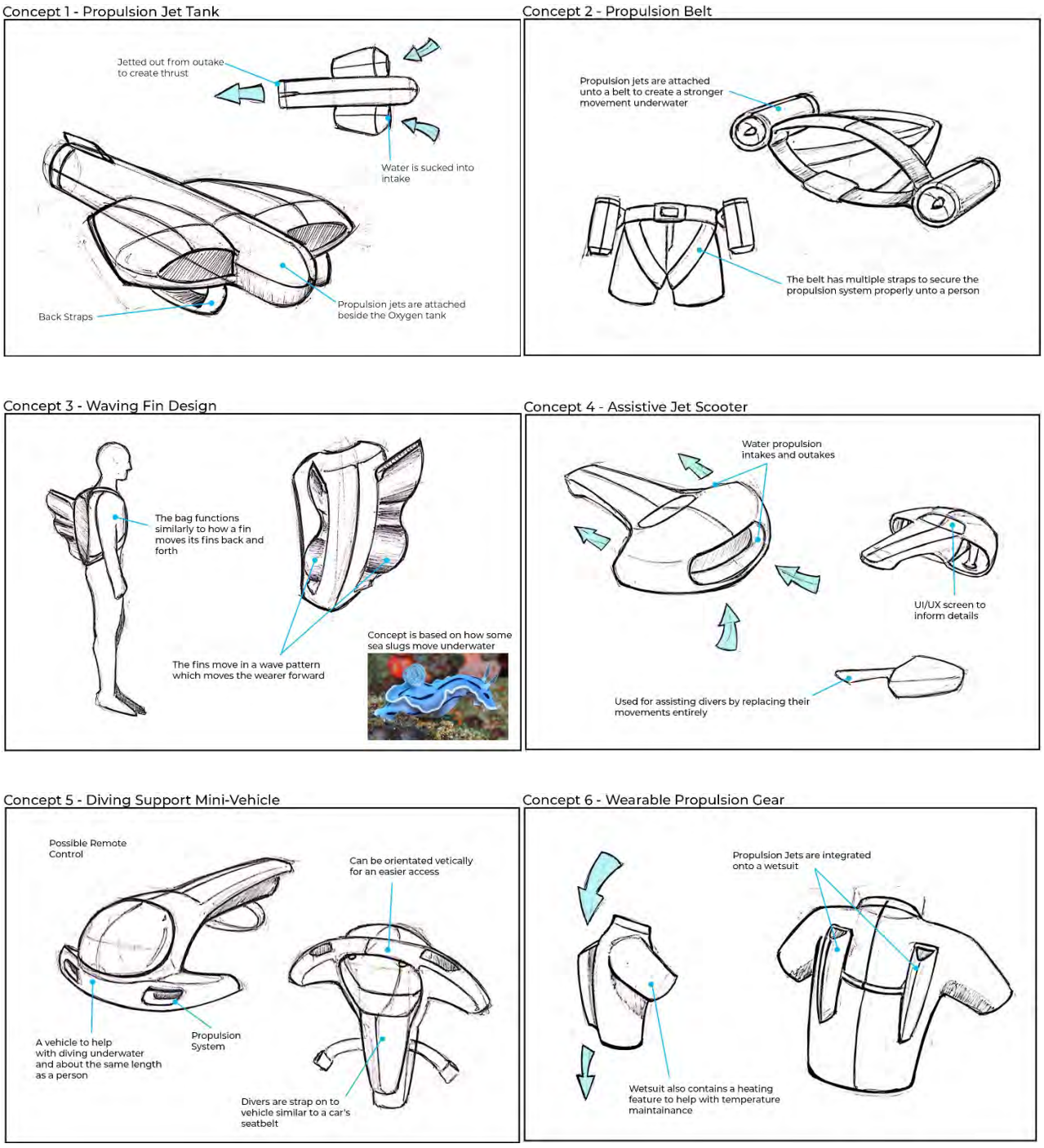


Figure 31 - Ideation Sketches

4.2 Preliminary Concept Explorations

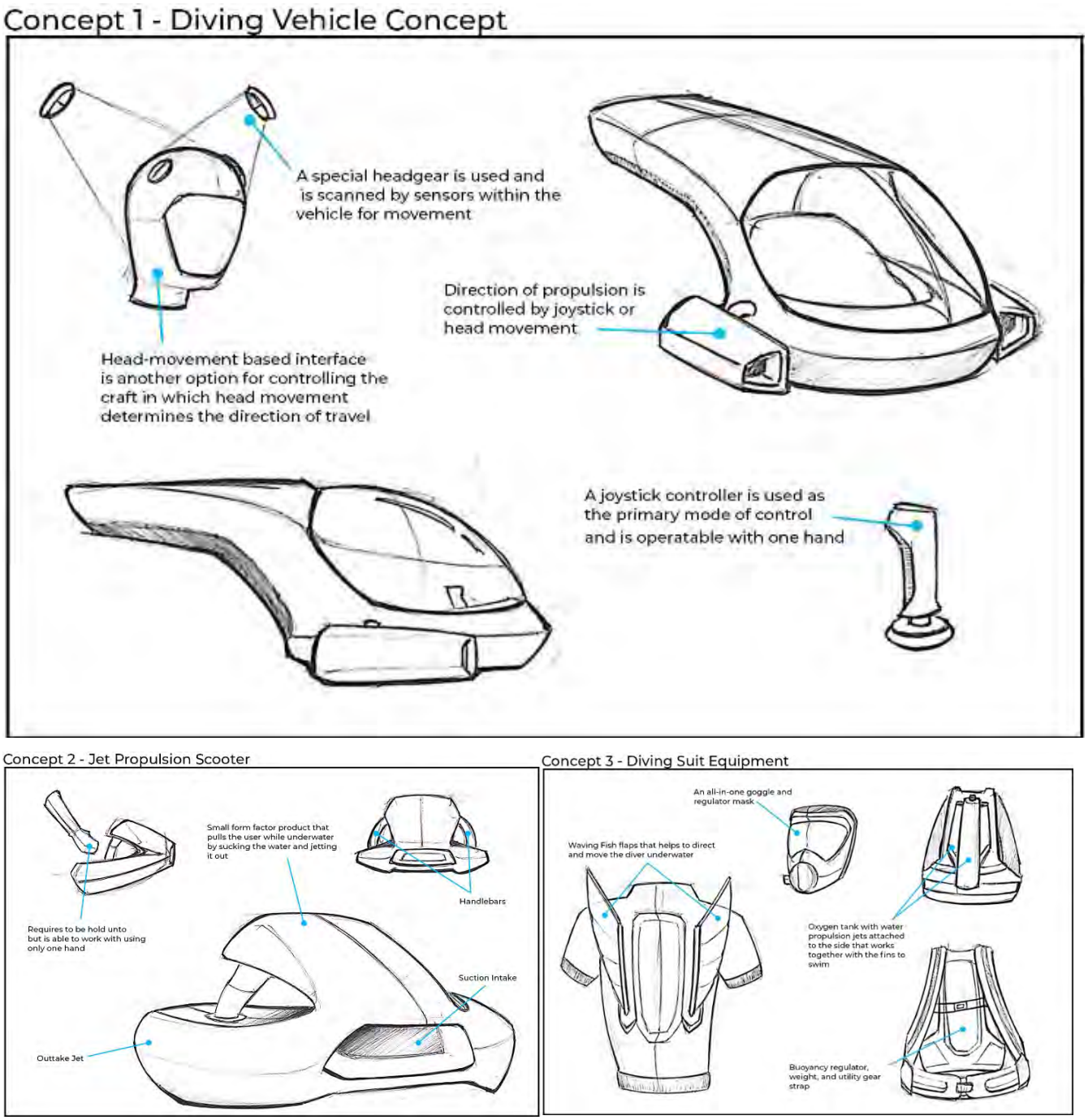
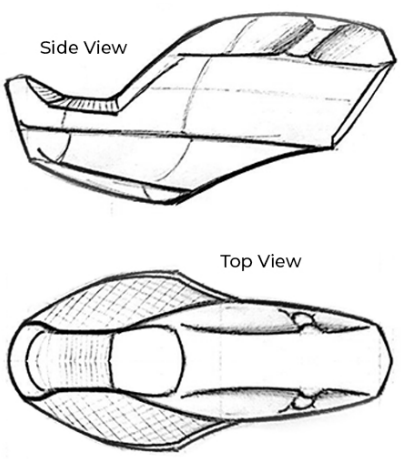
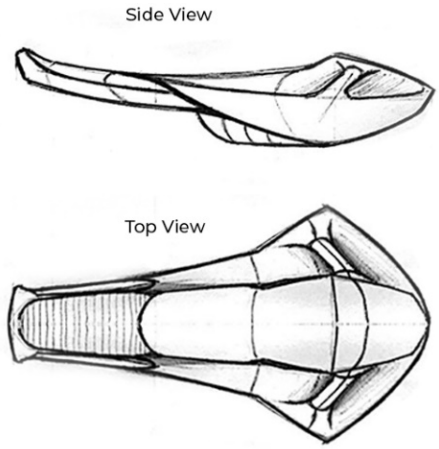
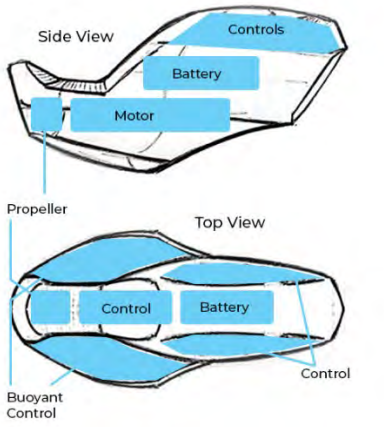
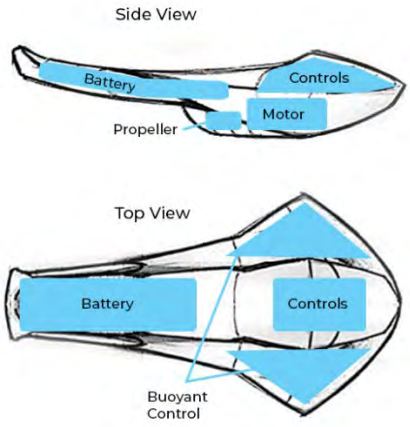
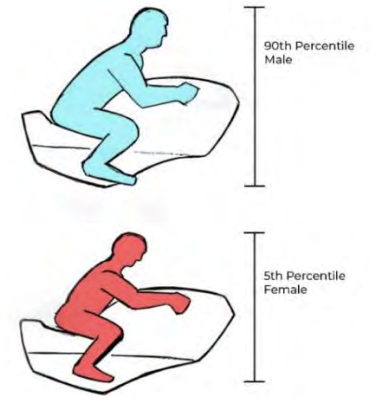
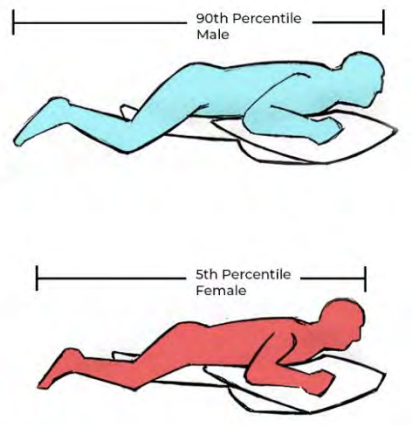


Figure 32 - Preliminary Concept Exploration

4.3 Concept Strategy

Table 11 Concept Strategy

CONFIGURATION 1 Propulsion Underwater Mobility Board	CONFIGURATION 2 Underwater Scooter Vehicle	DEFINITION / EXPLANATION
		List of Components: • Motor • Propeller • Controls • Battery • Body • Buoyant Control Locations affected by the components: • Interactions • Ergonomics • Functionality • Aesthetics
		**Configuration Diagram:** These diagram shows the possible locations of each component that will be included into the concept product. These locations will be based on the interaction of the product with the user, what the functionality of the product is, and its design aesthetics.
		**Ergonomic Diagram:** The purpose of this diagram is to show the ergonomic interaction with both a 5th percentile female and 95th percentile male and the befitting anthropometric dimensions that will best suite the human dimensions.

4.4 Concept Refinement

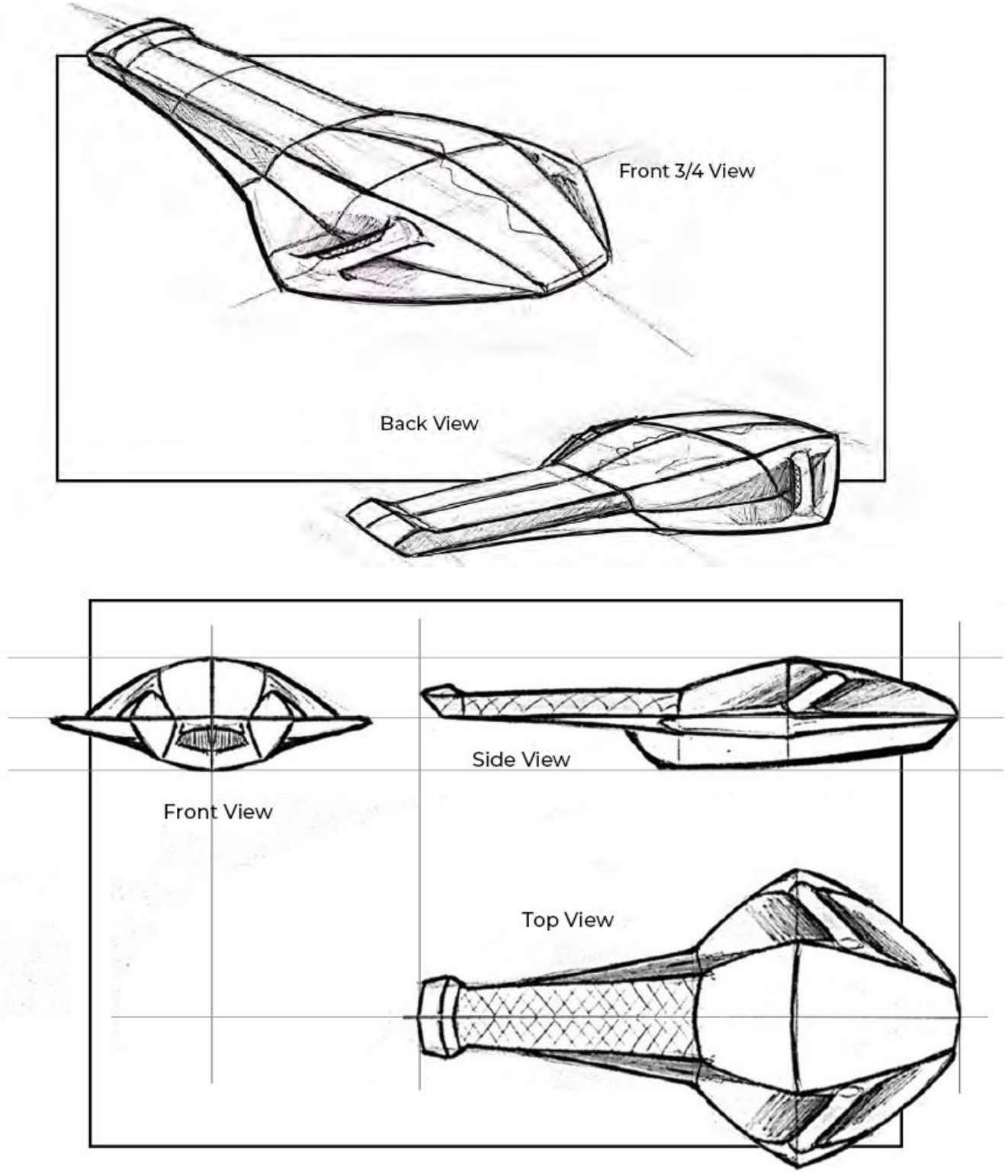


Figure 33 - Concept Refinement

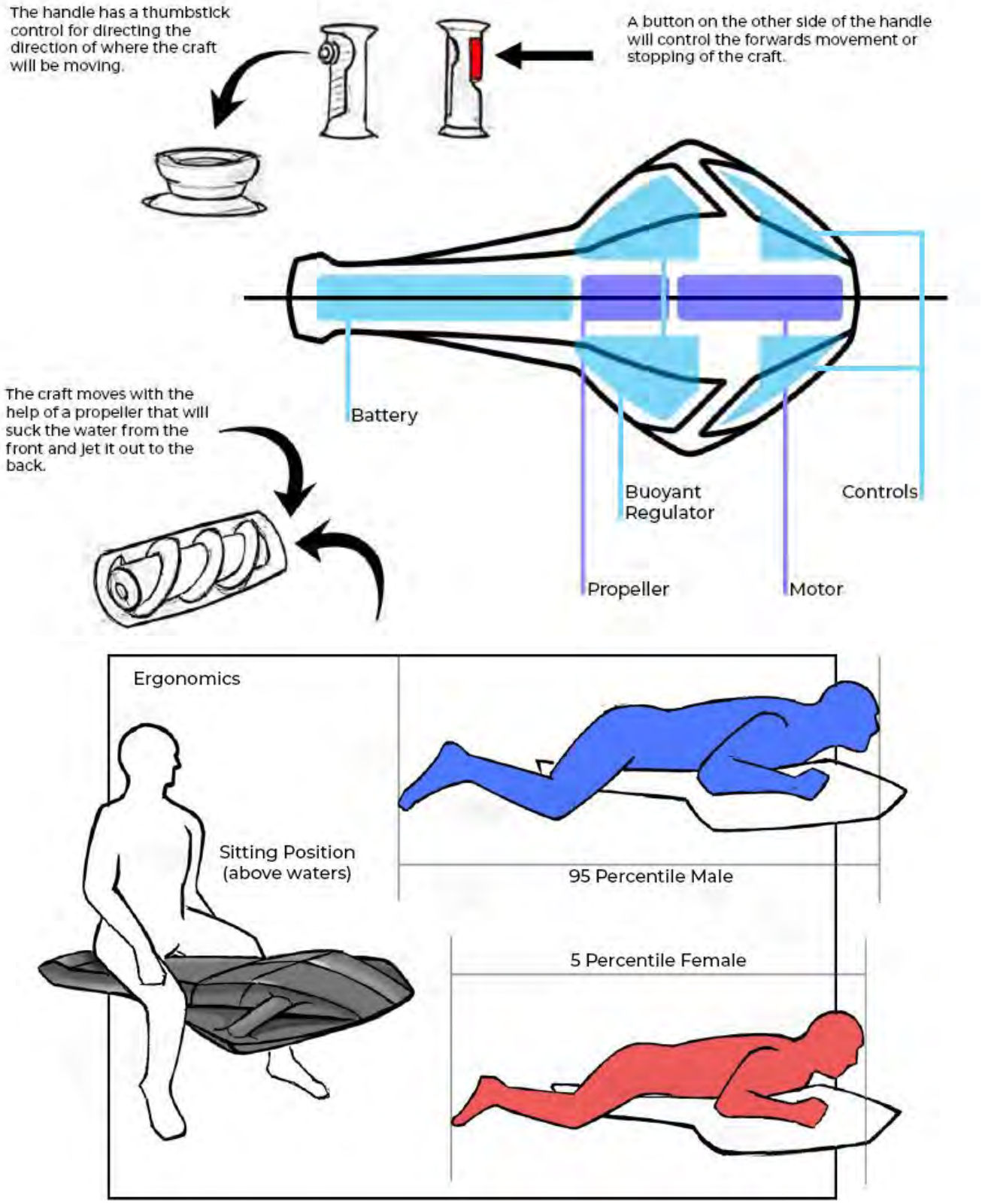


Figure 34 - Concept Refinement with Parts and Ergonomics

4.5 Design Realization

4.5.1 Physical Study Models

1:5 Scale Ratio, Measurements: IN

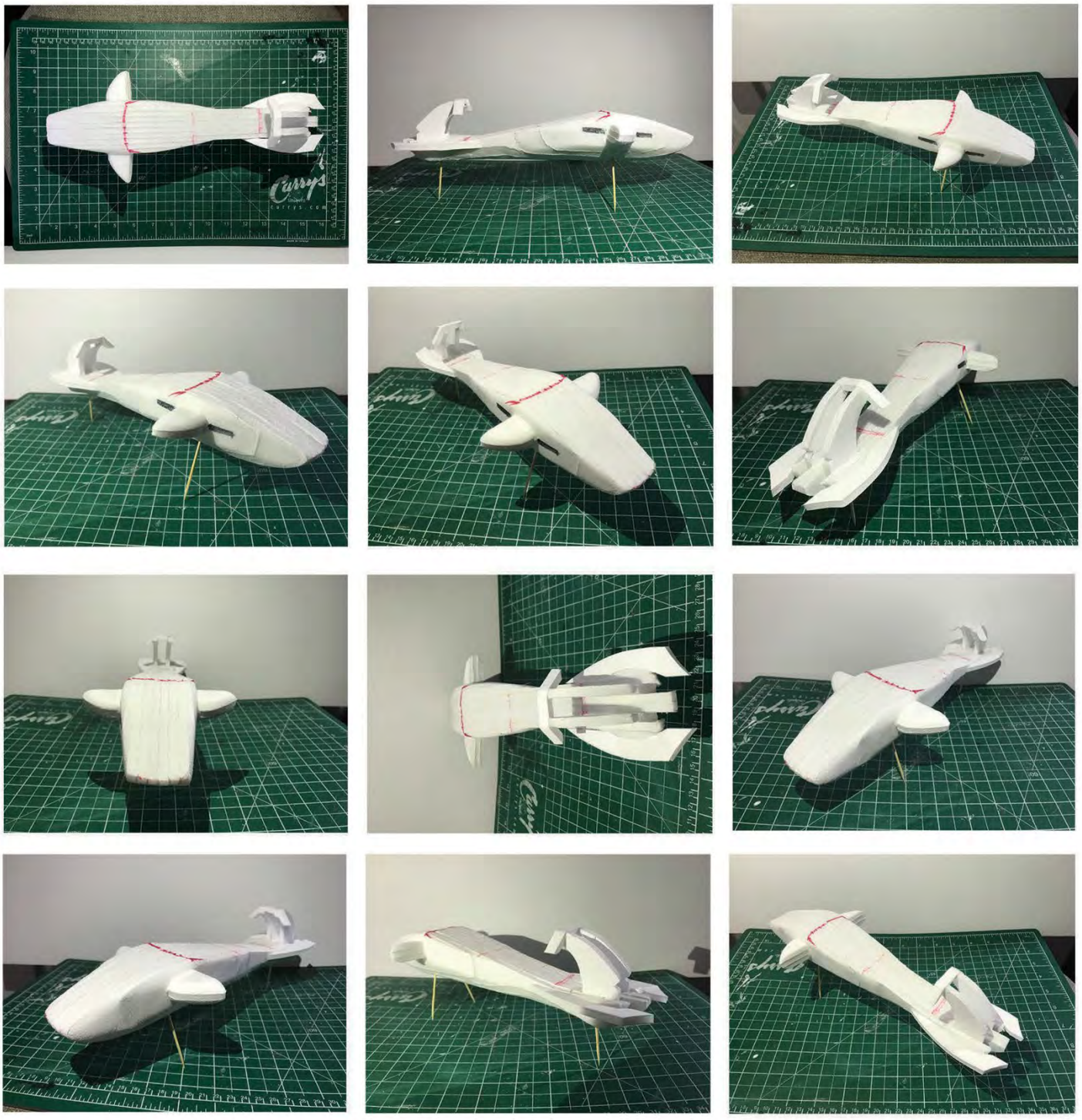


Figure 35 - Physical Study Model

4.5.2 Product Schematic and Further Development

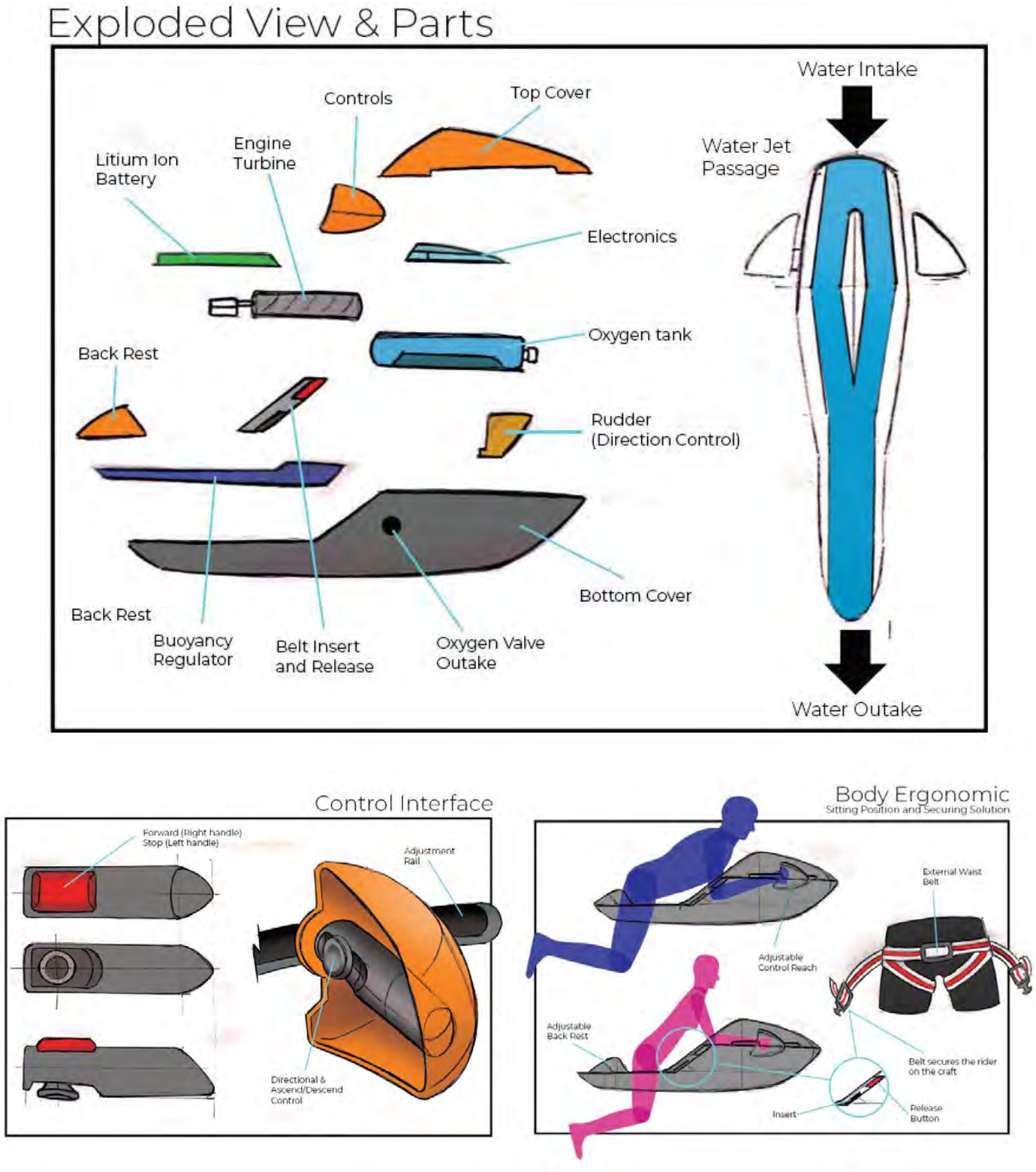


Figure 36 - Product Schematic and further Development

4.6 Design Resolution

After doing some careful consideration and further development on the concept product itself, the final design of the concept will be a scooter that will support the upper body in which the user will lay flat on their stomach. Like how a surfer lays flat on their board and pedaling their arms to gain speed, the user will be in a “superman” position to use and operate the scooter. Another feature to consider is the inclusion of a support are that will help to keep the user onto the scooter while moving. This will especially help those with physical disabilities as they may have a hard time stick on the scooter while moving. Further development on the shape, aesthetic and design of the concept will be done during the CAD work.

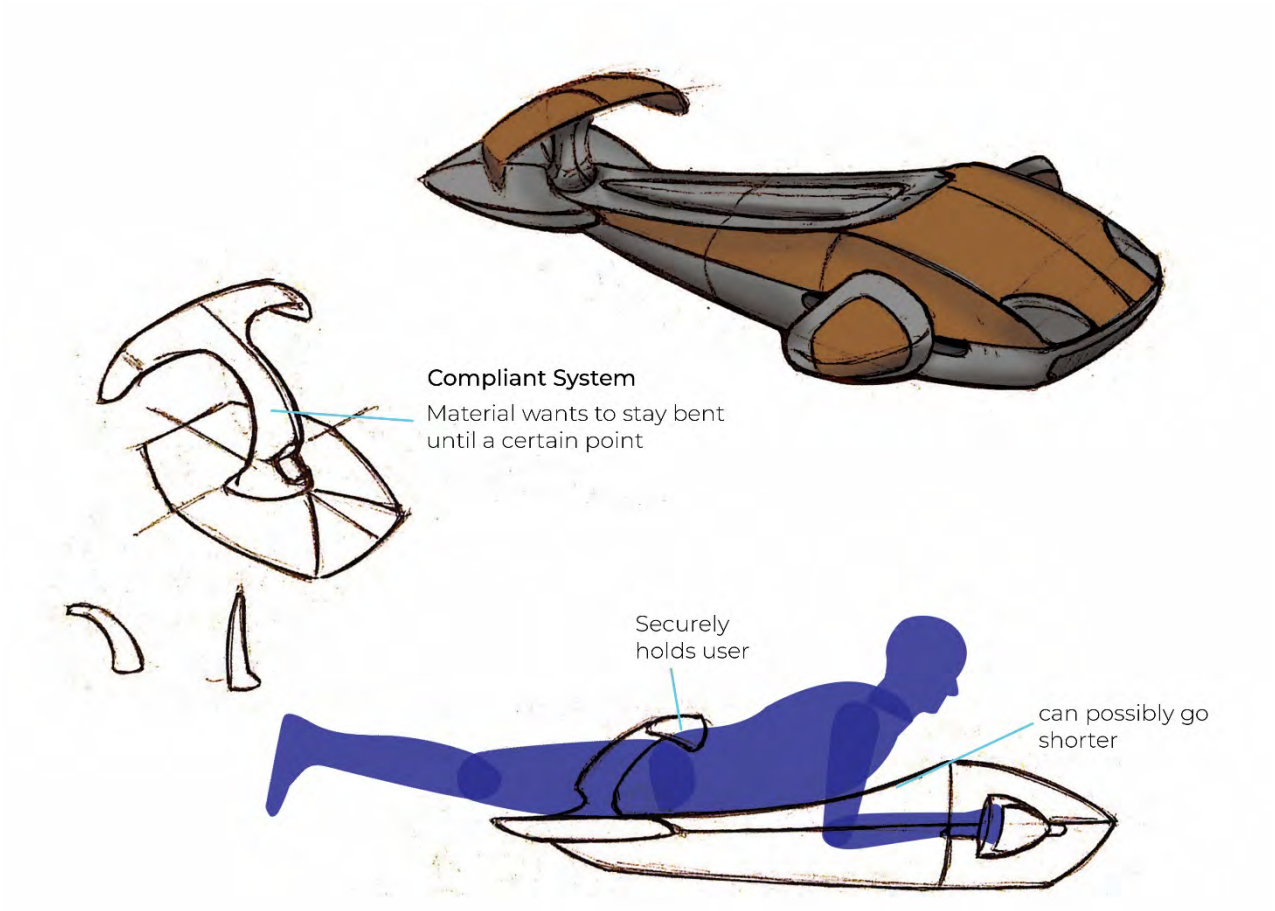
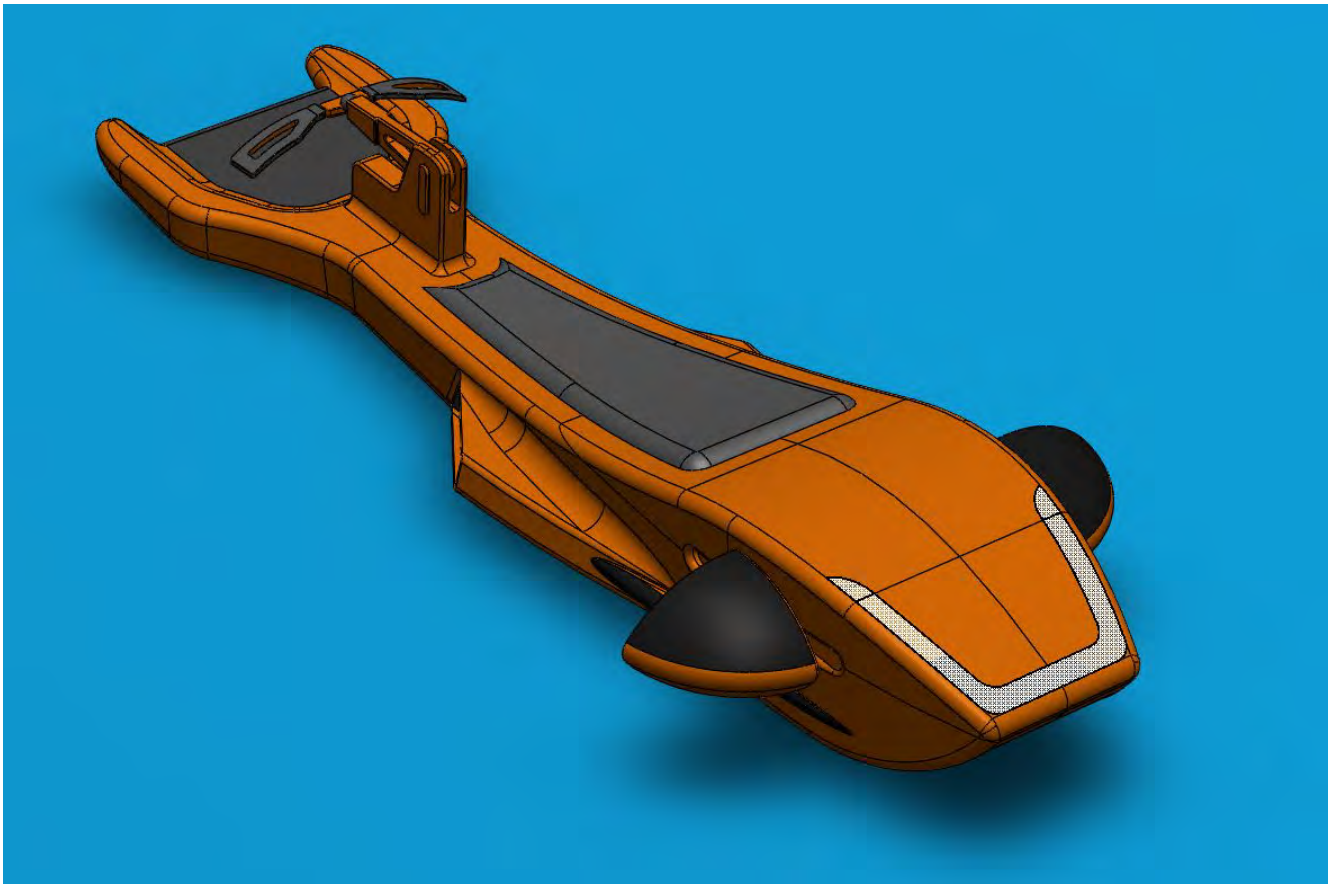


Figure 37 - Design Resolution

4.7 CAD Development

Preliminary CAD work:



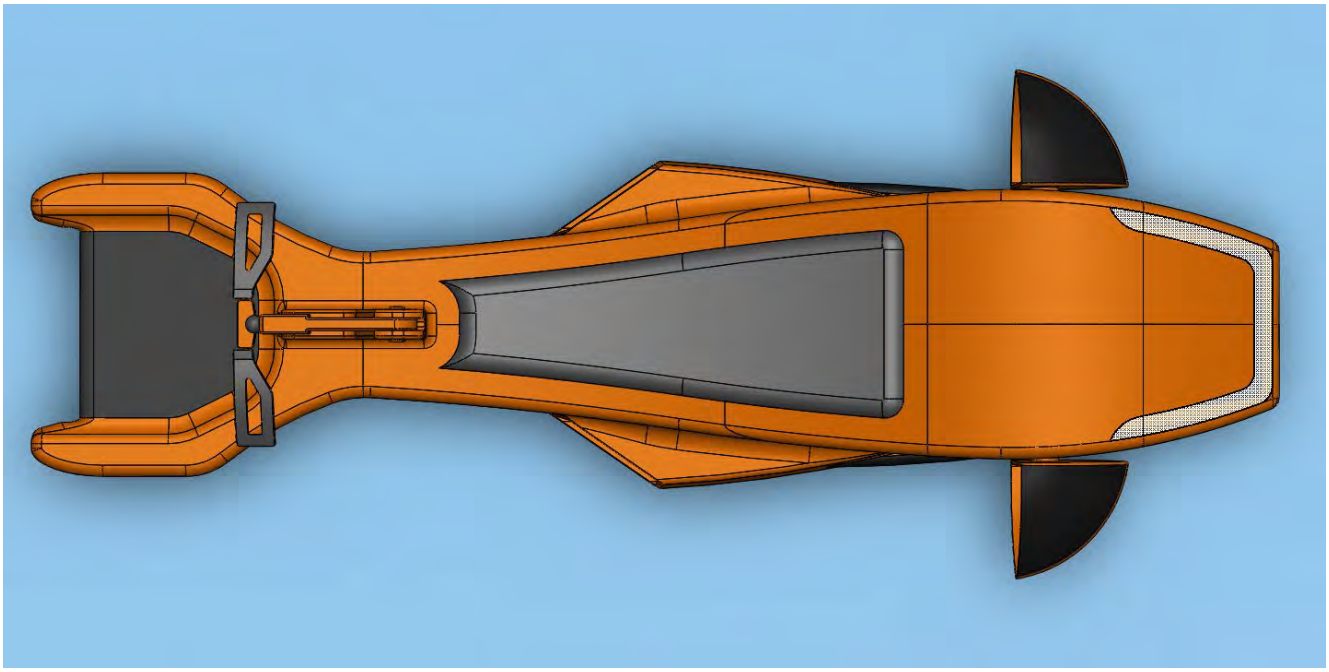


Figure 38 - CAD Development 01

Figure 39 - CAD Development 02

Further Development:

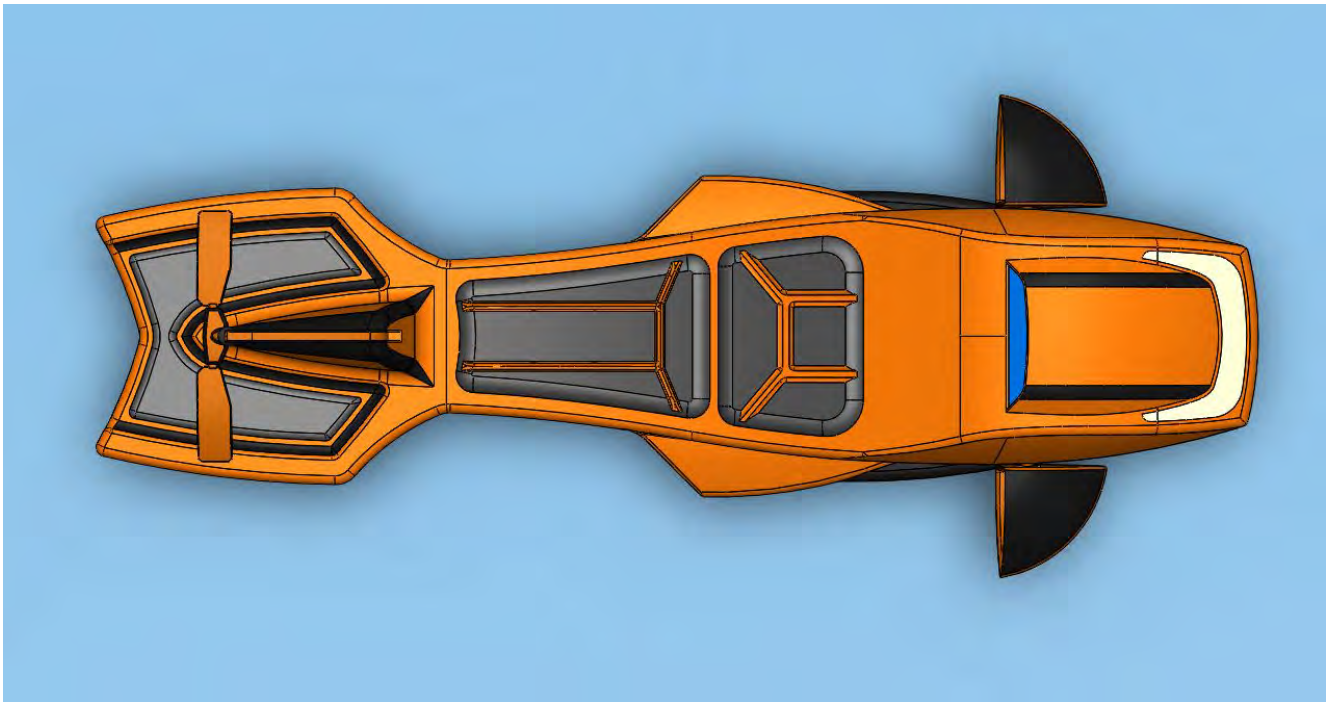


Figure 40 - Further CAD Development 01

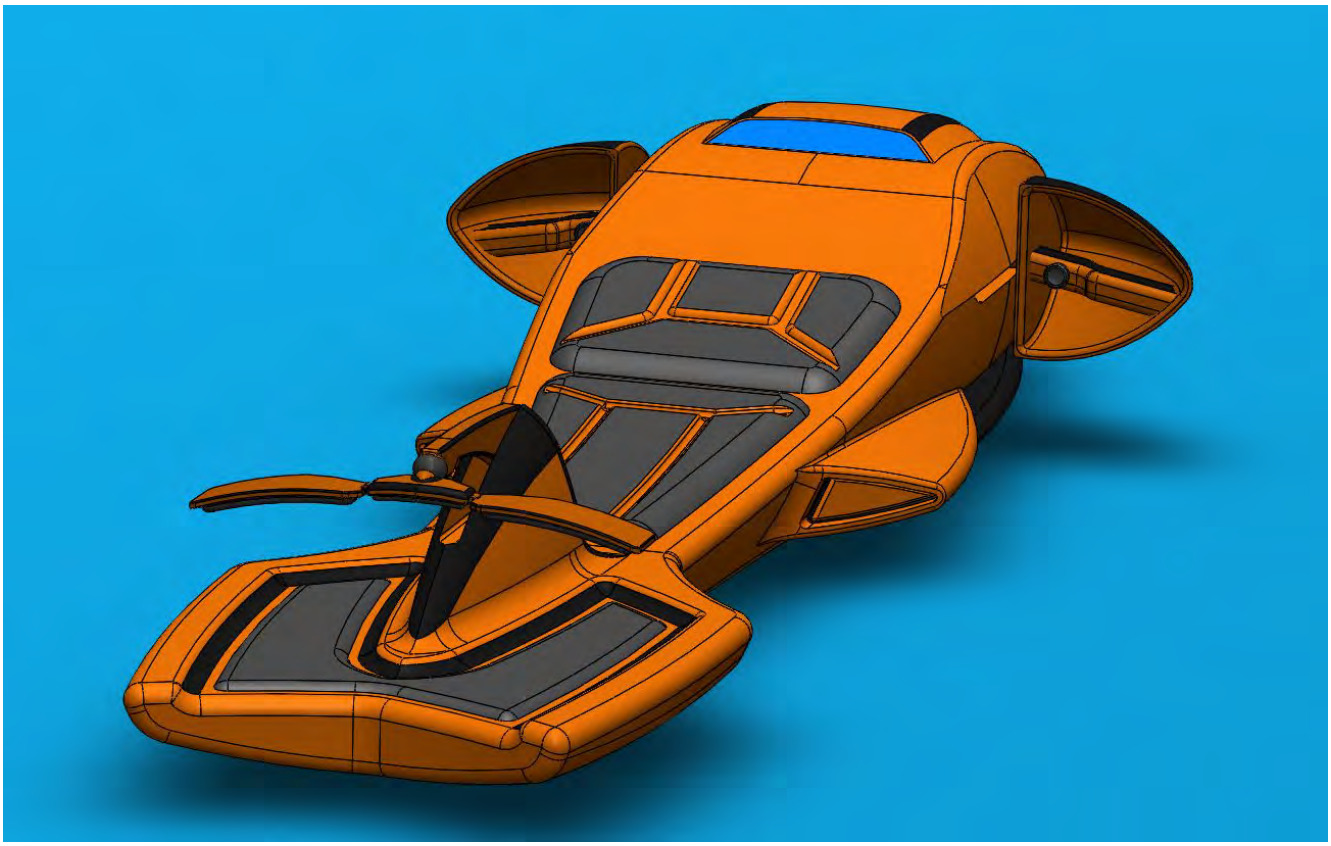


Figure 41 - Further CAD Development 02

4.8 Physical Model Fabrication

Due to some constraints that are currently present, fabricating the model will be mostly done on the confines of the home, as school and all the available equipment that it has to offer is not an option for many of the students due to the restrictions. Thus, the fabrication of the model will be done with the available tools that are present at home.

The fabrication of the model will be done using a 3D printer to create the body of the concept model. From here, a decision is needed to be made whether it should be done by a third-party 3D printing company or done in-house by buying 3D printer. After personally listing and considering each of the options pros and cons, the final solution was to buy a 3D printer.

The CAD model was done in a 1:1 scale which means to print the physical model, it will need to be scaled down to fit the printing bed but not too small that it loses many of its details. A 1:5 scale was chosen as the best scale to print at, but the model was still too big for the printing bed. This required to cut the model into two so that it can be printed at a 1:5 scale. After printing the model, primer is applied and then sanded to have a more finished surface.

Figure 42 - 3D printing Model

5 Final Design

5.1 Summary

DELFIN is an underwater scooter designed to accommodate for the physically challenged individuals that wishes to go scuba diving without having to worry about their disability hindering their mobility underwater.

Current scuba diving practices and procedures a standardize to accommodate abled body individuals. People that are physically challenged or has a disability can still go scuba diving, but along the way of trying to prepare and learn to go scuba diving, they will find that there are very little if not zero equipment or products that are designed to help physically challenged individuals underwater. One of the main reasons for this is that many scuba divers are abled bodied individuals and those that are physically challenged are small on numbers, which leads to many companies that design scuba diving products to focus more on the large audience to gain more profit and sales.

DELFIN plans to address this issue by being designed to accommodate those that are physically challenged of physically disabled. The main purpose of DELFIN is to become a person’s main mode of mobility underwater so that the users can focus more on experience the underwater environment and all the things that it has to offer, such as observation on the marine wildlife that swims around the water, the things that falls on the ocean floor, and much more.

5.2 Design Criteria Met

5.2.1 Full Bodied Interaction Design

DELFIN is designed so that it can accommodate people with physical disabilities. The scooter accomplished this by utilizing the arm support that is install at the back of the scooter. The purpose of the arm is to clamp and hold onto the user's legs or body with a comfortable amount of force, just enough to hold the user onto the scooter. The support arm has a pressure sensor installed on the pad that hold the user which senses whether there is enough force to hold the user but not too much that it will hurt them. The arm has a large range of motion so that it can also flip and hold the body instead of the legs or stand up right so that it can be used as a back rest if the user wishes to be on a sitting position on the user.

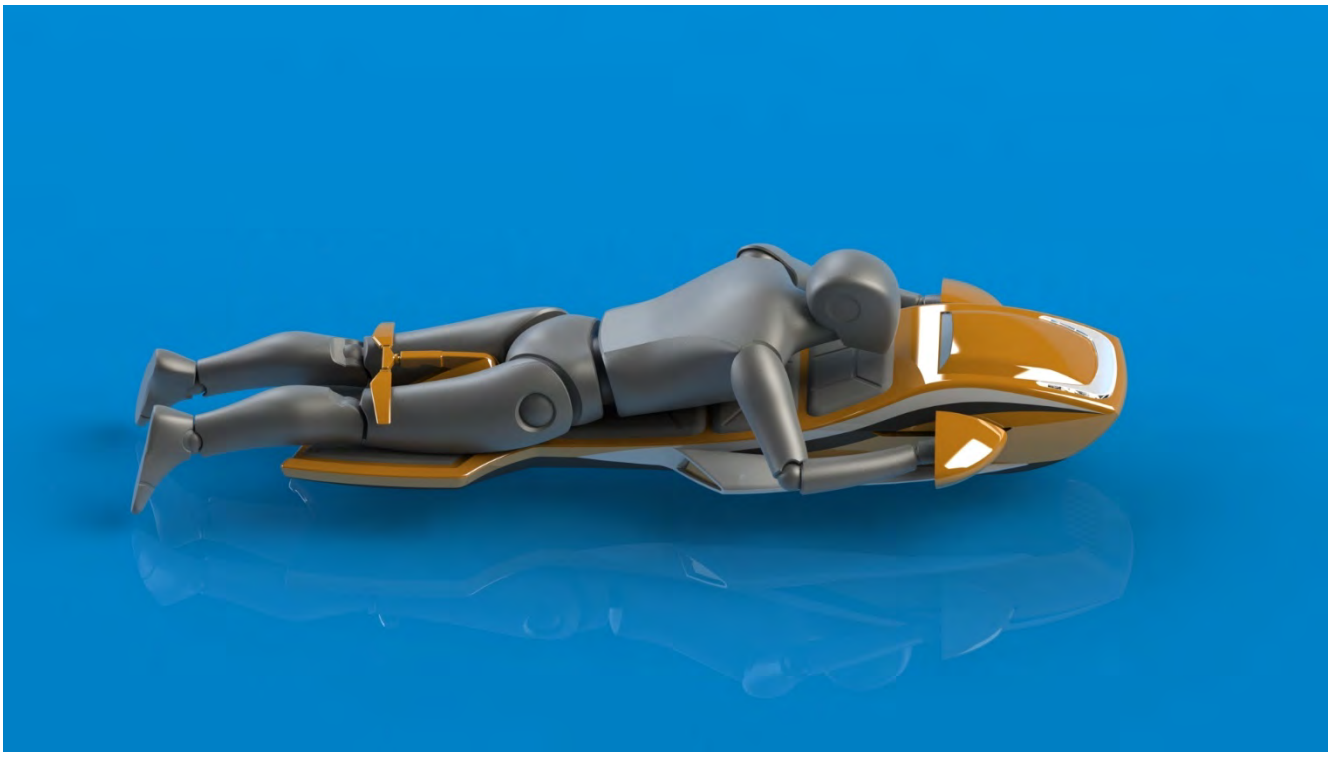
5.2.2 Materials, Processes and Technology

There are multiple factors as to why the materials that will make-up the concept product is chosen for its construction. In terms of the outer body, the material chosen is a list of recyclable plastics ranging from plastic materials such as Polycarbonate, polypropylene, PET (Polyethylene Terephthalate), Polyethylene, etc. Using such plastics will help with the sustainability aspect of the concept. Using plastic as a material also leads to using manufacturing processes such as plastic molding, which helps in creating high mass production numbers but low manufacturing maintenance needs and cost.

Another aspect of the concept that contributes with sustainability is having the concept electric powered. Moving to a renewable energy source helps with contributing to multiple sustainability actions such as decreasing the fossil footprint, reusing materials and moving away from raw material extraction that leads to negative affects to the environment, and increasing the need for renewable power production.

5.3 Final CAD Rendering

Figure 43 - CAD Renderings



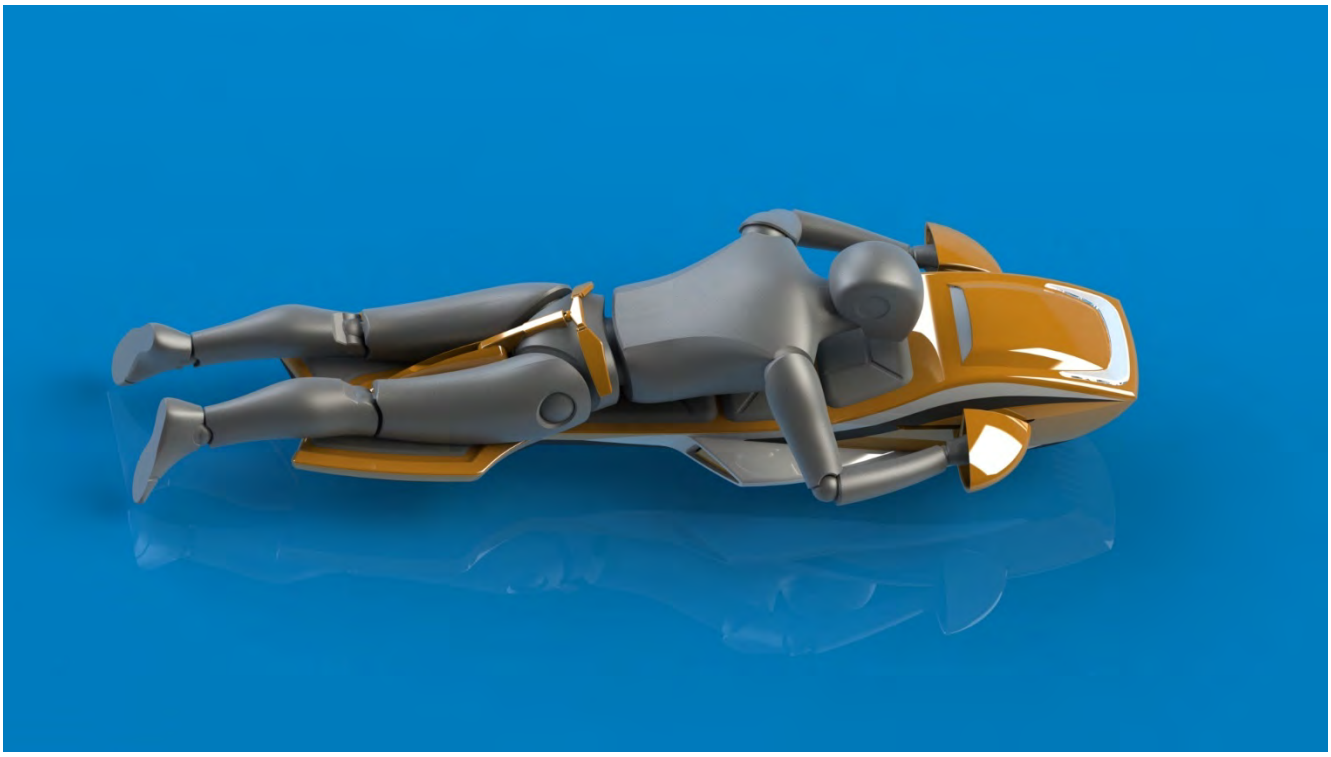


Figure 44 - CAD Rendering with User

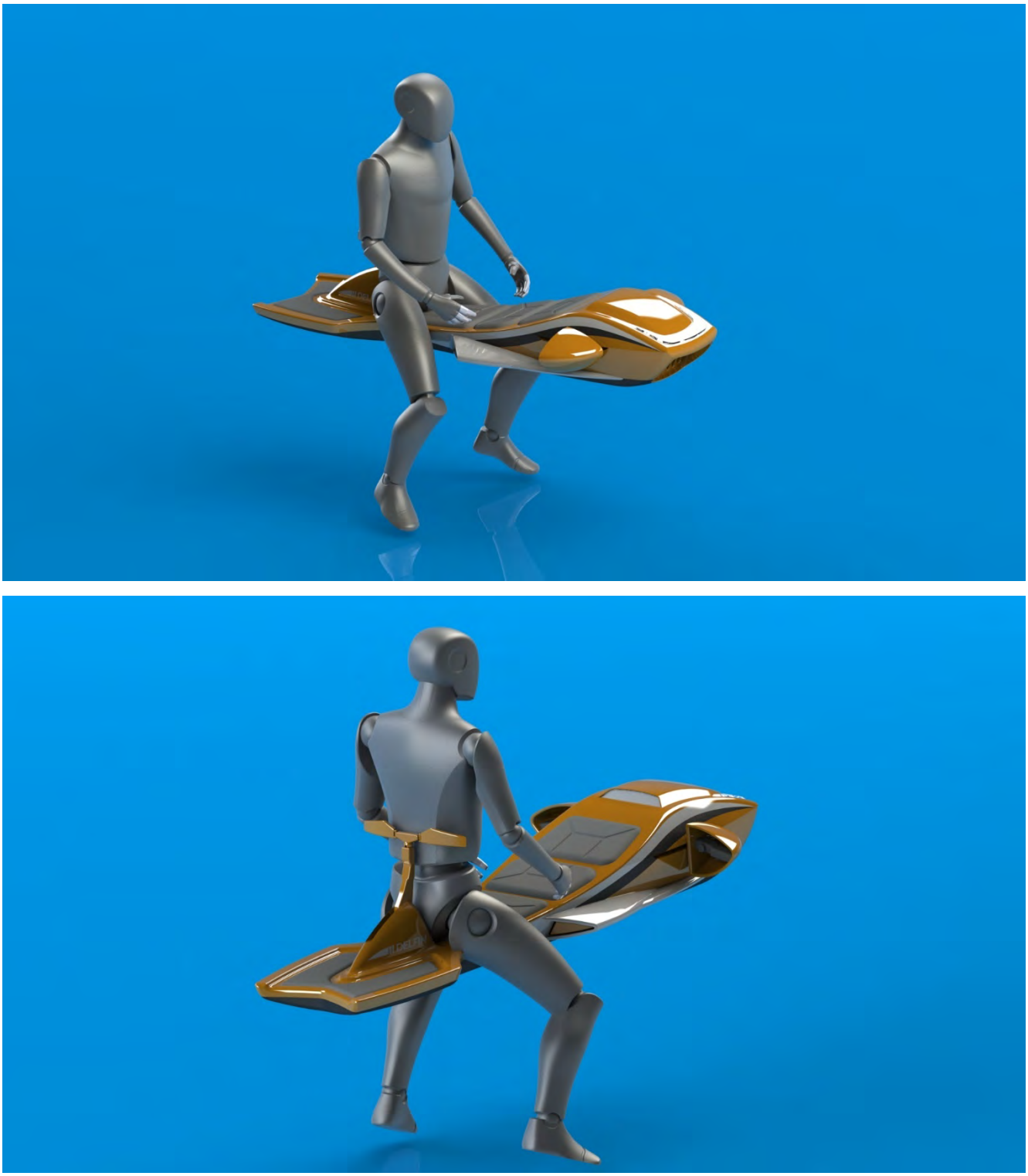


Figure 45 - CAD Rendering with Sitting User

Figure 46 – In-Situ Rendering

Figure 47 - In-Situ Rendering 02

5.4 Physical Model

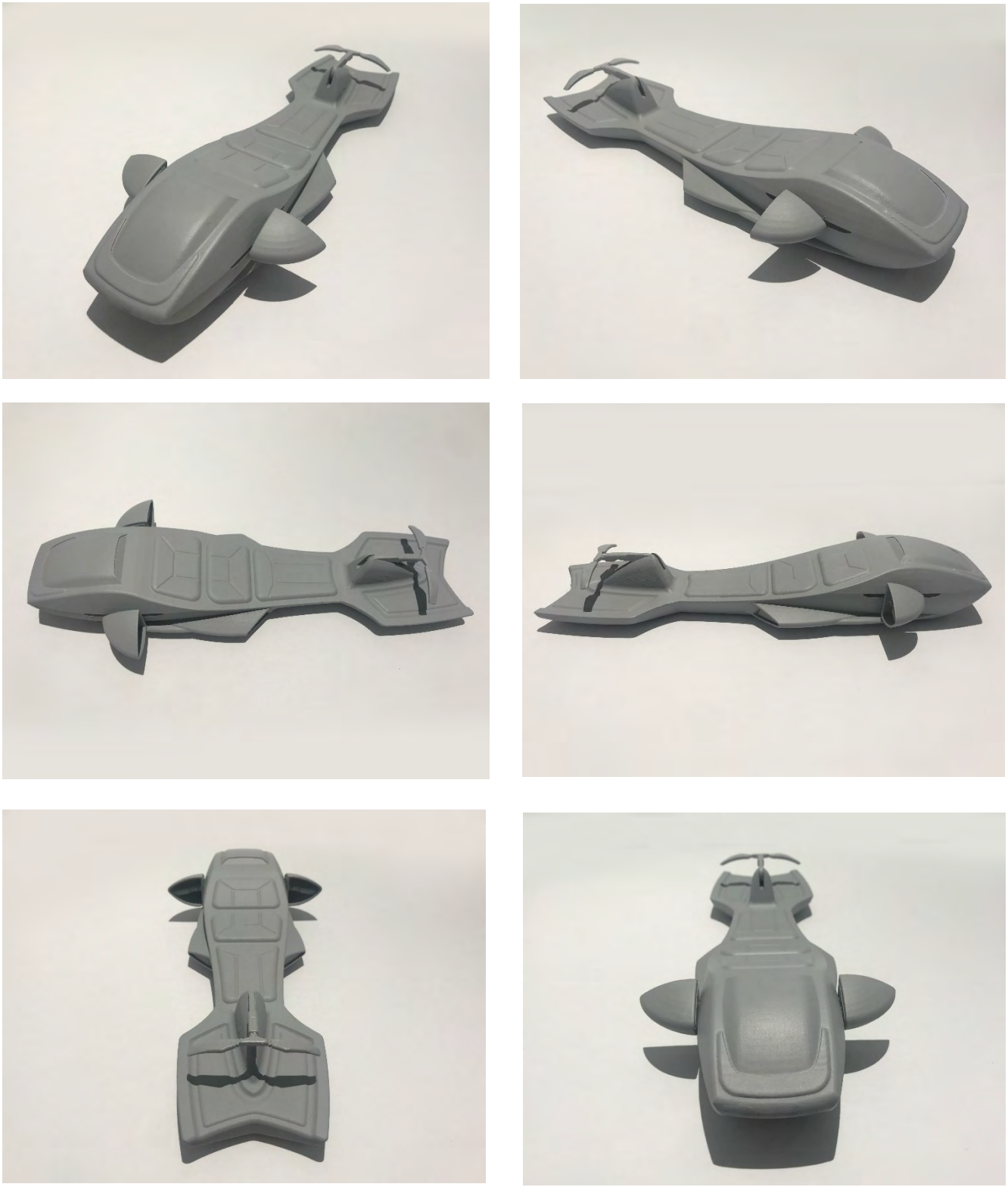


Figure 48 - Physical Model

5.5 Technical Drawings

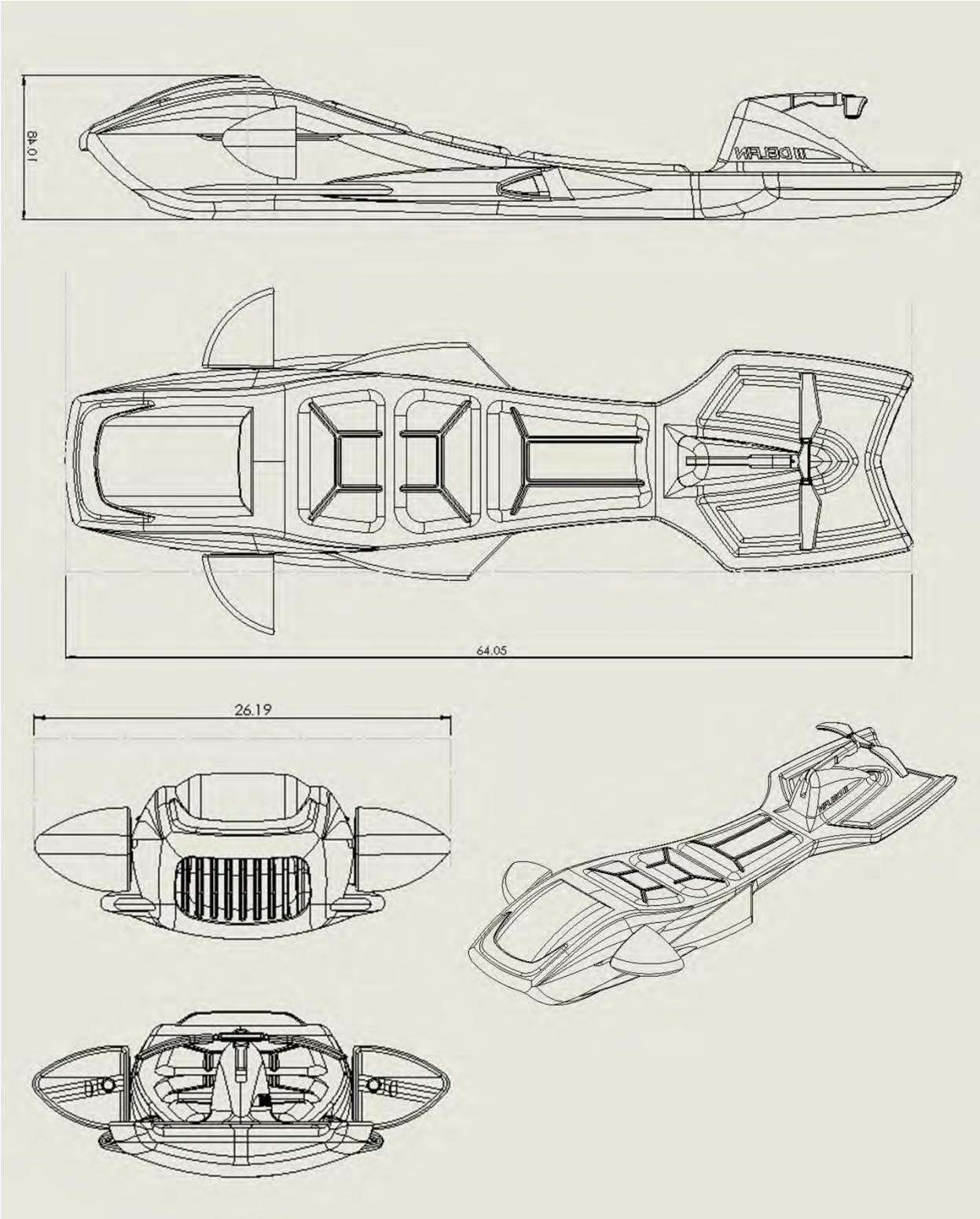


Figure 49 - Technical Drawings

5.6 Sustainability

With all things to consider, the development of the concept product of an underwater scooter for the disabled will be completed with the sustainability that will be taken into consideration for the product which will help to show the final design of the concept by going into things such as material usage and manufacturing, effects on the environments, and any other ecological and social values the product will affect during its whole life cycle. The material that is being considered for the main outer body is a light and recyclable plastic body. A biodegradable plastic is one consideration, but its biodegradable capabilities may affect its performance underwater as it may start to degrade if the coating used is not applied properly thus a plastic that can easily be recycled is a better solution. For a battery solution, a Sodium based battery can become a better alternative for Lithium-ion batteries as research suggest and it also contributes to the environmental aspect of the products sustainability as there is plenty of sodium that can be extracted in seawater. A Dyson type propeller can replace the traditional propeller as it can be more efficient with moving water which can result in less power consumption for the same amount of effort. With these considerations for the design of the scooter, the sustainability of the product can be better compared to the current existing products and can have a beneficial result to the environment, social values, and economy.

6 Conclusion

6.1 Summary

Scuba diving is a fun but strenuous recreational activity where people can dive underwater for a long period of time with the help of Scuba diving equipment. Scuba diving is done all around the world and all a person needs to do is some training and learning the proper safety and procedures. The current equipment used for scuba diving has gone through multiple renditions and advancements compare to the previous older models, such as moving from a heavy metal frame body to a softer and easy to move in latex wetsuit/dry suit. The equipment of today can accommodate for many people but even so, current equipment does not fully support people that are physically challenged since the diving equipment are standardize for abled bodied people.

DELFIN is an underwater scooter designed specifically to support people with disabilities and are physically challenged. The scooter acts as the main way of mobility which allows the user to focus more on experiencing and observing the underwater environment and marine wildlife.

DELFIN addresses the issue of lacking equipment that supports and are designed to work properly with the physically challenged. It also adds things such as increase sustainability with its usage of sustainable materials in its production and utilizing the growing usage of electric powered products with rechargeable batteries. Though the main problem of lack of support for the disabled and physically challenged is address, another matter that the concept DELFIN brings into the table is the increase in awareness for disabled divers in general. Thus, hopefully by the end of this thesis, more people will know and be aware of the issue at hand and that more companies would take into consideration the other demographics of divers.

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