GoBabyGo-D

GoBabyGo

Preliminary Report

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1. BACKGROUND

1.1. *Introduction*

Go Baby Go (GBG) is a project that aims at helping children that are disabled to move just like normal children. This is by making them toy cars that they can ride on by themselves without the help of any other person. This is not a commercial exploit and the cars that are made through this program are given out for those who are in need. Our team is one of the many teams across the world that is doing this kind of work.

We intend to make a unique design of a child toy car. The team will come up with its own prototype, find the funds that are to be used, and proceed to build the design. We hope that after the completion of the project that we have helped one more baby to be able to ride it independently. This project is also a chance for us to give back to society what it truly deserves, as well as offering an avenue through which to give through the funding of this project.

The GBG project started with research on the development of young children and the impact it will have on their lives in the future. This was conducted by the pioneer of the project, Professor Cole Galloway from Delaware University. Per Galloway, if a child has a vibrant childhood, they tend to grow into a normal adulthood. He also stated that children ought to play and have all the fun in the world even in spite of their disability because if they do, they will be no different from any other child when they grow up.

Some of the benefits that the child will get is having a better intellectual capacity. When children are playing, moving about, and discovering things, it builds their intellectual capabilities. The second benefit is that it allows them the ability to relate well with other people. When children play together, they are building relationships with each other which is something that they will be able to do in the future if they are able to have fun with their cars at a young age. Finally, it will be a form of rehabilitation for children as it will help to strengthen bone weakness for example. One of the main goals of this project is to offer disabled children an opportunity to play and interact with other children normally, without their disability getting in the way.

1.2. *Project Description*

Children with limited mobility often do not receive the much-needed exposure to socialization to cognitively develop at a normal rate. Existing research shows that equipping young children with a capacity for self-control over their own environment can have a meaningful impact on the long term outcomes of impairments such as cerebral palsy or muscular dystrophy. The GBG project, which began at the University of Delaware, has developed a set of DIY cars for families with children who suffer from mobility restrictions. These cars have been designed on commercially available ride-on toy car platforms (like Power Wheels) and have been deployed worldwide by the GBG team. These cars have proven to be a cost-effective means of enabling young children to move and interact with their peers.

As such:

"The goal of this project will be to design and build a new version of the GBG retrofits – specifically, to design a universal control for children with extremely limited mobility of their arms and/or legs".

1.3. *Original System*

This project involved the design of a completely new Pressure Pad GBG. The project included a number of new designs that the team worked on in order to prepare well for the construction of a new, highly developed GBG car. Other retrofits of GBG are mostly old-fashioned since they all depend on a car and require some modifications.

1.3.1 Original System Structure

The original system is something that is unique and completely different from all previous ideas and designs for the GBG mission. In this case, it will be a toy car with a lot of modifications. The GBG team would like to establish a toy ride that satisfies the needs of the disabled child, incorporating the latest technologies such as a hand pressure system that would allow the child to wander around by themselves without the help of a parent. Another new technology would be to implement a renewable energy source for the car to make it environmentally friendly. These are just two of the modifications that the team will develop throughout the project. The objective of this project is to build a low-cost car with the latest technologies to help serve the child as well as possible.

2. REQUIREMENTS

The GBG team met with the client, Dr. Oman, to get double check the current customer requirements based on the project description that was provided to the team. These customer requirements must be met by the final product.

2.1. Customer Requirements (CRs)

The GBG team has five main customer requirements (CR) which will be weighted using a scale of 1 to 5 (5 = top, 1=bottom), depending on the importance of each CR.

In the table provided below (Table 1), there is a list of specific CRs – each requirement is accompanied by a brief description to clarify customer requirements clearly.

Table 1: Customer Requirements (CRs)

Customer Requirements	Description
Power system	The system should include an acceleration controller, a cruise controller, and safety breaks
Physical	The system should have comfortable seats, trunk mobility, and leg support
Operating system	The system must be easy to operate so that the child can use it independently and with ease
Financial	The system must come at a low cost, not exceeding $400
Safety	The system should ensure the safety of the child at all times through the inclusion of a seatbelt harness and bars

2.2 Engineering Requirements

The following engineering requirements were created by GBG team in order to ensure the delivery of the five Cars as listed in Table 1.

In the next table provided (Table 2), there is a list of engineering requirements, with each requirement followed by a brief description for the purpose of clarifying each requirement clearly.

Table 2: Engineering Requirements

Engineering Requirements	Description
Weight (lb)	The final solution should not exceed a total weight of 60 lb., so that it can be easily moved or carried
Price/cost ($)	The final solution should cost up to $400 to complete
Smooth sides (rad)	The system should have smooth angles (no sharp edges/points) to secure the safety of the user (s)
Suspension (lbf/in)	The system should have springs to ensure that there is no jerking motion when the system is used on uneven roads
Store energy (w)	The system should generate and store electrical energy
OSHA standards	The system should meets OSHA's standards to ensure the safety of the child
Multiple speeds	The system should have at least three different speed settings (for example: low, medium, high)
Steering options	The system should incorporate a new steering option instead of a regular steering wheel

2.2.1 Revised Engineering requirements

The team went through many detailed changes in the final design which made the team try to update the house of quality, so it could satisfy all the requirements to be met.

The table below illustrates the updated engineering requirements. Ordering parts and battery life were added to the ERs, and suspension was removed from the ERs, since it's not concerned as a problem anymore.

Table 3: Engineering Requirements

Engineering Requirements	Description
Weight (lb)	The final solution should not exceed a total weight of 60 lb., so that it can be easily moved or carried
Price/cost ($)	The final solution should cost up to $400 to complete
Smooth sides (rad)	The system should have smooth angles (no sharp edges/points) to secure the safety of the user (s)
Ordered Parts	The team has a maximum period of ordering parts, 14 days as a tolerance and 7 days is the team's target.
Store energy (w)	The system should generate and store electrical energy
Battery life (hrs)	The system should be working for at least 2 hrs as target.
Multiple speeds	The system should have at least three different speed settings (for example: low, medium, high)
Steering options	The system should incorporate a new steering option instead of a regular steering wheel

OSHA standards	The system should meets OSHA's standards to ensure the safety of the child

2.3 testing Procedures (TPs)

Testing procedures (TPs) focus on how attributes help cover the range of engineering requirements. Not every engineering requirement has a testing procedure. The table below (Table 4) links each engineering requirement with a description of how it will be tested.

Table 4: Testing Procedures (TPs)

Engineering Requirements	Description for testing procedures
Weight (lb)	The combined weight of the device consists of the weight of each material that will be used. As such, each material will be weighed in order to consider whether it exceeds the target/tolerance
Smooth sides (rad)	Checking the goods that the team intends to purchase for the project beforehand to ensure that there are no sharp edges/points
Store energy (w)	This will be considered throughout the design process. The system is having a store energy battery
Battery life	The hoover board has an estimated time, but with the body added to it, the weight has increased which takes more energy, so the testing procedure will be taking the time while having it charged.

2.4 Design Links (DLs)

Design links introduce how each engineering requirement will be satisfied through the construction of the proposed design. Every engineering requirement has a design link. Below is a table of each engineering requirement listed alongside its respective design link (Table 5).

Table 5: Design Links (DLs)

Engineering Requirements	Description for design link
Weight (lb)	The final design meets the weight target with the help of predictions based on the research. The weight will be within a tolerance of 55 lb.
Price/cost ($)	The final solution budget was maintained. The cost was $350.
Smooth edges (rad)	The design has smooth angles which ensures the safety of the child and achieves the target of having curved edges.
Ordered Parts	The team has a maximum period of ordering parts, 14 days as a tolerance and 7 days is the team's target.so far none of the ordered parts exceeded 8 days.

Store energy (w)	The design stores energy with the use of a battery. The battery cannot be charged whilst the car is driven. The team has covered this ER but the target has not yet been reached.
Multiple speeds	The final system has no speed option which is better than the team's target - it accelerates from zero to the maximum speed and rests on whatever speed the child is comfortable driving.
Steering options	The final design incorporates a pad through which steering can be controlled.
Battery life (hrs)	the testing procedure will be taking the time while having it charged. Then we will be satisfying that by double checking the time life of the battery by taking the time from fully charged to empty battery.

2.5 House of Quality (HOQ)

The current house of quality (HOQ) is a diagram which helps in determining how the customer needs are being valued and weighted with regards to the product.

Table 6: HOQ

Customer Requirement	Weight	Engineering Requirement	Weight << (60 lb)	Price/cost << (400$)	smooth edges >> (no 90° angle)	Ordered parts << (no more 14 days)	Store energy >>	Battery life >> (2 hrs)	Multiple speeds >> (2 speeds)	steering options >> 2 ways	OSHA Standards >>
1. Power system											
a. Control acceleration	5		9	5	0	0	9	0	9	9	9
b. brakes	5		5	0	5	5	5	0	9	5	9
2. Physical											
a.Comfortable seats	5		1	5	9	5	0	0	0	0	9
b. trunk mobility	4		9	0	0	0	0	0	0	0	0
c. legs support	3		0	9	9	0	0	0	0	5	9
3. Operating system											
a. easy to operate	5		0	0	5	1	0	0	9	9	9
4. Financial	5		0	9	0	0	9	8	0	0	0
5. Safety											
a. Seatbelt harness	5		0	0	0	0	0	0	0	0	9
b. bars	3		9	5	9	0	0	0	0	0	9
Units			lb	$	rad	N/A	W	hrs	m/s	N/A	N/A
Target			45lb	380$	90	no	1.5 hrs	2 hrs	3	2	N/A
Tolerance			55 lb	390$	80	less	1.25 hrs	1.5 rs	2	1	N/A
Testing Procedure (TP#)			5	4	1	4	5	5	5	5	N/A
Design Link (DL#)			5	1	8	7	6	4	2	3	N/A

3. EXISTING DESIGNS

There are many existing designs for GBG created out of similar ideas of a wheel chair, toys, and mobility games. Three different ideas caught the group's attention: the scoot, the current GBG retrofit (electric car), and the scooter. These products have some disadvantages that need to be fixed or improved. The team will start to think briefly in order to create a new idea for mobility that could meet the client's needs. The existing design element of this project is important for the team and will be helpful for the future of this project.

3.1. Design Research

On November 2015, the GBG organization was created. This organization takes care of children with special needs by helping them to live as normal a life as possible through the construction of mobility devices that they can use to play [6]. Children with special needs are part of the community so the GBG program assists them in achieving their dreams and playing for fun. The organization faces some difficulties with regards to the designing of GBG devices because every single child has a particular profile of need(s). Consequently, this team will be facing similar challenges too.

Research has shown that most of the ideas are similar to each other and most of them are also expensive to build. The group has a limited budget so the research did not look at those ideas which had proven to be too expensive. Most of the research was done through the use of online websites, and the team benefitted from the generation of a lot of ideas due to the undertaking of the ME286 class at the Northern Arizona University (NAU). Other universities also have GBG programs, and it would seem that schools are competing with one another in the creation of a new design that can be useful for children. However, almost all universities do not have a unique GBG design - most designs generated at schools are similar to a modified toy car.

3.2. System Level

The GBG project requires a main system of mobility to transport a child from point A to point B. The current systems mainly depend on using a retrofit with tires to transport the child. The main system level will be dependent on the customer requirements and on how it relates to the requirements. Accordingly, there are many different systems that were used for each retrofit. For example, wheelchairs rely on human energy in order to move a patient from point A to point B.

The three main system designs which will be discussed are the following:

1) Scoot
2) Current GBG retrofit (electric car)
3) Scooter

1. Existing Design 1: Scoot

The scoot is a current main system that is used for both normal and disabled children to transport them from a point to another. This system can be used in three different ways – the first method is that it can be used by crawling. Crawling will help the child in exploring and strengthening the upper body muscles such as the abdominal area [2]. The second way to use this system is by scooting. Scooting allows the child to move while sitting up straight and using their legs. This will help the child move more freely to explore outer surroundings. The final way to use this device is by riding it. The device allows the parent to add a tire on each side which will make the device act like a wheelchair. This system depends completely on human energy since there are no electrical components involved and the user has to move physically by himself or herself to maneuver it.

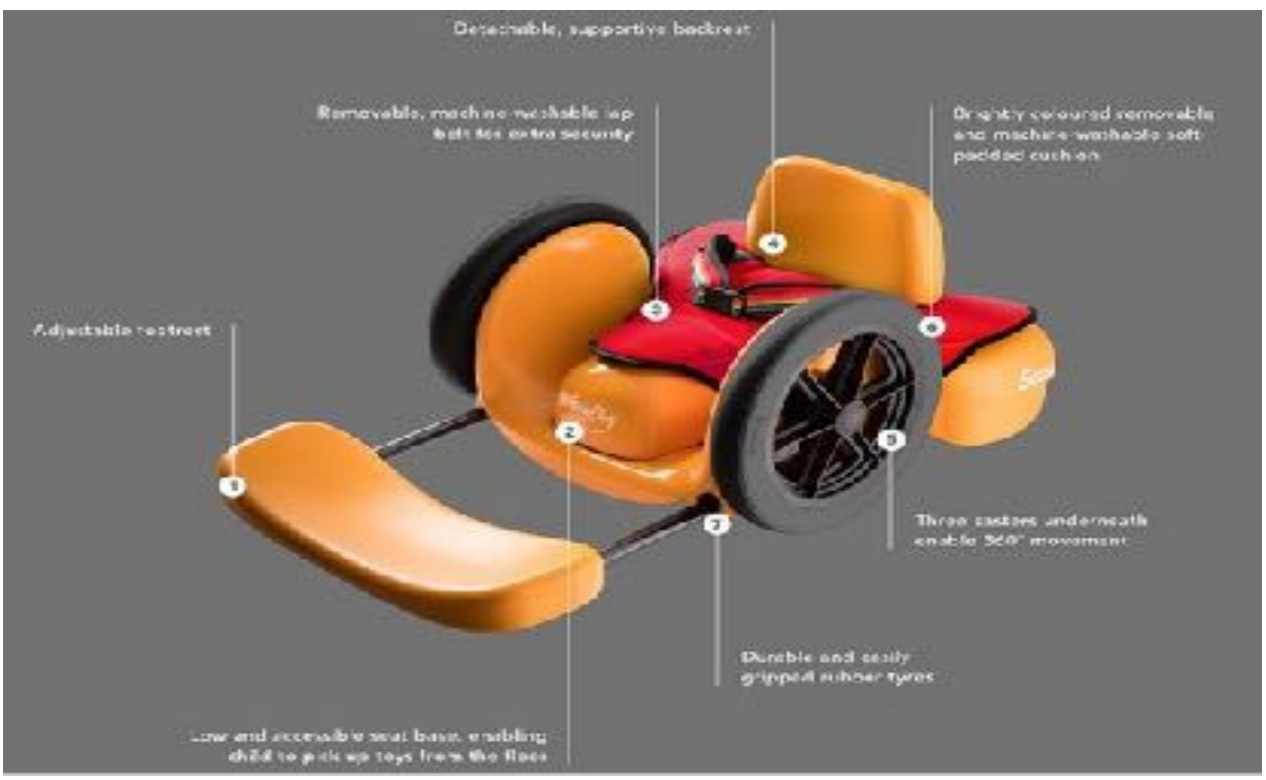


Figure 1: Scoot [2]

2. Existing Design 2: Current GBG Retrofit (Electric Car)

The current design for the GBG project is a great system for use by disabled children to socialize and transport themselves freely and independently. Current GBG retrofits are based on electric toy cars that are modified based on each requirement [1]. The cars are cost-effective and do not cost much compared to medical solutions that cost much more than the GBG retrofits. This current system relies on electrical power that is controlled by the child in order to accelerate and decelerate. The present solution mostly does not control acceleration – it is only adjusted to one speed. Each retrofit is designed differently depending on the disability of the child.

Figure 2: Current GoBabyGo Retrofit [1]

3. Existing Design 3: Scooter

The final existing system that is used is the toy scooter. The chosen system is a three-wheeler retrofit that depends on human energy in order to move [3]. This device is mainly used to transport the child from one point to another using the three wheels attached. Additionally, there is a stick which allows the parent to control the movement of the child with regards to the direction of the scooter. This will give the parents more control over the child in terms of their movement and will therefore not be able to meet the requirements of most disabled children.

Figure 3: Scooter[3]

3. *Subsystem Level*

Any machine or mechanical design must contain a support system for main system mobility – for example, controlling parts and energies. For this GBG project the team will follow the sponsor's requirement with regards to the design in order to help able-bodied and disabled children. During the research stage, there were three main categories of subsystems that the team explored: human power, electrical power, and main control system

3.1. Subsystem 1: Human Power

Human power represents energy that is transferred from the human body to power a machine into operating. This may involve using one's arms and legs [4].

3.1.1. Existing Design 1: Arms

As shown below in Figure 4, arms are the source of human power of the scoot's main subsystem. It works when a disabled child pushes and rolls the scoot's wheels in order to move from one place to another.

Figure 4: Scoot Wheels [2]

3.1.2 *Existing Design 2: Legs*

Legs are the most efficient power source for many transport machines, such as a scooter. In the scooter's existing design, we can see that children have the ability to move the scooter by pushing the pedals.

Figure 5: Scooter Pedals[3]

3.1.3. Existing Design 3: Human muscles

Human muscles is another source of human power. For example, children's that do not have arms and legs they can use the shoulder muscles as a human power body part. Moving the muscles sideways and the design will move is one of the human body powers.

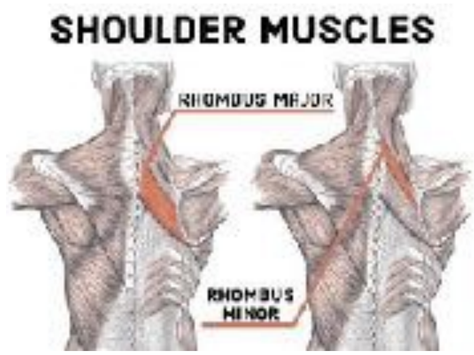


Figure 6: Shoulder Muscles [7]

2. Subsystem 2: Electrical Power

Electricity has been used in everyday human life consistently because it is a strong source for machines. There are two existing designs which showcase the usages of electrical power – this report will now outline two of those: batteries and electric motors.

2.1. *Existing Design 1: Battery*

Batteries are good sources of energy. They have chemical energy contained within the case which can be converted into electrical energy. Some batteries can be recharged as well.

Figure 7: Batteries [8]

2.2. *Existing Design 2: Electric Motor*

Using an electric motor as a subsystem converts electricity into mechanical energy. Therefore, this piece of machinery will help with the GBG future design.

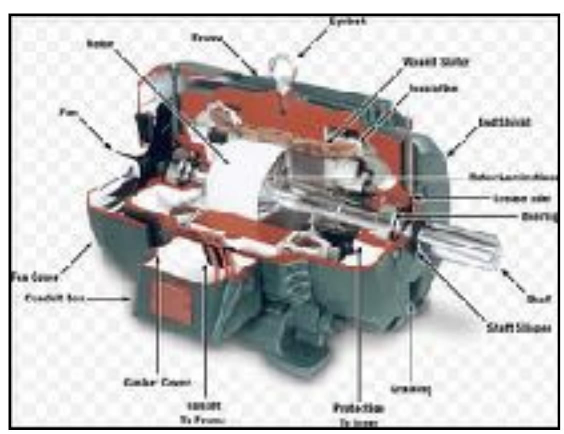


Figure 8: Electric Motor [9]

3.3.2.3 Existing Design 3: Solar Panel System

The solar panel system works by collecting photons from the sun, then release electrons from the solar panel to the wires or any electrical device to run the machine.

Figure 9: Solar Panel System [10]

3. Subsystem 3: Main Control System

Every device should have a spatial control system – in cars, this allows the rider to control the vehicle and display its duration. For this subsystem, a steering wheel and pressure pads have been deemed to be the most effective for the purposes of the GBG project.

3.1. Existing Design 1: Steering Wheel

Most vehicles have a steering wheel to control it, and the team might use this control system for the car.

Figure 10: Steering Wheel [11]

3.2. Existing Design 2: Pressure Pads

Self-balancing scooters have become very popular today. They operate according to a clever idea – the pressure pads are fixed around the scooter. They work by having many small systems implemented under the pads, so that human balance and nerves from the body control how the scooter operates – to move, stop, steer and

Figure11: Pressure Pads [14]

rotate [5]. The team is interested in using this notion by designing a hand pressure pad instead of self- balancing pressure pads which require the use of the legs. These hand pads will help children who suffer from disabilities involving their legs so that they can control the car by using their hands instead.

3.3.3.3 Existing Design 3: Joystick

Joystick control system have been used for video games, but in our case using a joystick as a control system for the car designs. By select any button on he joystick the car will start work and by moving it the car will move for the directions the person choose.

Figure 12: Joystick [12]

4. DESIGNS CONSIDERED

The hypothesized functional model is an important aspect of this report because it is what challenges one to know and understand the way the project works and functions. As for the material, energy, and signals used in the device that has been created, it tells you clearly what is inside your project, how it works, and what comes out of it. Creating the functional model has given our team the ability to understand how to work the device and how it will operate without the use of some sources of the device. Engineers are supposed to know how to reverse engineer their projects. The models clearly give us a true understanding in determining the inputs, outputs, and the sub functions of the project itself. The team learned exactly how to deal with the pressure pad and the signals that move it. In reverse engineering, one needs to know the ins and outs of the signals themselves in order to have a better understanding of the project. The group also learned that if in any case the project becomes expensive, there are parts that can be reduced to lower the cost. A functional model has taught us a lot about how to take care of the different elements of the project.

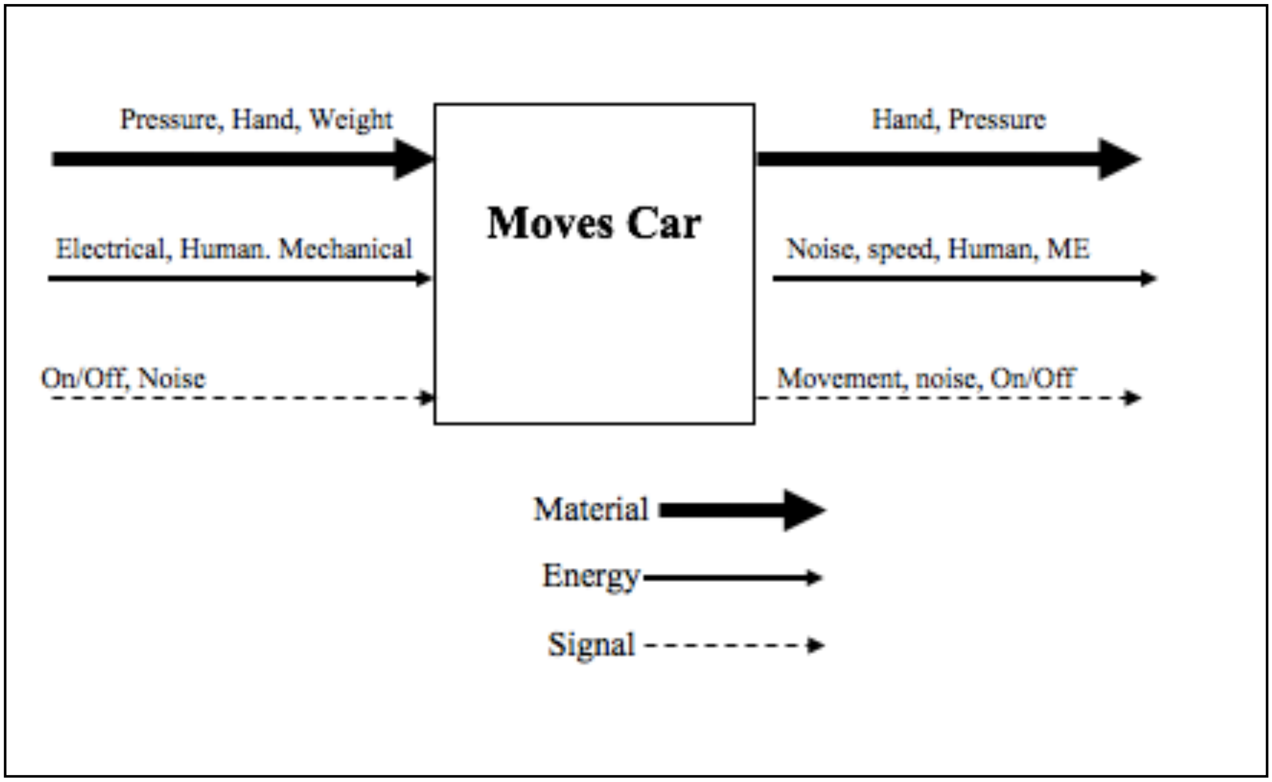


Figure 13: Black Box Model

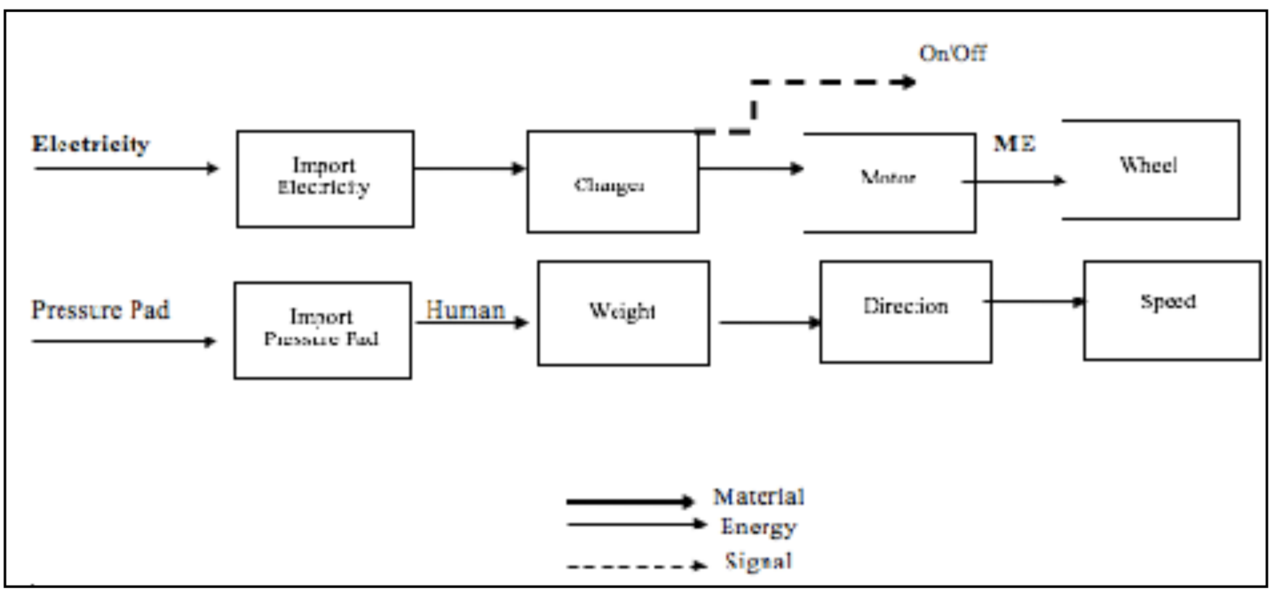


Figure 14: Functional Model

4.1. *Design 1: Suspension Seat*

In this design there is a screen control system, back support attached to the seat with safety bars, and between the seat and the tires there is an attached suspension system.

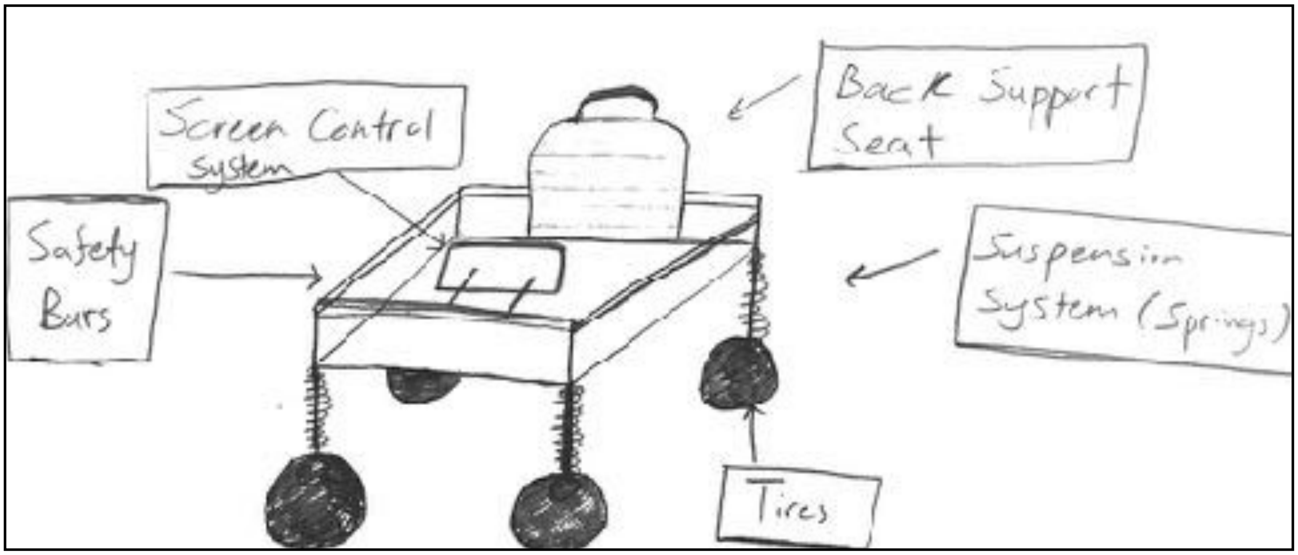


Figure 15: Suspension seat

Table 7: Design 1 Adv. and Disadv.

Advantages	Disadvantages
No jerking motion due to suspension system	The height of the seat might not be pleasing to the child due to it not touching the ground
Safety bars	

4.2. Design 2: Hover-board Bed

This design is inspired by the self-balancing hover-board pads system. There are additional tires attached to the gear chain system. When the tires on the self-balancing hover-board pads rotate, the actual tires also rotate.

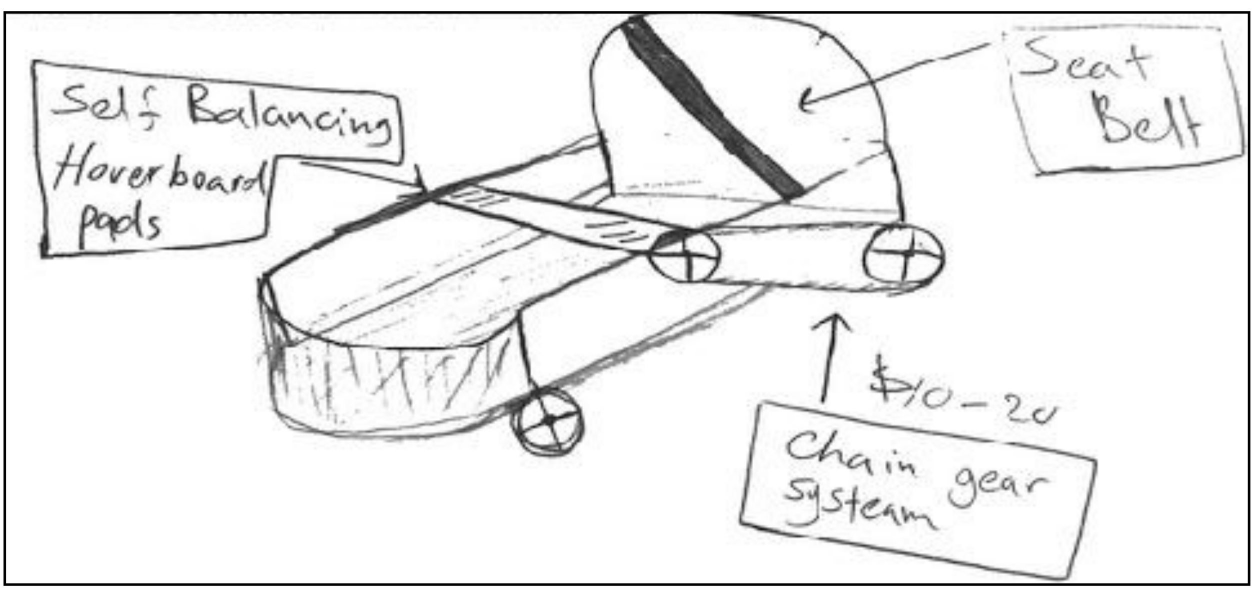


Figure 16: hover-board bed

Table 8: Design 2 Adv. and Disadv.

Advantages	Disadvantages
The seat belt offers extra safety to the child	The gear chain may dislocate
The car's low height means the child can ride with more ease and comfort	

4.3. Design 3: Monitor Scooter

The design is based on a normal scooter design with some changes. Instead of a scooter steering wheel, the team decided to add a monitor touch screen system. Another change added is a comfortable seat with a seatbelt harness.

Table 9: Design 3 Adv. and Disadv.

Advantages	Disadvantages
The touch screen means it is easy to control	The weight of the user may impact the balance of the chair
Safety can be extended by installing a seatbelt	

Figure 17: Monitor scooter

4.4. Design 4: Electric Scoot

This a scoot design that has been designed to minimize physical use. Instead, the team added a hand pressure pads control system to make it an electric scoot.

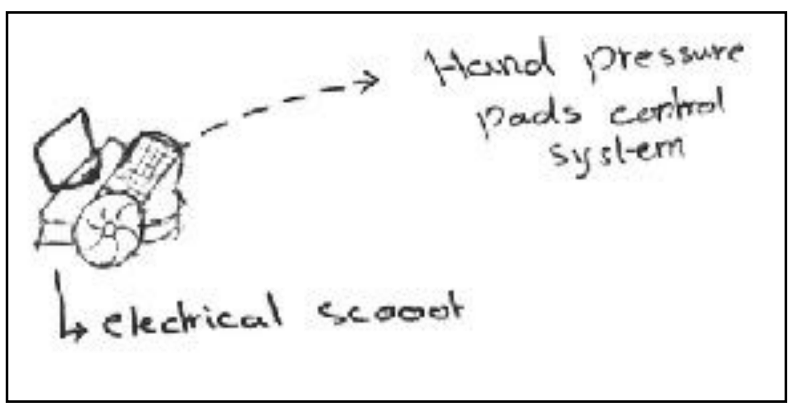


Figure 18: Electric scoot

Table 10: Design 4 Adv. and Disadv.

Advantages	Disadvantages
Comfortable seat	The device may be too low/close to the ground
The child can feel the ground	

4.5. Design 5: Hydraulic Baby Walker

This CV has a hydraulic system so that the child has the choice to move freely and the baby walker also has a control panel system.

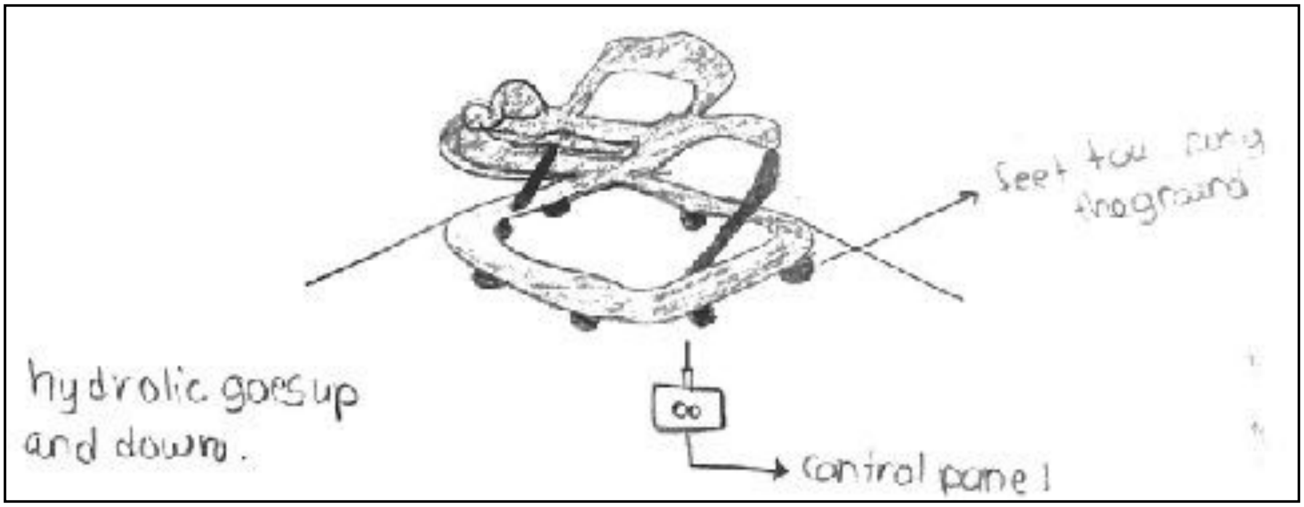


Figure 19: Hydraulic baby walker

Table 11: Design 5 Adv. and Disadv.

Advantages	Disadvantages
Due the to the hydraulic system, the child will be able to feel and move freely	There are not enough safety features, therefore, the parent/guardian will need to monitor use

4.6. Design 6: Baby Walker

This design is based on a normal baby walker but the team chose to add an engine which can be controlled via a control panel.

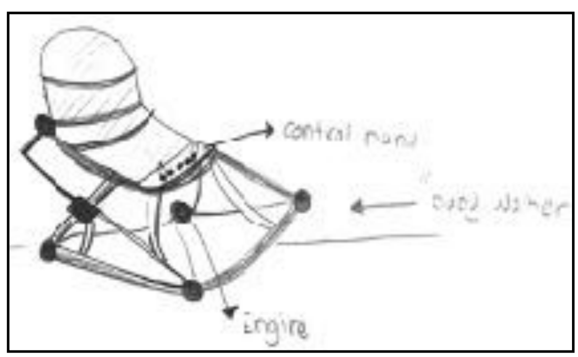


Figure 20: Baby walker

Table 12: Design 6 Adv. and Disadv.

Advantages	Disadvantages
The child has the ability to control the baby walker	The engine is underneath the child, but it is not enclosed in a safety box which is hazardous

4.7 Design 7: Speed and Direction Controller

This design has a speed and direction controller system which requires the use of the feet. Therefore, the steering wheel is simply an aesthetic and of no use. Also, the design has both automatic and remote control brakes.

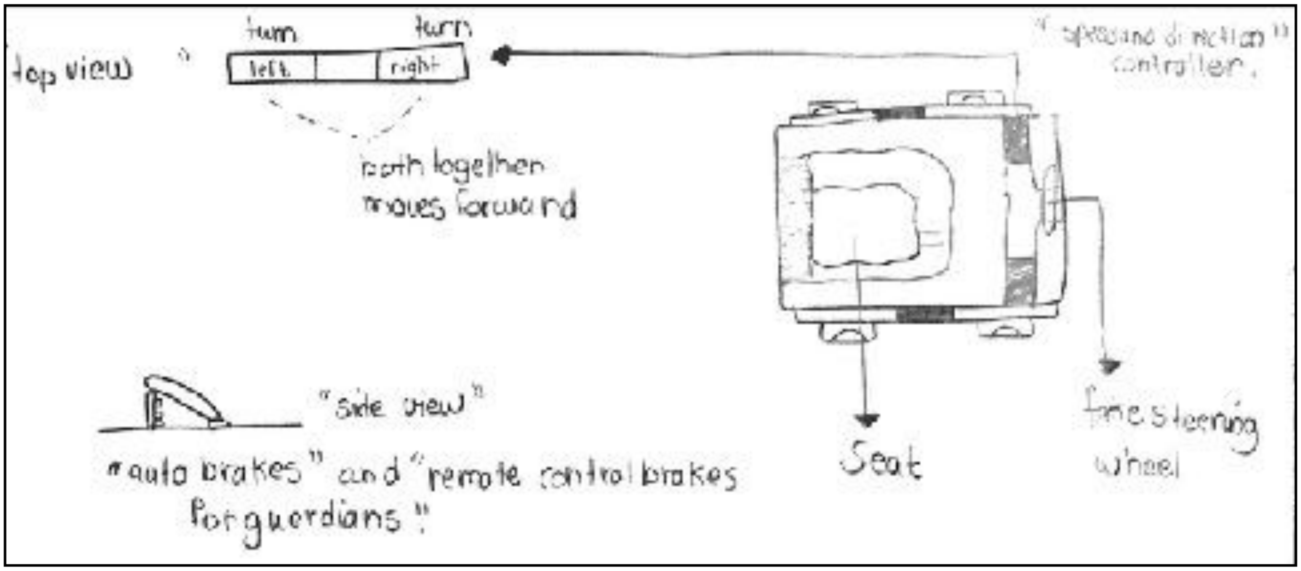


Figure 21: Speed and direction controller

Table 13: Design 7 Adv. and Disadv.

Advantages	Disadvantages
Comfortable seat	Since it is operated using the feet, the foot brake can be distracting.
Remote controlled brakes for parent/guardian	

4.8 Design 8: Superman Bed

The idea of this design is inspired by a hospital bed. The child can lay down on their stomach and use the controlled steering wheel which is attached to the engine to direct him/herself.

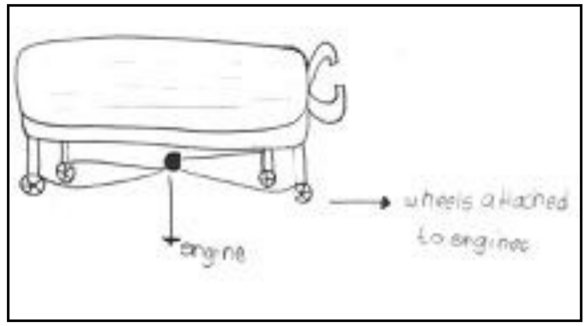


Figure 22: Superman Bed

Table 14: Design 8 Adv. and Disadv.

Advantages	Disadvantages
Very comfortable operating position for the child laying down	The bed may be too big to control

4.9 Design 9: Pumping Ball

This ball design can be used over water and grass. There is an oxygen motor for the user to breath into and it is through this that air is pumped into the ball.

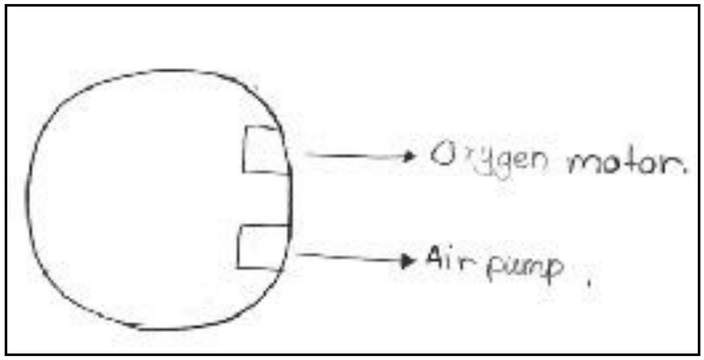


Figure 23: Pumping ball

Table 15: Design 9 Adv. and Disadv.

Advantages	Disadvantages
It is quite physical to operate which can improve the child's fitness over time	The ball may break easily
Easy to use in a swimming pool	

4.10 Design 10: Scooter

For this scooter design, a comfortable seat with a harnessing seatbelt and a scooter steering wheel have been included. This design has three wheels for additional stability.

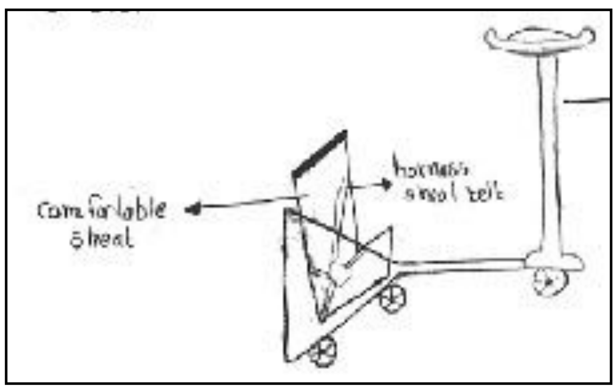


Figure 24: Scooter

Table 16: Design 10 Adv. and Disadv.

Advantages	Disadvantages
Comfortable seat	The steering wheel may be too high to reach
Not dangerous to use	

5 DESIGN SELECTED

There were 10 main designs that the team created according to the black box model and the functional model. Each design had some advantages and disadvantages These advantages and disadvantages were listed below each design in a table form. The advantages and disadvantages gave the team a brief idea on how each design will perform if it was built in real life. The provided tables of advantages/disadvantages were not enough to choose the final design for the project and the team needed a better method to choose the final design of the project.

5.8 Rationale for Design Selection

In order to ease the selection of the final design and to make sure that the best design was chosen the team followed a certain rationale for design selection. The design selection part consisted of two main sections which were Pugh chart and decision matrix. In the Pugh chart the team listed all 10 different conceptual designs in a table and started grading them using specific criteria. After that, the team chose the top 4 scores from the Pugh chart and used them in the decision matrix table to finalize the decision.

5.8.1 Pugh Chart

The team has created a total of twenty concepts in order to finalize the design of the project. The concepts were created based on different customers such as able-bodied children and children with disabilities. The team then chose the top ten designs in order to compare them using the Pugh chart below. The Pugh chart allows one to make a comparison depending on the criteria listed below, where all the designs were compared to the CV9 design. CV9 was chosen since the design was an out-of-the-box design and the lowest in meeting the Pugh chart criteria. The chart below will display the most creative designs in order of having the most advantages. The winning designs in the Pugh chart were CV's 2; 4; 5. The winning designs later moved to be compared in the decision matrix in order to choose the final design.

Criteria

a. All material and construction costs must be under $1500

b. Development risk (will it work? What are the chances it won't?)

c. Technical difficulty (does the team have the skills/resources to create the CV?)

d. Schedule risk (will the team be able to finish the device by the due date?)

e. Does it meet the customer requirements?

f. Does it have jerking motion?

g. Is it accurate?

h. Is it made of standard components?

Table 17: Pugh Chart

Concepts	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
a	+	+	+	+	+	+	--	+		+
b	--	S	--	--	+	--	--	--	**D**	--
c	--	+	--	--	+	+	--	+		+
d	S	S	S	S	S	S	S	S	**A**	S
e	+	+	+	+	+	+	S	--		S
f	+	+	--	+	S	S	+	S	**T**	+
g	+	+	+	+	+	--	+	--		--
h	--	+	+	+	+	+	+	+	**U**	--
Σ +	4	6	4	5	6	4	3	3		3
Σ--	3	0	3	2	0	2	3	3	**M**	3
ΣS	1	2	1	1	2	2	2	2		2

5.8.2 Decision Matrix

After considering the three designs from the Pugh chart - CV 2; 4; 5 - the team used the decision matrix (Table 18) with the same criteria that was used in the Pugh chart. The criteria weight has to total a sum of one, therefore, the team allocated a ranking for each criterion per design according to the most important to the least important scale. After weighting according to the criteria, the team considered a raw weight out of 100 for each CV with each criterion. Then, the teams used the weight criteria and multiplied it by the raw weight to achieve the final weight of each CV. Finally, by summing up the final weight, the team arrived at the total weight for each CV, and ranked each CV, beginning with the highest total weight. The final design that the team will go ahead with is CV4 (the electrical scoot).

Table 18: Decision Matrix

Designs		CV2		CV4		CV5	
Criteria Weight							
All cost must be under $1500	0.1	80	8	85	8.5	40	4
Development risk	0.2	80	16	90	18	40	8
Technical difficulty	0.25	80	20	80	20	60	15
Schedule risk	0.15	90	13.5	100	15	75	11.25
Does it meet the customer requirements?	0.1	85	8.5	85	8.5	70	7
Does it have jerking motion?	0.05	100	5	100	5	80	4
Is it accurate?	0.1	70	7	75	7.5	30	3
Is it made of standard components?	0.05	85	4.25	85	4.25	100	5
Total Weight	1		82.25		86.75		57.25
Relative Rank			2		1		3

5.9 Design Description

It is important for every new project to have a parts research on what the project might face during the manufacturing process. Every component in the project has its difficulties therefore, each team member contributed on an individual research on specific analysis. The analyses were the following:

1- Hover-board analysis
2- Weight analysis
3- Budget analysis
4- Website analysis
5- Material analysis.

5.9.1 Hover-board Analysis

5.9.1.1 Introduction

Since its introduction, the hover-board has demonstrated widespread popularity across the country and globe in equal measure. The hover-board is also known as a two-wheeled and self-balancing scooter. Over the last few years, the production of hover-boards has skyrocketed following a massive consumer demand for the technology, especially in 2015. However, mass production has led to poor production of some hover-board brands. As a result, the popularity of the technology took a hit as several incidents of fire were reported across the globe.

5.9.1.2 Problem statement

Hover-boards have been catching fire all over the country and indeed around the world. This has led to the issuance of several bans across numerous countries and states. Apart from the UK, several states in the U.S have issued regulations to ban the production, sale, and use of hover-boards in a public area [14]. The bans are as a result of safety concerns from hover-board fires as well as several injuries associated with the technology. While a hover-board is a two-wheeled and self- balancing device, the safety and balance of the rider is not guaranteed.

These fires have been associated with complications as a result of Lithium-ion batteries. The batteries are made of a flammable electrolyte and very slim covers. While hover-boards are safely designed, the complications as a result of Lithium–ion batteries render them unsafe for use. However, it is imperative to note that the way the batteries are used and packed in the hover-board is also a source of the problem. The main reason for hover-board fires is due to the fact that the batteries used are more powerful as compared to those used in laptops and smart phones. Additionally, some of the batteries are of poor quality.

This project will attempt to address the current issue of hover-board fires by assuming a novel design that regulates the power consumption of the technology. Also, several design modifications will be made to the type of power source used for the hover-board design.

5.9.1.3 Components

A hover-board, a two-wheeled, auto-balancing scooter, is made up of several different components: steel or aluminum frame with a central pivot, two wheels, a logic board, two gyroscopes, a lithium-ion battery pack, a motor, pressure pads, infrared sensors, a charger and a plastic shell. Additional accessories may include a remote control, Bluetooth, and LED lights. The logic board is used to regulate the speed of the hover-board. It is also used to control the tilt of each wheel.

The hover-board technology employs the use of a self-balancing steering system that is the same as a Segway unit. The pressure sensors configured on the technology are used to control the board. It is controlled through pressure sensing switch pads which are situated under the foot deck of the board. When the pressure pads are pressed backward or forward, they compress the switches beneath them thus blocking light from reaching a light sensor. An internal LED is used to generate light used in the pressure sensors. The board continues to remain immobile as long as the light is hitting the detector. The logic board is used to activate the matching motor to rotate in a specific direction when a section of the light is obscured from reaching a sensor.

5.9.1.4 Control logic

The operator can employ the use of this logic to control the speed of the board by shifting the amount of pressure in each foot pad. Additionally, the user can employ the use of the same logic to regulate the direction of movement through the use of opposite foot motion. The logic board plays a significant function in the operation and design of the board. It is responsible for the control of tilt and compression variables. These variables allow the user to utilize the logic board to change the direction and speed of the hover-board [14]. Alterations of the tilt variable are used to control the direction of the two-wheeled, auto-balancing scooter, while the alterations of the compression variable are used to regulate or alter the direction of the hover-board.

5.9.1.5 Lithium Ion Battery

A hover-board employs the use of a lithium-ion battery pack as the main source of power. The lithium-ion battery pack is made up of a collection of individual lithium-ion cells. The battery pack used in hover-boards is rated for 36 V and has several thousand mAH capacities. The technology requires a lot of power since it is used for movement. Lithium-ion batteries are basically used for energy storage. It is used to transform chemical energy into electrical energy through a chemical reaction. Lithium ions move from the anode to the cathode through an electrolyte during the discharge phase. On the other hand, the opposite process occurs during the charging phase of the battery. Lithium ions move from the cathode, through an electrolyte, to the electrode. This process converts the chemical energy stored in the battery to electrical energy, which is used to power the hover-board.

This design will employ the use a fuse to prevent the over-current discharge or overcharging of the lithium-ion battery. Apart from a fuse, the design will employ the use of a cut-off switch to regulate the amount of current drawn from the lithium–ion battery. A cut-off switch or a fuse plays a significant role in regulating the rate and level of charging as well as the amount of current drawn from the battery pack. As a consequence, it addresses the current issue with hover-boards by preventing unwanted and explosive chemical reactions within the battery. It is imperative to also note that faults with the hover-boards can be attributed to the damages within the battery cells and the insulating material inside the battery which can result in internal shorting, thus leading to a fire.

There are several standards and tests that can be used to assess the design and aptitude of a battery to sustain normal operations and various types of misuse [13]. Customers and users of hover-boards can identify whether a product has attained the applicable regulations and rules through the use of the CE marks or statewide acknowledged testing lab mark. The standards for lithium-ion battery, UL 142, demands charge-discharge cycle testing, in addition to impact, shock and crash tests.

5.9.1.6 Equations for calculations and assumptions

To address the problem associated with the hover-board fires and explosions, it is imperative to analyze the amount of power stored or that can be drawn from the battery without causing overcharging or overheating. Additionally, it is crucial to determine the duration that the batteries used in the hover-board should be charged.

The discharge time of a lithium-ion battery is the mAh or the Ah rate divided by the current drawn by the hover-board [13].

Discharge time = current capacity of the lithium / load current

For instance, if the electrical components of the hover-board draw a load current of 300 mA and the lithium-ion battery is rated 2200 mAh, then the discharge time of the battery can be determined by the quotient of the two current ratings as follows:

- Discharge time = 2.2/0.3 = 7.3 hours.

On the other hand, the time taken to charge the lithium–ion battery depends on the charge current and the battery chemistry. The duration of charging is determined by the quotient of the battery rating and the applied current. That is:

- Charging duration = battery current rating/ the applied current

The equation used in determining the charging duration assumes that charge is 100 percent efficient. However, the lithium–ion batteries used in hover-boards are not ideal batteries. As a consequence, the equation is used to determine an estimate of the actual charging time. It is significant that it is necessary to keep the charging duration of the battery within the determined range so as to prevent overcharging the cell [13]. This equation plays a significant role in preventing fire and explosions associated with overcharging lithium-ion batteries sued in hover-boards.

Additionally, it is worth noting that lithium-ion batteries have almost 100 percent charge efficiency, however, energy charge efficiency relies on the charge rate. In most cases, higher charge rates are associated with lower efficiencies due to increases in resistive losses towards the end of the battery charging phase.

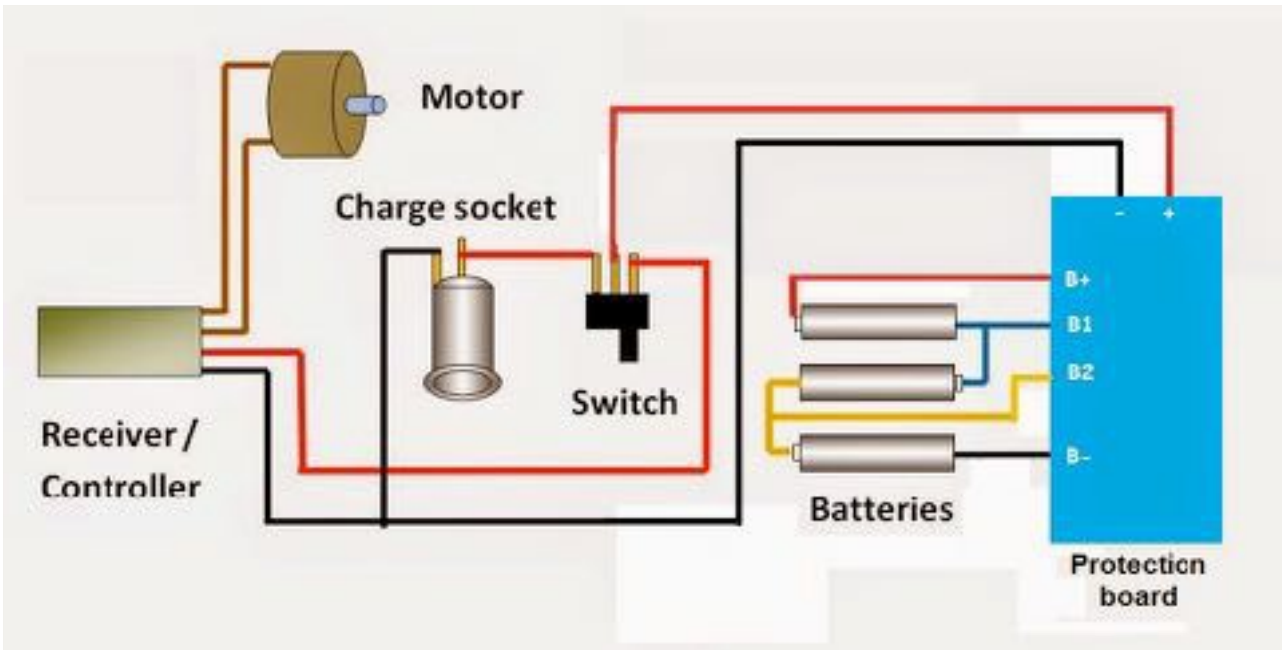
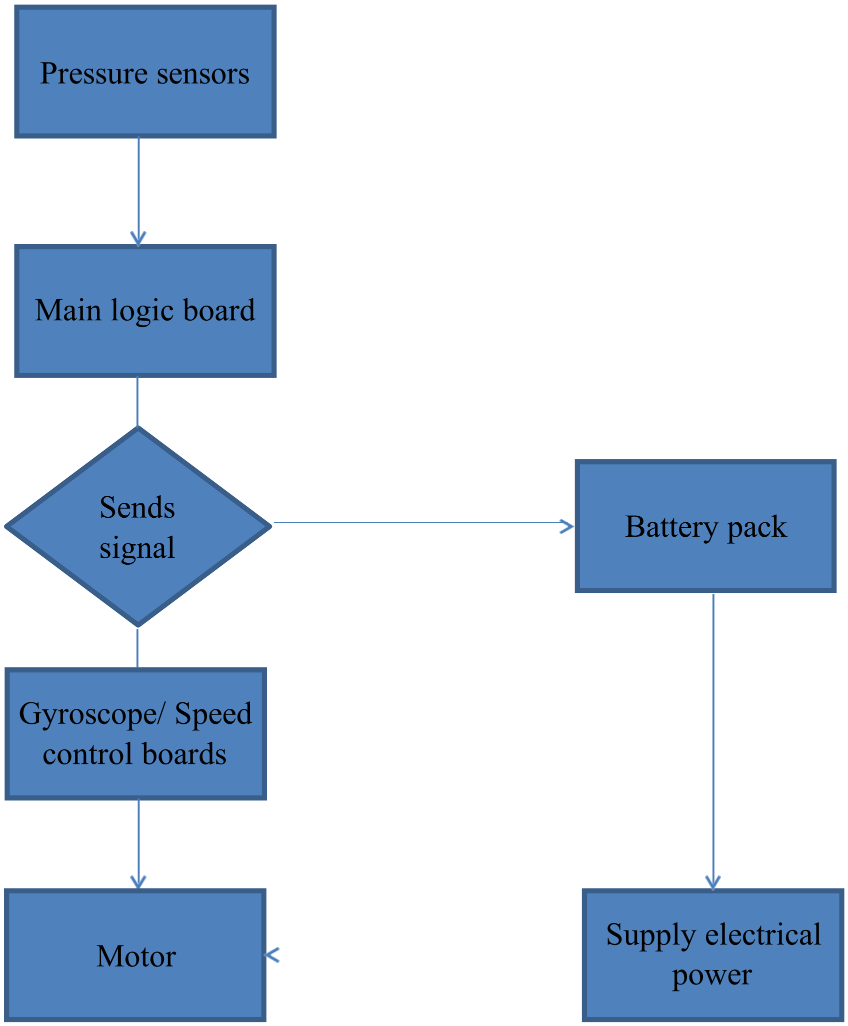


Figure 24: A diagram for balanced charging system for a hover-board [13]

5.9.1.7 Lithium-ion operating temperature

The performance of the hover-board and any other electrical device that uses the lithium-ion battery is affected by the operating temperature of the battery. It is crucial to point out that the working temperature of a lithium-ion battery is a significant factor that affects the performance of the hover-board. The battery temperature of lithium-ion varies during discharging and charging processes [14]. These variations in temperature call for analysis of the battery heat production rate. The rate of heat generation in lithium–ion batteries is affected by numerous factors such as; the battery aging effect, the operation current, temperature, and the state of charge. The produced heat during charging and recharging is made up of reaction heat and Joule heat.

Flowchart



5.9.1.8 Details of physical modeling

There are several components that will be used for physical modeling of the hover-board project. A hover-board, a two-wheeled, auto-balancing scooter, is made up of several different components: steel or aluminum frame with a central pivot, two wheels, a logic board, two gyroscopes, a lithium-ion battery pack, a motor, pressure pads, infrared sensors, a charger, and a plastic shell. Additional accessories may include a remote control, Bluetooth and LED lights. The logic board is used to regulate the speed of the hover-board. It is also used to control the tilt of each wheel.

The motor is the actuator which is used to convert the electrical signal from the battery to a mechanical motion, thus driving the hover-board. The most significant factor to consider is the power of the motor. It is imperative to select a motor with at least 300 watts in order to provide sufficient mechanical energy to drive heavy loads [15]. The motor will be connected directly to the wheel to provide a drive train. It is this direct connection between the motor and the wheels that allows the hover-board a rapid response.

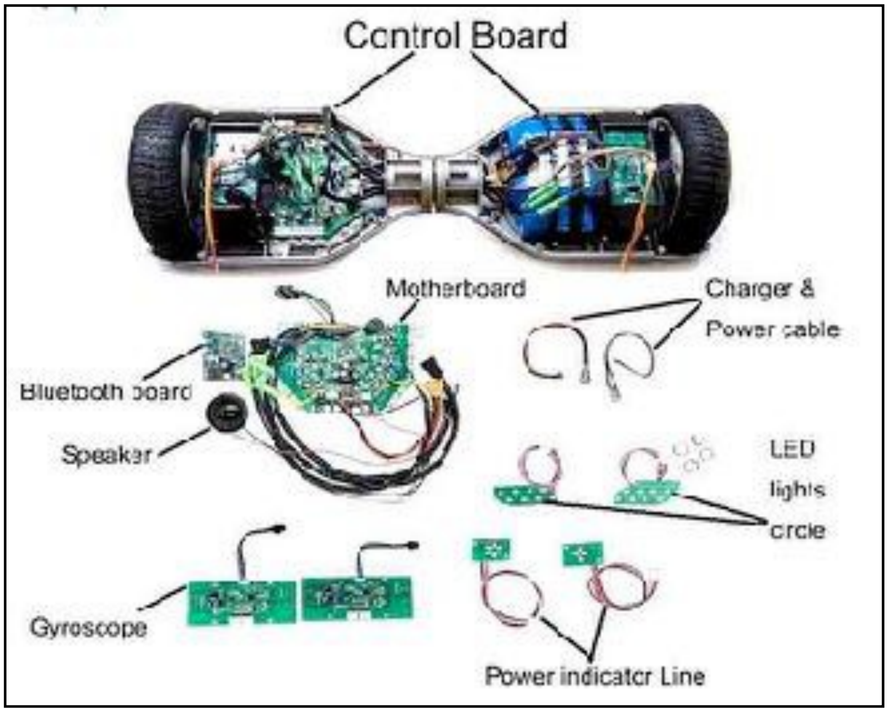


Figure 25: Physical component of a hover-board [16]

5.9.1.9 Conclusion

Hover-boards offer an alternative source of light and short distance transport. As compared to other types of scooters, it is a simple and light design that provides numerous benefits to users. However, it is imperative to minimize power consumption by utilizing energy efficient components such as motors and sensors, so as to mitigate potential overcharging of the battery.

5.2.2 Weight Analysis

5.2.2.1 Introduction

The GBG project is a project that focuses and aims on children with disabilities and limited movement. This project will help children with limitations in movement to move freely and will ease the process of moving and living normally. Team 9 in the GBG project has designed some different concepts that involved more than twenty designs in order to find the best suitable design to fit the needs of the customer. The final solution that the team came up with was a creative design that used a hover-board in order to move the user from one point to another. This analytical report will mainly concentrate on the weight analysis of the device. Different perspectives of the weight analysis will be covered such as the average weight of the child, and a comparison between the minimum and maximum weights of users to operate the sensors of the hover-board.

5.2.2.2 Average Weight of Child

Since the design of the GBG project will be used by non-disabled children and children with disabilities, the average weight of normal children will be compared in order to cover the analysis. The project is mainly focused on children with disabilities but the project might still be used by normal children. The research is mainly focusing on children from the age of 2–12 years old. Table 19 below shows the average weight of normal children from the age of 2–12 years old for both females and males.

Table 19: Average Weight of Children [18]

Female Children			Male Children		
Age	Weight	Height	Age	Weight	Height
2 yrs	26.5 lb (12.0 kg)	33.7" (85.5 cm)	2 yrs	27.5 lb (12.5 kg)	34.2" (86.8 cm)
3 yrs	31.5 lb (14.2 kg)	37.0" (94 cm)	3 yrs	31.0 lb (14.0 kg)	37.5" (95.2 cm)
4 yrs	34.0 lb (15.4 kg)	39.5" (100.3 cm)	4 yrs	36.0 lb (16.3 kg)	40.3" (102.3 cm)
5 yrs	39.5 lb (17.9 kg)	42.5" (107.9 cm)	5 yrs	40.5 lb (18.4 kg)	43.0" (109.2 cm)
6 yrs	44.0 lb (19.9 kg)	45.5" (115.5 cm)	6 yrs	45.5 lb (20.6 kg)	45.5" (115.5 cm)
7 yrs	49.5 lb (22.4 kg)	47.7" (121.1 cm)	7 yrs	50.5 lb (22.9 kg)	48.0" (121.9 cm)
8 yrs	57.0 lb (25.8 kg)	50.5" (128.2 cm)	8 yrs	56.5 lb (25.6 kg)	50.4" (128 cm)
9 yrs	62.0 lb (28.1 kg)	52.5" (133.3 cm)	9 yrs	63.0 lb (28.6 kg)	52.5" (133.3 cm)
10 yrs	70.5 lb (31.9 kg)	54.5" (138.4 cm)	10 yrs	70.5 lb (32 kg)	54.5" (138.4 cm)
11 yrs	81.5 lb (36.9 kg)	56.7" (144 cm)	11 yrs	78.5 lb (35.6 kg)	56.5" (143.5 cm)
12 yrs	91.5 lb (41.5 kg)	59.0" (149.8 cm)	12 yrs	88.0 lb (39.9 kg)	58.7" (149.1 cm)

Children with disabilities do not average on a certain weight depending on each disability. Some children with disabilities weigh less than normal children as it all depends on the situation of the child. The average weight of a normal child or a child with disability will play a huge role in moving the device from point A to point B. This is due to the motion of the hover-board that mainly depends on the motion sensors and pressure pads to move.

5.2.2.3 Minimum & Maximum Weight of User

The hover-board is an important part in the design of the GBG project and the team's concept. The design essentially consists of two different parts. The first part is the seating part where the child sits and operates the device to move. The second part of the device consists of the hover-board, where it controls the movement of the device to other locations. The hover-board is triggered to move by applying the users pressure on the pressure pads using his or her legs. In the design, the hover board will be controlled by the user using their hands instead of their feet to control the hover-board. Figure 18 shows the final conceptual design for the GBG project.

As shown in the design, the user will be able to sit in the middle with their legs below the hover-board and the hover-board will be controlled through the user's hands. In order to move the hover-board, the pressure pads need a certain amount of pressure to move in different directions. There are two types of weights to determine the pressure delivered, durability, and movement of the hover-board. The first type is to determine the maximum

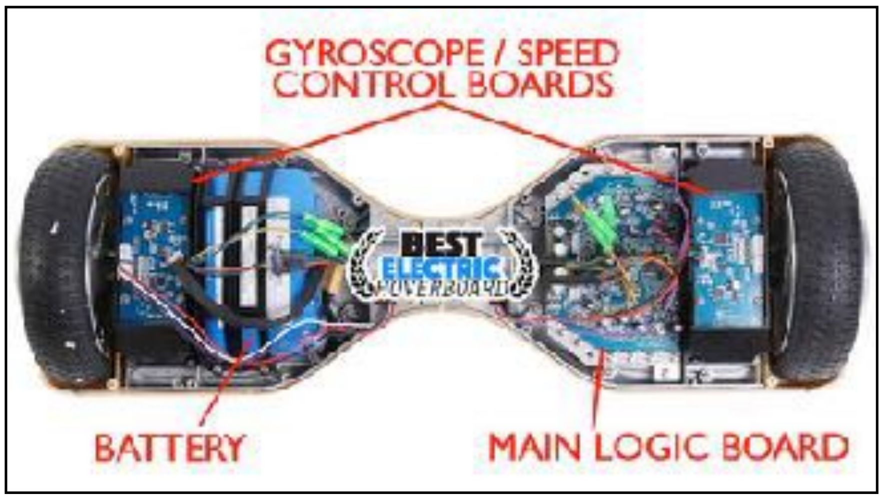


Figure 27: Hover Board Main Parts [17]

weight that the hover-board can withstand. The second type is to determine the minimum weight to operate the device. Figure 27 displays the main parts of the hover-board.

Hover Board Main Components [17]:

1. A steel frame with a central pivot
2. A logic board
3. Two gyroscopes
4. Two infrared sensors
5. Two electric motors (located inside the wheels)
6. Two tilt/speed sensors (located inside the wheels)
7. Charging port
8. Power switch
9. A battery pack
10. LED lights
11. Pressure pads
12. A plastic shell

There is a speed sensor in the tires of the hover-board that detects the amount of RPM's in the tire. This will be sent to the two gyroscopes where they will be calibrated to the user using the device [17]. This is where the weight is used to move the pressure pad. The maximum weight used in order to move the hover-board is different depending on the components used in each company's production line. Each company uses different types of batteries, speed sensors, and pressure pads. Additionally, the type of wheels used in a hover-board will determine the durability of that hover- board depending on the weight. The weight limit of the user averages around 220 lbs. (100 kg) and can go up to 325 lbs. (147 kg) [3]. Since the design built by the team depends on having the user use his or her hands instead of using of his or her legs, the minimum weight will be more important in this situation. To find the minimum weight appropriate for using the hover-board, the team was able to get a hover-board and test it using their hands. This testing procedure was performed by having a team member sit on a chair with the hover board laying on the member's lap. Pressure was then applied by the team member using their hands to see if the tires will move or not. The results showed that the device moved using hand pressure to get it as close as possible to the final design in figure 27.

5.2.2.4 Conclusion

In conclusion, the hover-board was the main component of the weight analysis in order to find the maximum and minimum weights to operate the hover-board. The team was able to test the hover -board using hand pressure instead of finding the minimum weight of operation. It was determined that the maximum weight for the user was not a problem that the team faced since the average maximum weight was determined to be 220 lbs. (100 kg) which is high compared to the average weight of a child. Different numbers emerged when seeking the average weight of a child. All in all, further testing will be required to have more conclusive results and to compare amounts of pressure required to move the device.

5.2.3 Budget Analysis

5.2.3.1 Introduction

NAU participated in the GBG program, which was established at different universities across the US. This program was created to support children with special needs and to help them move and act as normally as possible. This analytical paper discusses budget and cost analyses used to create a device that facilitates this.

From the decision-making process that involved a Pugh chart and a decision matrix, the process narrowed down to two main options that would enable us to come up with a GBG design that fulfills the client requirements as well as the engineering requirements. The decision-making tools also assisted in making decisions that were within the budget. With the consideration of all these factors, CV4 was selected on the criteria that it performed highest on the decision-making matrix. However, noticing the small difference between CV2 and CV4, the client proposed that the two conceptual ideas should be combined to devise a better product on a budget of $1,500. Therefore, to account for the amount required for the design and construction of the GBG design, it is necessary to consider the engineering requirements to develop the budget for the whole project. The design elements in comparison with existing models that dictate the overall cost for both the concepts are discussed below.

5.2.3.2 Background

The purpose of the project is to combine hover-board technology with a scoot® design. Two designs were chosen that integrate these technologies. The first, CV2, is based on a hover-board design, while the second, CV4, is based on a scoot® design.

CV2 Hoverboard [19]

This is the new and recent design of a scooter driven by an LED light. The LED light is a sensor that allows the user to be able to ride it using their emotions as it connects to the learning mode. Below are its engineering requirements:

- Hard ABS Outer Body Casing
- Aluminum Wheels with Rubber Tires
- Maximum Weight Limit: 220 lbs (100kg)
- Minimum Weight Limit: 44 lbs (20kg)
- Speed: 2 – 8 mph (3 – 12.8 km/h)
- Range: Up to 7 – 12 miles
- Charging Time: ~1 Hour
- Learning Mode
- Bright LED Lights (Headlights)
- Battery: Top Quality Brand Lithium with Sentry Shield
- Power: 100 – 240 Volts
- Size: 23w x 4h x 7d (inches)
- Product Weight:22 lbs. (9.9kgs) [20]

CV4 Scoot® [21]

This kind of device is manually operated and is designed to primarily support children with disabilities to be able to maneuver around. The scoot® is comprised of the following parts:

- Adjustable footrest
- Low and accessible seat base
- Lap belt
- Detachable

- Three casters
- Soft padded cushion
- Gripped rubber tires [21]

On their cost comparison, next is a table (Table 20) showing the costs of CV2 and CV4, which are both available in the market.

Table 20: Price variations of main component of CV

CV type	Market name	Cost
CV2	Hover Board	$199-$499
CV4	Scooot® 3-in-1	$595

5.2.3.1 Material and Cost Analysis

As mentioned earlier, the group decided on a new design that incorporates the ideas of both the CV4 and CV2. The design disadvantage the group tried to avoid in CV2 is the use of a lithium battery, known to be very dangerous and possessing significant risk to the user. Therefore, the team considered a CE FC ROHS battery as a safer idea.

The operation of the device will be managed from a pressure pad to control the device as the LED head lights will help the kids move by providing better lighting in the direction of travel. The project will involve the assembly of parts which are readily available on the market. For benchmark purposes, the table in Appendix A shows a catalog of the parts for the new designs vis-a-vis their images and markets.

Table 21 displays the budget analysis of all materials that the team will use in this project. The team started ordering the first item which was the K'Nex® building sets in order to make the prototype. This table lists actual price, expected variance, and the final cost of each component. Expected variances might include price changes from the supplier such as shipping charges, tax rates, item cost, etc.

Table 21::Budget Analysis Table

Type of Items	Actual Cost	Expected Variance	Final Cost
Back booster	$54.97	+$10	$64.97
Hover board - Smart Balance Scooter	$199.99	+$20	$219.99
LED motorbike headlight bulb	$30.99	+$10	$40.99
Lap Seat Belt	$16.96	+$5	$21.96
VIIVRIA® 9 in 1 Balance Scooter Circuit Repair Kit Board Main	$49.99	+$5	$54.99
RocketBus Replacement 6.5" Inch Power Motor	$39.95	+$5	$44.95
(CE FC ROHS)36V 4.4Ah 158Wh Battery	$84.99	+$5	$89.99
D@Boards Replacement Rubber Parts for 2	$14.98	+$5	$19.98
Smart Self Balancing Scooter (Adapter)	$9.64	+$5	$14.64
K'NEX Combat Crew 5-in-1 Building Set	31.50	+$17.5	$49
TOTAL COST	**$533.96**	**$87.5**	**$621.46**

5.2.3.2 Conclusion

The overall budget analysis took into consideration other budgetary expenses such as price fluctuations on the high side and shipping costs for those parts that are not locally produced. The estimates were made in consideration of other commodities and terms dictated by vendors that were factored into the expected variance column to come up with the final cost as shown in Table 8. The final budget totaled $621.46 which is less than the budget ceiling provided, thus making it viable. This budget analysis is not final; it may change in the future depending on team and design requirements.

5.2.4 Website Analysis

5.2.4.1 Introduction

Each team member has his own analytical report to research on. Website analysis is what this report will cover going through some details. Having a website for the project is a sign of highly professional work, where the website may include details such as difficulties, challenges, and other such considerations. The report will cover areas that either are present or will exist on the website.

5.2.4.2 Background

This report about the website analysis should be considered as a short component of the project, since it does not need a lot of research or mathematical calculations. Creating a website for the project is important: through the website, the team has the medium through which to showcase how the project came along and what the challenges were while building the device, as well as providing all the references, resources, and contact details that are relevant. There are many examples of successful and unsuccessful websites. For unsuccessful websites, there could be a difficulty in navigating the website, or it may suffer from technical lapses, or a lack of coherent information. On the other hand, successful websites tend to have a very striking homepage, brief but relevant descriptions, and well-organized information flows. After much internet surfing, the team came up with its own criteria for determining the success of a website which would serve the team well for the building of its own website.

Creating a website presented many challenges, such as learning how to use the Dreamweaver software, which costs $153.95 for a full package. Luckily, it is provided through the university for the team's reference [26]. Another challenge was how to organize the information about the project so that the reader can understand the process that the team underwent. Other aesthetic considerations: how should the main page look? Should it be divided into subsections with icons? These difficulties were faced during the creation and construction process of the website.

5.2.4.3 Conclusion

In conclusion, the website will act as a portfolio of the team's documents and proposals. In addition, it will illustrate the team's efforts which contributed towards fulfilling the requirements of the project. This website will be the team's future reference and will remain as evidence of the team's professional career long after this project.

5.2.5 Materials to be used for the project

There are four main materials that are used in this project. The materials are wheels, a wooden board frame, pressure pads, and steel. First, the wheels are used in the project to control the car and allow it to travel from one place to another. Second is the wooden frame, which is made entirely out of wood. The wooden frame will be used to harden the GBG car and also to ensure that the electrical connections can fit underneath. This would make the GBG car look more neat and better organized. Third is the pressure pads, they're made from plastic, electrical wires, and a hardened plastic cover to ensure that it won't break while applying pressure "Pressing". The pressure pads are used to direct the GBG in any direction the user wishes to move towards. Last but not least, stainless steel used in the project as a main component. The team chose stainless steel because it is one of the best and cheapest types of steel that is available in the market today. The materials were bought based on their quality to ensure the GBG is of the best standard for the client.

5.2.5.1 The chassis of the scoot

The chassis of the scoot will be the functional backbone of the scoot. It will be the metallic base on which the components of the scoot will be marred. First, the wheels will be mounted on the chassis from the underside of the chassis. In our case, we shall have a pair of caster wheels and a hover- board on the underside. On the upper side of the chassis, we shall have the other components fixed. These include the headrest, the seating area, and the pushing sections of the scoot.

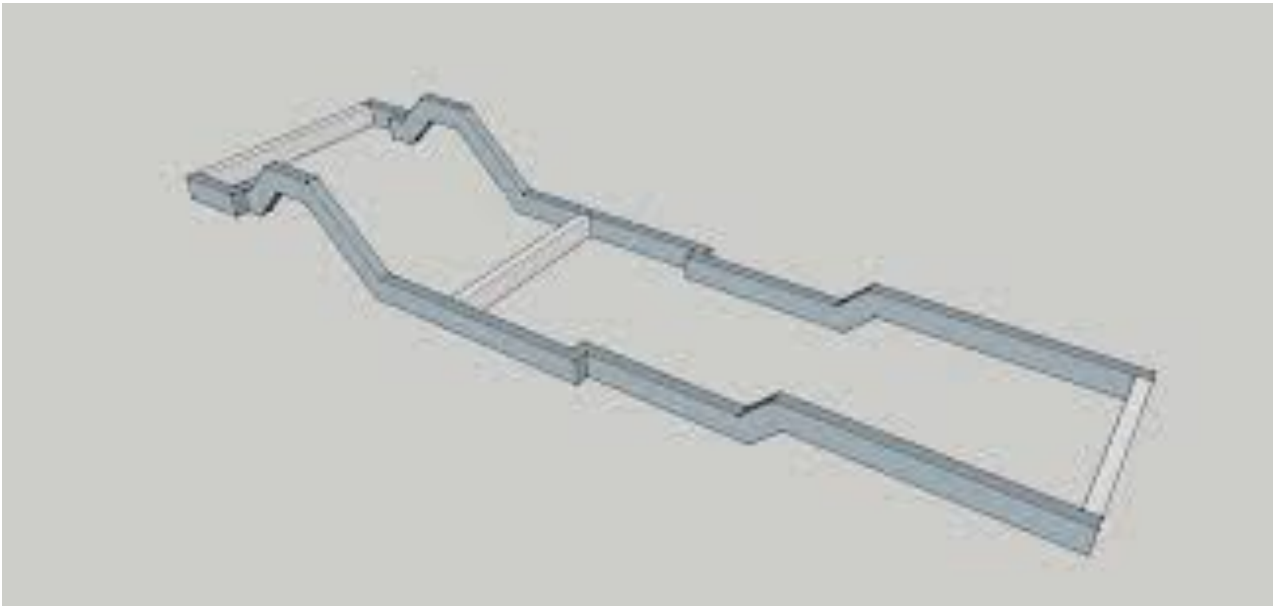


Figure 28: Chassis

5.2.5.2 Plastic seat and the head rest

In the model for our scoot, we need to ensure the scoot has a headrest and the seated rest is to be made from the same component. This will reduce the necessity of having to rivet the seat to the chassis at so many points. The headrest and the seat will both be made from plastic. The use of plastic is deliberate because it can assist in cutting down the cost of the device. With the two being conjoined, the seating pad is the one that will need to be riveted to the bottom.

Figure 29: Seat

5.2.5.3 Machine washable strap

Figure 30: Strap

The scooter will be mounted by small children. Children do not always have a sense of safety and precaution when they play. This calls for the need of having a strap that will strap the child to the seat of the scoot. This strap could be made out of nylon or cotton or a similar textile. However, whatever material that is used here should be strong and flexible to secure the child but not to harm them. This is because the strap will not be used like the seatbelt of a car. The strap will have to cross several times over itself so that it holds the child firmly and in position.

5.2.5.4 Paddle cushion

Our desire is to make riding the scooter an enjoyable experience for the the child is paramount. We will therefore need to ensure that the seating of the scooter is soft and comfortable. Using soft cushioning is a way of making sure that the kid has a gentle seat and a headrest too. The cushion can be put on the seat and the headrest of the scoot.

5.2.5.5 Casters underneath

The casters are made so that they can turn at angles that are as large as 360 degrees. The casters have rubber tubing on the outer surface with a metallic housing that holds the axis of the small wheels of the casters. The casters will be placed near the ear of the scoot. This is because the scoot will need to make direction turnings.

Figure 31: Caster

5.2.5.6 Hover-board

Figure 32: Hover-board

We said that the caster wheels cannot be used on all the wheels of the scoot. This is because, at some point, there will be a need to have two steady wheels that will maintain the steadiness of the scooter. The wheels of a hover-board would be the perfect match for this function. This is because they are steady and can be easily directed to go in a certain direction from their turning moments. This will be provided by the caster wheels.

6. *Proposed Design*

This chapter shows how the design will look for the first time after following the selection of the design through the Pugh chart and Decision Matrix. The design has been depicted using two methods: the prototype and the CAD design. An estimation of the materials that will be used for the manufacturing process has been included in the Bill of Materials.

6.1 Prototype

Because the electric scoot was the final selected concept, it was chosen for the proof of concept prototype. Figure 33 shows the team prototype that was created using K'NeX kids building game with some duct tape and construction paper. The design being built using these supplies by trying to match the sketch project design. For the moment the power supply is human power; one of the team members used his/her hand to push the scoot into movement.

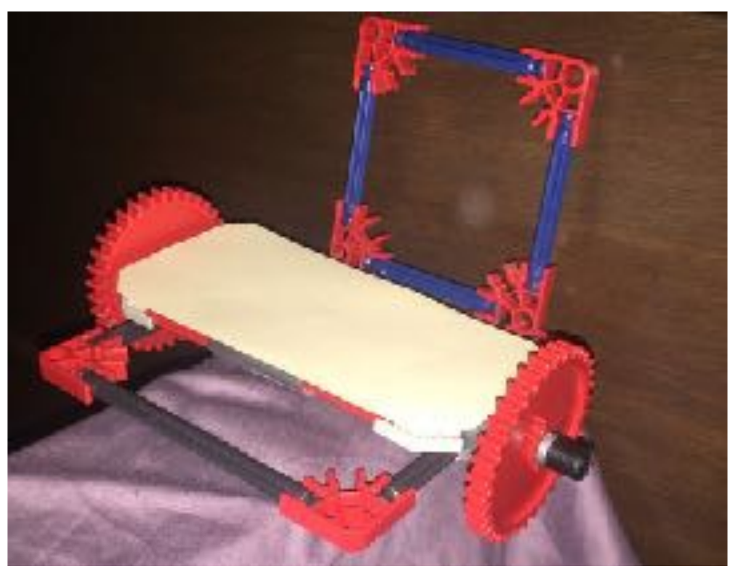


Figure 33: Final design prototype

6.2 Solid Work Design (CAD)

The following figure shows the solid work design for our project. As seen in the figure it consists of 4 wheels, a flat wooden frame to hold the seat, as well as the electronics (wires) which will go underneath them so that it looks neat. Furthermore, the rear two wheels are separated from the frame to ensure that the wheels move independently with the interaction of the frame. The metals that are attached to the frame are used to improve the movement of the GBG. This is drawn with solid-works to enhance a professional vision for the viewer of how the actual design will look. The front view of the solid-works design shows exactly how it will look when the design is completed.

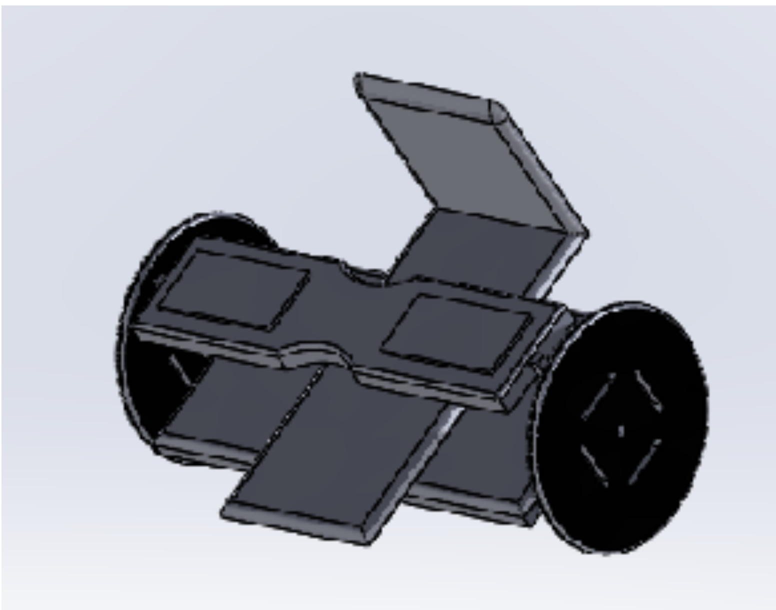


Figure 34: CAD first Design

6.3 Bill of Materials

Appendix A shows the parts the group decided to use in the final design for this project. However, the group has two options for the seat that may be in the final design. Option A is the kid car seat made out of plastic, foam, and fabric. Option B will be using aluminum, foam, fabric and super glue or screws that the group will assemble together. The majority of the parts mentioned can be purchased online. The price of each part is listed including an allowance for price variance, such as taxes, shipping, changing prices, etc. The vendors listed here have sufficient supply to allow ordering additional quantities in the event of damage or design aesthetic improvements. These parts will provide additional safety features and high quality design to allow for a broader market. Additional materials may be used in the future and are included here as a possibility.

7. IMPLEMENTATION

Throughout building 80-90% of the design and doing the possible testing, and with evaluating the design through the team notices, the design met the requirements safely. While testing the parts of the design, many creative thoughts came up from the team members, which resulted in some changes in the final design. This section covers the redesigns that were made during the testing processes.

7.1 Design of Experiments

To improve the quality of the design of the project the team carried out three different experiments for different reasons. The first category is the battery; the team got a package of four/six-volt batteries. The second experiment involved the alignment of the device to ensure that it drives straight and does not move sideways. The final experiment involved measuring the maximum weight that the device can withhold and the weight of the material to ensure that it is appropriate and does not hinder the performance of the device.

7.1.1 Batteries

The group will experiment and use all the batteries and try to reduce the amount of batteries to check if the device needs the exact amount of batteries to operate the device. The reasons for changing the amount of batteries are

1- To check the amount of power needed to operate the device.

2- To avoid electrical hazard for kids.

7.1.2 Alignments

In this experiment the team members will be pushing the device manually to check if the device can move straight and make the needed fixes. After attaching the batteries, the team will experiment the alignment again and make sure if adding any materials or removing any will cause damage in the alignments.

7.1.3 Weight

The group will experiment different weights to check which is the approximate weight that might cause any damages to the car. In other words, checking the factor of safety. Checking the weight will help avoid hard moving of the device and will cause using more battery. The final weight is important to make sure it is easy to transfer the project any place.

7.2 Design Changes

The design has completely changed from what was expected. Figure () shows the new design of the project. We have faced a lot of problems while manufacturing our old design. The frame was too small to handle all the expected electrical work that was going to fit inside the Go Baby Go car. Instead of leaving the seat with the wheels attached to it, we implemented a bigger wooden frame that would fit the electrical work and the seat. The team saw that the wheels would not move if it was close to the seat so we widened the rear wheels with a metal attached to the frame and at the end of the metal we attached the wheels to it. This is to enhance the movement of the wheels. Furthermore, two wheels weren't enough to make the car move freely and independently which was changed to 4 wheels with a rear wheel drive feature. This would give the rider a better way to steer comfortably from left to right.

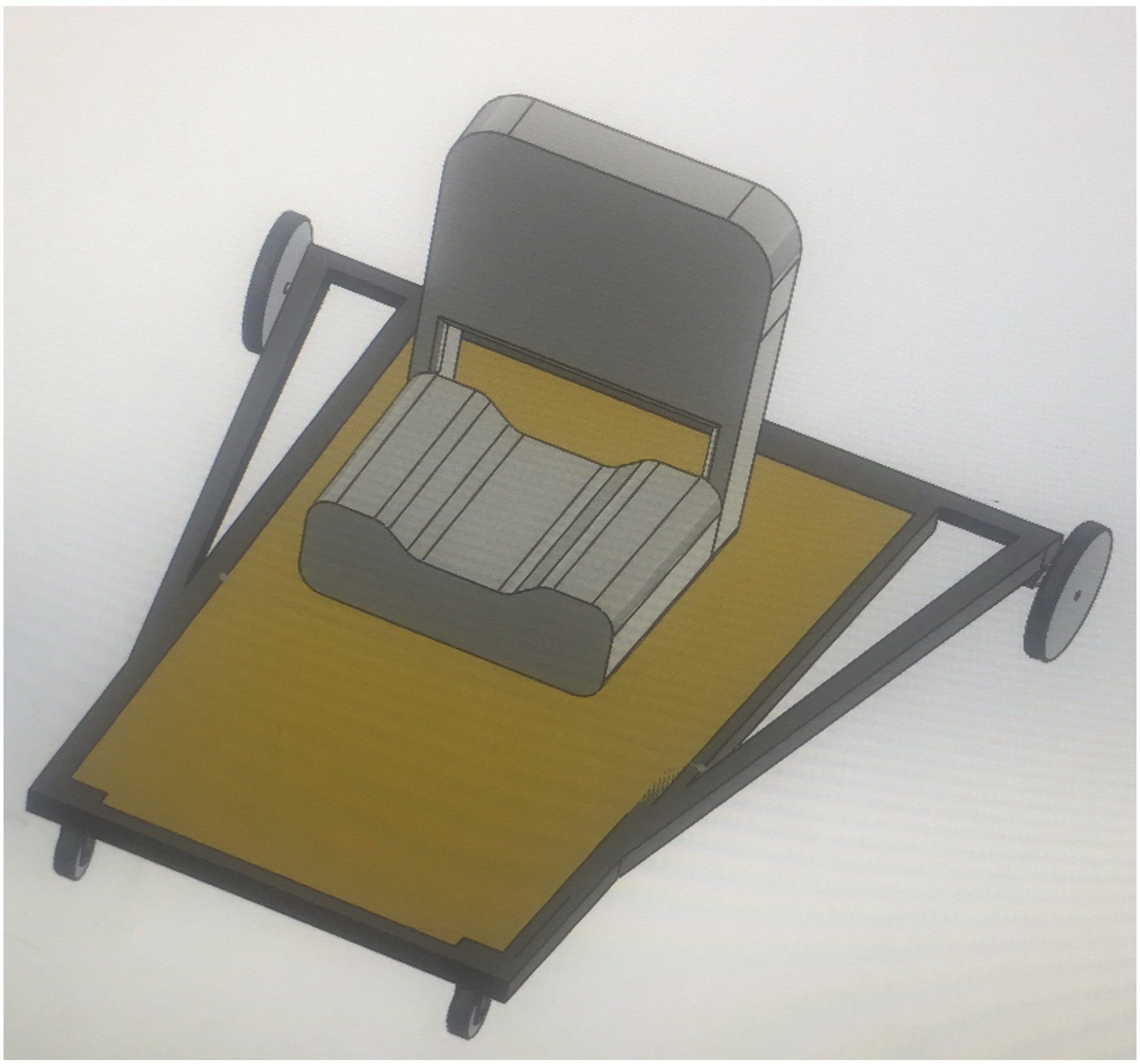


Figure 35: CAD final Design

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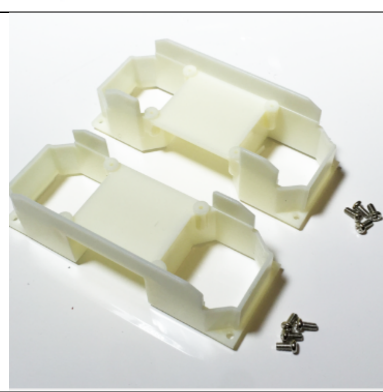
8. Appendices

Appendix A

Parts	Image	Market	Price
Toolkit 550 Piece Metric Sheet Metal Screw Assortment - Contains 13 Popular Sizes [27] Option-B		Amazon	$5.99
BAA SHOP Two Wheels Mini Smart Self Balancing Scooter (Adapter) [28]		Amazon	$10.99
D@Boards Replacement Rubber Parts for 2 wheel self balance scooter hoverboard [29]		Amazon	$15.00
Go-Ped Stealth II Hoverboard Electric Scooter Battery Set[30]		BatterySharks	$39.96
RocketBus Replacement 6.5" Inch Power Motor Wheel for Self-Balance Smart Scooter IO Hawk PhunkeeDuck Swagway Hoverboard [31]		Amazon	$139.94

VIIVRIA® 9 in 1 Balance Scooter Circuit Repair Kit Board Main Hover Board replacement parts 2 Wheel 6.5"[32]		Amazon	$69.99
Lap Seat Belt, Chrome Lift Latch, 60 Inch Length [33]		Amazon	$14.64
K'NEX Combat Crew 5-in-1 Building Set [34]		Amazon	$31.80
MDF Panel (Common: 3/4 in. x 4 ft. x 8 ft.; Actual: 0.750 in. x 48 in. x 96 in.) [35]		The Home Depot	$35.66
Minger Car LED Strip Light,4pcs DC 12V Multi-color Car Interior Music Light LED Underdash Lighting Kit with Sound Active Function and Wireless Remote Control, Included Car Charger [36]		Amazon	$20.99
Wise Economy Low Back Seat [37]		Amazon	$33.89

SOLOOP 480Pcs 12 Size Assorted Insulated Electrical Wiring Wire Terminal Crimp Connector Kit Butt Spade Set [38]		Amazon	$20.98
Caster Set (2 Swivel/2 Locking) [39]		Global Industrial	$33.89
Wire Rope Clip, U-Bolt, 1/2In, Forged Steel*4 [40]		ZORO	$49.63
48 in. x 1-1/4 in. x 1/16 in. Plain Steel Square Tube [41]		Home depot	$17.66
4 x (1-1/2 in. x 36 in. Plain Steel Angle with 1/8 in. Thick [9]) [42]		The Home Depot	$37.88
SENSOR BRACKETS FOR SENSOR BOARDS *2 COUNT [43]		Hoverbored Repair	$22.77