DesignforDisability--GoBabyGo BUniversal Control

Final Report

Team 32

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1 BACKGROUND

1.1 Introduction

Our project is to help the disabled children achieve independence and socialization even when feeling constricted by their disability. The sponsor has provided money that will help the team deliver a product that will allow those children to be able to live their life as normal children. In addition, these kinds of projects would benefit the sponsor and stakeholders of the business. There are a lot of children around the world suffering with limited mobility disabilities.

1.2 Project Description

The following piece has been pulled from the original post by the sponsor.

> "Children with limited mobility often do not receive the much needed exposure to socialization to appropriately cognitively develop. Existing research shows that enabling young children with self--control of their own environment can have meaningful impacts on the long term outcomes given such impairments as cerebral palsy or muscular dystrophy. The Go Baby Go (GBG) project that started at the University of Delaware has developed a set of DIY cars for families with children with 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 shown to be a cost--effective means of enabling young children to move and interact with their peers. 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 that extremely limited mobility of their arms and/or legs. As part of this capstone project, you will be asked to participate in the GoBabyGo club on campus. You are not required to be an officer or have an active role in the club, but must stay current with all builds and events that the club participates in" [1].

1.3 Original System

The current designs have been in existence for quite some time, where researchers have been looking for better ways on improving their effectiveness in assisting children with mobility challenges. The current designs are based on an on/off mode of movement where the on button allows the car to move instantly and the off button makes it stop instantly (Mcafee, 2015). Further, the current designs use joysticks and steering ring wheels, which allow for steering and making turns. The use of joysticks and steering wheels are not meeting the needs of all the children, those with upper body difficulties tend to be less effective in using the cars. The current designs are effective and serve their intended purposes. However, better designs would further improve on the effectiveness of these cars in order to benefit children in a great way.

1.3.1 Original System Structure

The original structure of the car is made to suit children of different sizes. The cars come in sizes that are able to meet the needs of the disabled children. The materials used in making the external body of the car are mainly hard plastic or light metal. The use of these materials allows for the car to be light and easy to move. In addition, the materials cause less harm to the children in cases of accidents, such as falling off or hitting each other. The interior of the cars is made of soft synthetic fiber which is important in improving the conformability of the car. The children should be able to sit comfortably even for long hours. The general concept of the design is aimed at ensuring safety, comfort, and effectiveness in operations.

1.3.2 Original System Operation

In the current design, a simple on/off speed control device is used to manipulate electrical energy to convert it to mechanical energy. The changes in motion are causing significant negative impacts to the children since they are getting scared by the instant movement and instant stops. In addition, the current designs use joysticks and steering wheels, which allow for steering and making turns. The use of joy sticks and steering wheels are not meeting the needs of all the children, where those with upper body difficulties tend to be less effective in using the cars.

1.3.3 Original System Performance

For children that are one to five years old, being able to feel independent when living with a disability will shape them into a more sociable, positive and other meaningful effects on them in their later days. The GBG cars have a choice of two speeds, stop and a sudden 2.5mph. They also have the ability to reverse, but this is only an option for the children with non--limb restrictive disabilities that can access this feature. There is a go switch and an easy to access kill switch for the parents to have control if something goes wrong with the steering. The lack of control for the upper body impairments makes it where the cars that are made with the steering wheels have limited access to changing directions. These cars are easily portable;; they can fit in the trunk of a car which makes it easier to run errands such as hitting the grocery store or the park for an easy ride along for the child. There is a rechargeable battery pack within the car for easily rechargeable fun. A parent with any form of education can easily assemble the car in case there is a malfunction and a part needs to be fixed.

1.3.4 Original System Deficiencies

The performance of the GoBabyGo cars is acceptable but there are a few deficiencies. If the family decides to go on a day trip or a camping trip with the car and the child decides to use it the entire time, there will be a point in which the car needs to be recharged. If they are stuck outdoors, there is no place to charge the car for the child. Also, if the child is off-roading in the car, the child could get stuck in a pothole, mud, or sand and not be able to get out. The child cannot climb out, in which the car needs to be light enough for the parent to be able to pull the child and car together out of the situation. When looking at the speeds of the car, the sudden increase to 2.5 mph causes there to be an unpleasant jerky behavior. This and also limited steering can cause poor accuracy when trying to arrive at a desired destination with a lot of turns or hills. For children with limb restrictive disabilities, the reverse gear is something non--accessible for these specific children. Having the kill switch easily accessible for the parents is great until the car isn't in reachable distance.

2 REQUIREMENTS

2.1 Customer Requirements (CRs)

Based on the project description and the design requirements of the GBG project, there are various customer requirements that shall enable the design to fully satisfy the clients. The customer requirements include a durable product that has a longer life span compared to the current cars, easy instruction manual. Progressive speed control and battery are not included based on the client instruction. One of the heavier weighted customer requirements that the client focused on the greatest is to have 12-volt power battery instead of 6-volt power battery because 6-volt battery cars have shown to create fires in the past. Based on the weightings of the customer requirements that the team had received from the client, shown in Appendix A, the most important of the requirements are easy instruction manual, easy to build, and safety. The least important when weighting is delicate appearance which is making the GBG car more fun for the children to look at and ride in.

2.2 Engineering Requirements (ERs)

From an analysis of the customer requirements, the team broke down these specifications into engineering requirements that would allow for successful completion of the project design in relation to the client's needs. The first major engineering requirement is an extended battery Life: This requirement involves the use of a battery that is capable of storing a charge for a long time, one possibility would be a 12V battery that could be used for a period of 3-5 days without needing to be recharged. The next major requirement that was discovered from the customer requirements is the need for clear and simple instructions: The use of clear instructions is important to ease the learning curve upon the use of a product for the first time. Providing a more successful and smooth transition into the next stage in the customer's lives. The next engineering requirement is a control system for the product that is not overly complicated. The target users for this product are young children who may have various forms of disabilities and may find it difficult to use more complicated system. Keeping the system simple will enable the customer to begin utilizing the product sooner and enjoying their newfound mobility. Readily available materials: The materials used in the GBG project are subject to fatigue. Therefore replacement materials used should be readily available in the event that the customer needs to replace any key parts of the car. With the lifespan for the materials used should be at least 1 year. How the product accelerates is another engineering requirement found after the customer needs. A Speed control device: Since the operators of the car have a disability, the product should include a device for speed control. Where the speed can be managed controlled so that there are no sudden stops or acceleration and it has a smooth transition from stopped to full speed. Similar to other mechanical objects the GBG project requires some safety measures, one such measure would be a Seat belt: At times cars are involved in accidents with other cars or objects, where the operator could get injured. Using a seatbelt would improve the overall safety of the product as well as ensuring that the operator stays within the confines of the car in the event of an accident. From past GBG projects one noticeable characteristic is seen and that is how long the cars can be used before needing to be recharged. The use of 12V battery will allow for a greater range of operation than the 6V batteries that are currently being used in the GBG project. This type of battery would contain enough power to enable the product to be used over the course of several days for 3-5 hours a day without being recharged. A 12V battery would also contain plenty of power to move the car at the desired speed even with an operator within the vehicle. Then a steering system that requires little to no use of hands and legs: The design for the product should be easily modified to fit the needs of the customer including but not limited to the potential customers having limited movement and control of hands and legs so that the customer has the best experience when using the device. The appearance of the product should be aesthetically appealing to the customers, as well as being structurally sound so that in the event of an accident the device would still be usable and keep the operator of the product safe. Finally the last engineering requirement that was created from the customer requirements is low cost: The cost to purchase and maintain the product should be reasonable to encourage low income families to make the purchase to help less mobile members of their family be capable of enjoying the same freedom of mobility that the rest of their family has.

2.3 Testing Procedures (TPs)

As seen in Appendix C, there is a testing procedure for each engineering requirement. Some of the tests that will be performed are to run until it dies for the battery, have an average parent read the instruction manual and see if understandable, and time how long it takes to make to see if it is decent for an average parent to make. Other tests include the team checking at an average store to see if all appliances are easily attainable, use an accelerometer to check the speed increments, and test the car with a dummy to see how safe it is. The team will also use a millimeter in order to test the battery voltage, use a scale to check weight, and keep the receipts of materials purchased in order to see total expenses of final product to check if obtainable price.

2.4 Design Links (DLs)

When looking in Appendix C, the House of Quality also shows the design links. Each engineering requirement is included in a certain design and some are included in all of the designs. The engineering requirements that obtain to a certain design are the steering control and speed increment. The steering control concept corresponds to the belt design idea while the harness design idea corresponds to the speed increment concept. The rest of the engineering requirements are included in both of the design ideas.

2.5 House of Quality (HoQ)

See Appendix B.

3 EXISTING DESIGNS

The GBG started at the University of Delaware to develop various types of DIY cars to be used by children with mobility restrictions. The designed cars have been developed in various shapes and sizes in order to meet the increasing demands (Mcafee, 2015). They have been produced all across the world by the GBG teams in order to assist children from all across the world. The cars are a cost effective way to that allow children to be able to move as well as interact with their peers. However, they are limited in various ways because the retrofits are designed to be inexpensive as well as DIY for parents (Mcafee, 2015). There have been little changes to the original design. Our team seeks to design a GBG variant that addresses disabilities that haven't been accommodated by previous versions.

The current designs have been in existence for a couple years; researchers are looking for ways to improve their effectiveness in assisting children with mobility challenges. The current designs are based on an on/off mode of movement where the on button allows the car to move instantly and the off button makes it stop instantly (Mcafee, 2015). Further, the current designs use joysticks and steering ring wheels, which allow for steering and making turns. The current designs are effective and service their intended purposes. However, better designs would further improve on the effectiveness of these cars in order to benefit children in a great way. These designs are presented in Appendix A (Benchmarking).

3.1 Design Research

The research started from analyzing the current design. These designs are limited and have significant downfalls. For example, through analyzing the design, the users are finding it a challenge moving from place to place in regions where the ground is not even. This causes increased chances of falling. In addition, maneuvering the cars is becoming a challenge since some of them are difficult to move due to their weights. In addition, the designs are all based on the user, where it allows them to define how to move from position to position. Based on the analysis of the design, the team came up with various ways in which the original design may be improved based on the downsides that the original designs were based on its use.

The team further used benchmarking in order to seek other information that would allow improving of the design. This allowed us to gain information that would help in integrating technology, such as the use of progressive speed system in controlling the cars and improving on their movements. Based on the information, the team seeks to come up with a design that is different from the normal stick or wheel control since children with upper body difficulties may not be able to fully use such a design. In addition, the team seeks to incorporate the use of progressive speed, not movement that is instant since such movement tends to scare the users. Based on the original design in relation to its effectiveness and its downside, we seek to retain some of the designs that allow effective use while working on the improvements in order to increase their effectiveness. Some of the factors include durability, having an easy instruction manual, fitting to most of the car sizes, be easy to use, easy to build, have enough power, be safe, have progressive speed control, having steering for upper body limited mobility, low costs, and aesthetics (Mcafee, 2015).

3.2 System Level

This project focuses on prototyping an improved version of the current GBG project kit. The design specifically aims at designing a universal control for the children who have extreme limitations to the mobility of their legs or their arms. The design is centered on the development of modern microprocessor control for purposes of effective steering as well as the traction motor. Further, the design shall incorporate smart control reliability in order to allow for more control over the car as well as allow for consistent and smooth transitions between 0 and 2.5 mph for theusers.

3.2.1 Existing Design #1: Frozen Car

The first existing design is the Frozen car that does not include a joystick, instead it acts as if it is a normal car with a basic steering wheel, on/off speed control, 6V battery, easy instructional manual, easy to build, easy to use, safe, delicate appearance and low cost (Appendix A). This car needs improvements in order to meet our client requirements and those include having progressive speed control and steering for both upper and lower body difficulties.

3.2.2 Existing Design #2: Frozen Car with AJoystick

The second existing design is the Frozen car includes a joystick instead of a steering wheel. This car allows a child to maneuver with only his right hand but it also does not fully help the children with upper difficulties to use those steering sticks. This car operates on a 12V battery, which is a requirement. It has a difficult instruction manual and has some electric materials that increase the cost of the car. There is no progressive speed control; it has an on/off speed control consisting with the first design.

3.2.3 Existing Design #3: Barbie Car

The third existing design is the Barbie car. It replicates a normal car and has a steering wheel. It is similar to the first existing design. It has an easy instruction manual, 6V battery, on/off speed control, easy to build, easy to use, safe, delicate appearance and low cost (Appendix A). Like the first two existing designs, it has no steering device for upper and lower body difficulties and no progressive speed control.

The Barbie car is a form of the steering wheel car, but there are many other frames that could be set to be gender satisfying for example a Cars themed frame, racecar or a basic car frame, such as a mini cooper or a jeep.

3.3 Subsystem Level

On the subsystem level we want to design a method that allows the child of upper and lower difficulties to maneuver without using hands or legs. The current design utilizes a steering wheel, which is controlled by upper body strength in order to steer. A way to connect his waist movement and wheels would be great, which shall allow for effective control of the car by the user. Another important thing on the subsystem level, we need to create a way to make the child fully control the speed. Currently, the speed is constant and has a simple on/off system, which is not comfortable for the children. The design seeks to make it better through providing a progressive speed system.

3.3.1 Existing Design #1: Frozen Car

On the subsystem level for first existing design there is a simple speed control on/off device to manipulate electrical energy to convert it to mechanical energy. The changes in motion are causing significant negative impacts to the children since they are getting scared by the instant movement and instant stops. The design seeks to make it better through providing a progressive speed system. Another interior thing is steering which is very simple using the steering wheel to steer wheels. The steering method needs to be changed to help both upper and lower body difficulties and the speed control device needs to be changed to control speed at different levels.

3.3.2 Existing Design #2: Frozen Car with A Joystick

On the subsystem level for the second existing design there is a stick for steering not a wheel. The design will improve on the steering concept of the car, where it shall not use the common steering of a wheel. The car shall involve the use of a steering system that allows children with upper and lower body difficulties to be able to effectively use and steer the cars. The steering system shall be effective for use with children who have challenges with the use of their upper or lower bodies. Further, the other thing is a 12V not a 6V battery. There are no other differences from the first existing design on the subsystem level. Changes need to be made to satisfy the customer needs in steering and speed control.

3.3.3 Existing Design #3: Barbie Car

On the subsystem level for the third existing design there is no difference for the first existing design. Changes need to be made on speed control and steering device for both upper and lower difficulties to satisfy the client requirements. Further, these cars have an on/off system, where the movement and speed of the cars are instant. This design shall change the concept, where it shall incorporate the use of progressive speed, where the car shall gain speed gradually rather than instantaneous. This shall allow for comfort for the children using it. The different frames that could be used cause the children to be able to represent themselves and let them show confidence.

3.4 Functional Decomposition

Shown in Appendix C, the functional decomposition shows the breakdown of what is desired to be improved from the current GBG car design. The two main concepts that the team desires to advance is the steering and the speed increments. From these, the customer requirements will be met with safety, easy to use and build, easy instruction manual, to keep current or longer life span and want to still reach the goal of a low costproduct.

4 DESIGNS CONSIDERED

The team had a meeting to brainstorm possible designs that would be beneficial for the GBG team to incorporate into their set of products. These ideas were based on the products studied for the past and present designs at hand. The brainstorming methods used were the brain ball exercise and the 6-3-5 method. The brain ball exercise is when a ball is thrown from team member to team member to create ideas in an instant. The 6-3-5 method was used but was modified to only include four members; this method is when you have six people with three ideas drawn out, one per paper, and each team member gets five minutes to add to the drawing that certain team member has.

When the meeting ended, the team picked out all the impractical ideas and was able to come to 10 ideas. Designs 1 and 2 were found by the brain ball exercise while designs 3-5 were found by the 6-3-5 method. The rest of the designs in this section, 6-10, were bio-inspired. These brainstormed designs focus on the speed, steering mechanism, sitting style of the car and style of charging battery. The rest of the car design is going to be unchanged. The team then put together a Pugh Chart in order to select the top three choices, which were then put in a decision matrix to rank greatest potential to least.

4.1 Design #1: Harness and Belt

The first design includes a belt for steering and a harness for progressive speed control. The steering system for this design is the use of the belt. The belt is attached to the steering mechanism, as well as the chair for safety, after the steering wheel has been removed, and allows for the ability to grab and pull from either hand if the child had mobility in their upper body in order to make tighter turns. For turning right, the child pulls the right side of the belt while for turning left, the child pulls the left side of the belt. The harness in the car allows for protection based on the progressive speed of the car. The harness comes down from the top of the car's seat, from both sides and runs across the child's chest to meet at the middle, where the straps are attached. This is a basic strap set up such as seen in a car seat. When the child sits, the harness is able to keep them steady, even despite changes in speed. The team is planning on programming a short delay in the acceleration present for if the child leans too far forward, then there would be a sudden acceleration that would throw the child back causing then a braking signal. This could be a flaw in the design but precaution will be added to help save this problem. The team also thought about a different version of the same idea of having two motors in the car, one attached to the left strap and one attached to the right, therefore when the child leans forward in one direction, that motor will accelerate more than the other and will cause the car to turn.

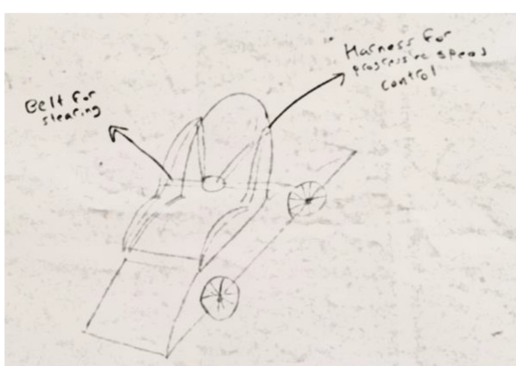

Figure 1: Harness and Belt Design

Advantages: Allows for smooth turning of the car, easy to use, low costs to install and maintain, safe.

Disadvantages: difficult for children with upper body limitations, may be a strain for the child in controlling since they have to understand how to balance the belt in order to go straight forward, in case of an accident the child may have a hard time getting off due to the harness.

4.2 *Design #2: Foot Levers*

In a vehicle, the pedals at one's feet are for the gas and brake, this design idea uses one pedal for left and one for right;; The more the child steps on one pedal, the tighter the turning radius is. The design eliminates the use of hand control systems that have been used in previous designs. The design shall allow for ease of control of the car by the users.

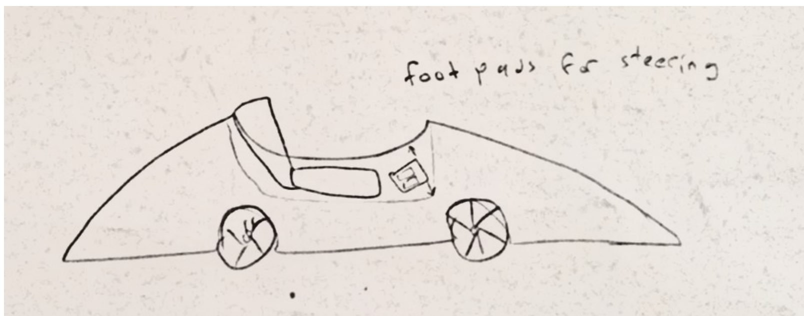

Figure 2: Foot Levers
Design

Advantages: ease of steering, low cost of installing and maintaining, does not require too much space to be installed.

Disadvantages: can only be used by children that can access lower body movement, can be tiring for the child if used for a long time.

4.3 Design #3: Joy Stick

The design using a joystick was made when thinking about little children and how much they enjoy video games. This design involves an improved version of the original design that incorporated the use of a joystick for control. This design uses a joystick for control, similar to the original design, but this design has the ability to move forwards and backwards for purposes of controlling the speed and left and right for purposes of movement of the vehicle.

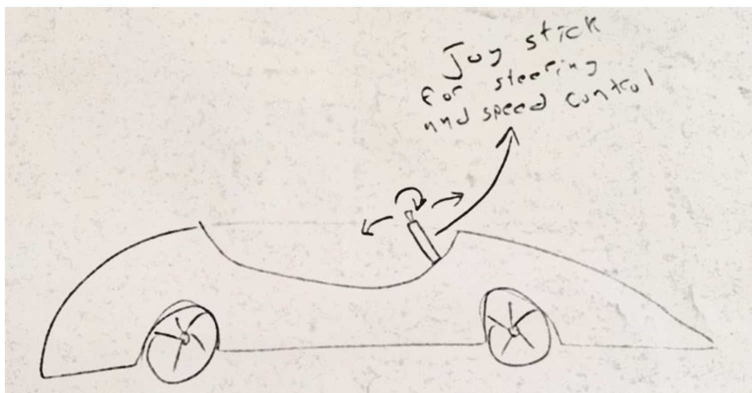

Figure 3: Joy Stick Design

Advantages: provides multiple uses of the joystick, places all controls in one device for ease of use, cheap to install and maintain.

Disadvantages: does not consider individuals with limited upper body strength, the joystick may have increased wear and tear and may require regular maintenance and replacement.

4.4 *Design #4: Electronic Tablet*

The team chose a design that applied to today's technology--using child. This design uses a tablet for purposes of controlling. The electronic tablet would be attached to where the steering wheel was in the original design of the car. The tablet would require charging regularly in order to ensure that it does not run out of charge when in use. Based on the design, the child must be able to have upper body mobility to be able to adjust the speed and direction of movement through the touch of buttons on the tablet's screen. The commands are transmitted from the tablet to the vehicle's motor and steering systems. An alternative to the tablet would be a touch screen that can be specifically programmed to perform the functions we desire.

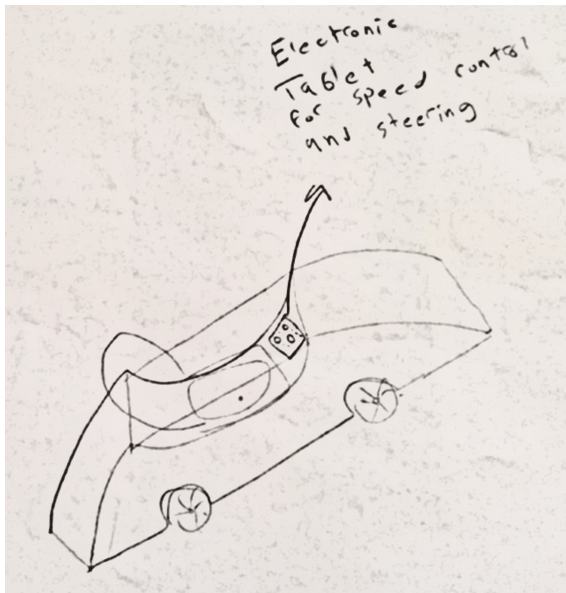

Figure 4: Electronic Tablet Design

Advantages: embraces the use of modern technology, ease of operation as the system requires only figuring out buttons, child does not get tired from controlling.

Disadvantages: tablet has to be recharged regularly since when it runs out of power it cannot operate as required, child may have to undergo a lot of training in order to understand the concepts used, expensive to install and maintain.

4.5 **Design #5: Chair Setup**

The team was brainstorming while sitting in wheelie flexible chairs. This design uses the concept of a moving chair that can control the direction of movement. As shown in the diagram, the design includes pivoting the chair at the middle of its underside. The pivot allows the chair to move round, both clockwise and counterclockwise. Since the chair is fitted into the car, the degree of rotation would be limited to 45^0 to either side, which would produce effective rotational steering and would be ultimately connected to the steering system.

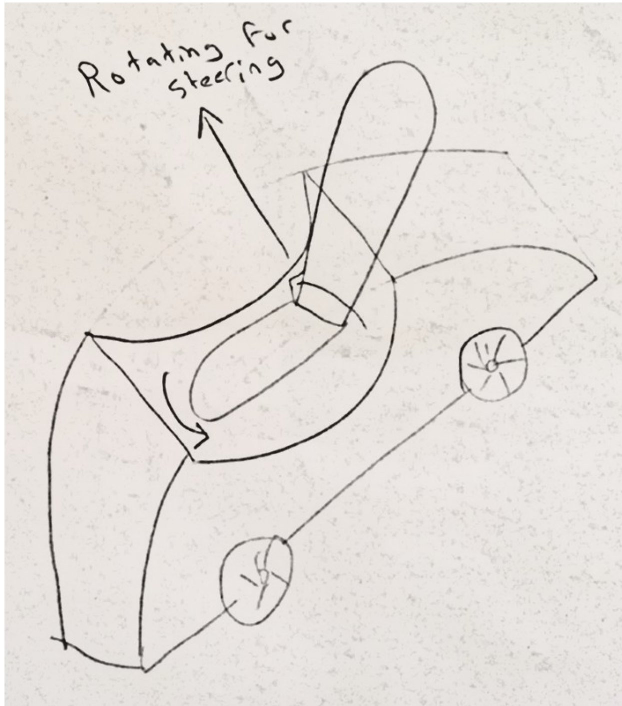

Figure 5: Chair Setup Design

Advantages: ease of steering of the vehicle, ability for children with either upper body abilities or lower body abilities, easy to install and maintain.

Disadvantages: may get tired due to changing direction with whole body, rotation is limited to a certain angle degree.

4.6 Design #6: Horse Reins

This design idea was bio--inspired by the reins placed on a horse when it is to be ridden. The reins regulate the direction one wants the horse to go and also controls the speed of the horse, that is, the reins control the movement of the horse. Basically, if a child was to pull the right side

of the reins, the car would turn right;; the tires would move with respect to how the reins were pulled by the child. When the child gives a little free range to the reins the car will start to move, with the looser the reins are, the more the car will speed up. When the child wants to slow down or stop, he or she will pull the reins towards the back of the car and the car will lose speed just as a horse would.

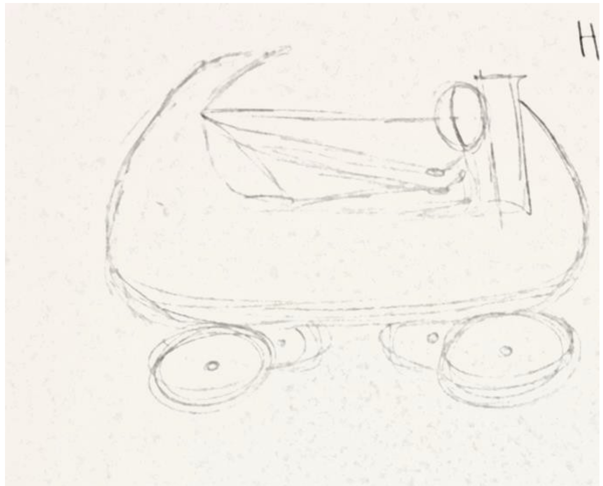

Figure 6: Horse Reins Design

Advantages: inexpensive, safe, long life span. Disadvantages:

need mobility in arms, difficult to construct.

4.7 Design #7: Horns of an Animal

This bio--inspired design was derived from an animal’s horn, such as a bull, that connects across their forehead. The team figured that this could be used as a steering wheel. Instead of the circular wheel that has to be held, the horn set up could have connections to strap hands in due to the fact of limited upper body mobility. The child can pull or push, whichever is easier due to disability, one side of the bar style steering wheel in order to turn the relative direction.

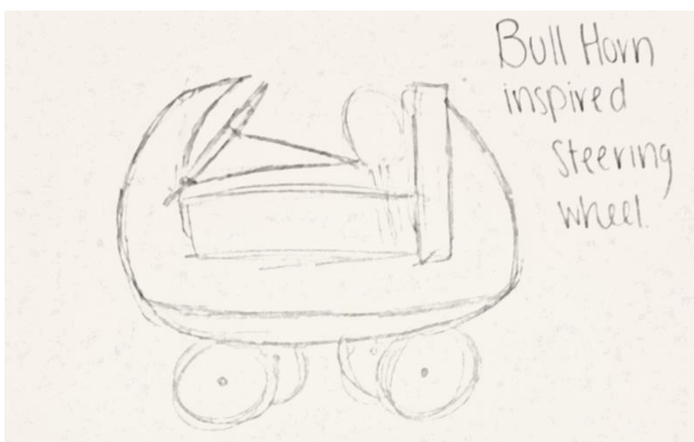

Figure 7: Animal Horns Design

Advantages: doesn’t need mobility in lower body, inexpensive, easy to build and use, long life span.

Disadvantages: need some sort of strength in upper body to pull/push arm attachments.

4.8 Design #8: Solar Power Battery

Solar power is a basic bio--inspired design that is being implemented everywhere. The team had an idea of making the car a hybrid. If the car was being used outside and/or somewhere that doesn't have a source of power to charge it, it can use a miniature solar panel pop out to charge up. The car would still have a plug to charge during rainy and snowy days or if it is overall easier to charge plugged in at that instant. If the team decided to continue with this idea, the team would need to perform further research to find the exact size needed to be able to charge the 12-volt battery.

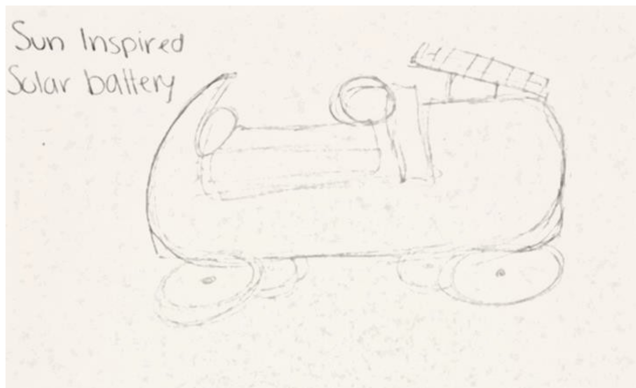

Figure 8: Solar Power Battery Design

Advantages: saves money for electricity in long run, easier to charge when outdoors.

Disadvantages: inconvenient, problem storing and transporting wouldn't be safe if heated up in sun, high startup costs, possibly hard to use.

4.9 Design #9: Kangaroo Pouch

A bio--inspired design was produced with safety as the key customer requirement in mind. A pouch mechanism, such as a kangaroo pouch, was a design the team had thought of in order to hold the child steady in the car. This design would provide comfort while keeping the child steady and prevent them from falling about or out of the car due to limited mobility and possibly bumps while moving.

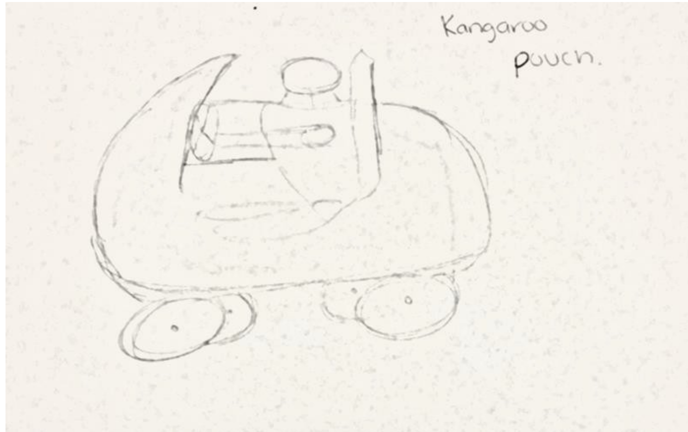

Figure 9: Kangaroo Pouch Design

Advantages: safe, comfort, good for limited mobility, easy to use and build. Disadvantages:

costly due to mass amount of material.

4.10 Design #10: Fan

The last bio--inspired design was inspired by a windy day in Flagstaff. The idea was constructed to use a fan for speed control. This design can be visualized to look like an airboat except on land and uses tires to move from to the wind. The fan can cause a constant acceleration and deceleration of speed when turning the switches from low to medium to high and back down, correspondingly. It would be made sure of that the fan blades are enclosed by a type of screen in order to provide safety to the child. In order to incorporate steering into this design, the team decided to attach two fans to the back of the car, when one fan is turned to a higher speed than the other, the car would turn to that corresponding direction.

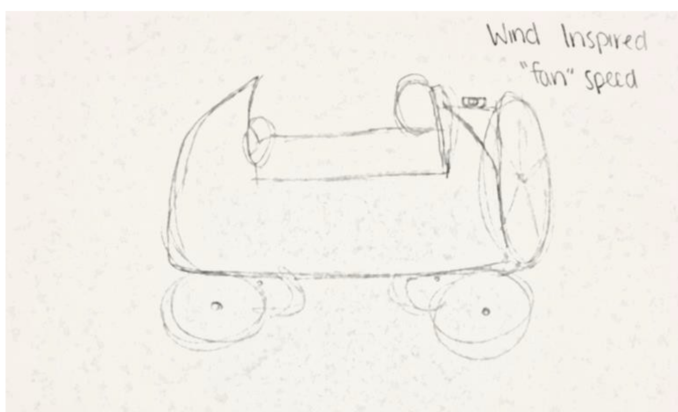

Figure 10: Fan Design

Advantages: no extra manufacturing (could just buy a fan from a typical store), inexpensive, easy to attach, progressive speed control, easy to use.

Disadvantages: back heavy, loud, drag, and possible short lifespan, possible to not be safe.

5 DESIGN SELECTED

5.1 Rationale for Design Selection

According to the Decision Matrix and Pugh Chart found in Appendix D, the designs that have the highest scores and meet the client's need the best are the Harness and belt design.

5.2 Design Description

The harness and belt design is represented in Appendix E. This design idea received the greatest score in the decision matrix for the expected life span of this device. This was because the device would only be destroyed by the children themselves and it is unlike that it would be destroyed by an outside force. This device is also the easiest to understand how it operates and therefore easiest to use out of all possible design solutions.

Since most GBG cars have to be assembled, it was important for this design to be easily replicated at home by the customer without having too many parts; this would be a burden to the construction of the device. The overall safety of the device is the biggest factor in which what device received the highest score. A multipoint harness reaches around the child and connects in front of the stomach of the child keeping them safe in the event of an accident.

When this design was created, it was generated with the intention of using a 12V power source. The progressive speed control and the steering for limited upper and lower body mobility customers in this design are controlled through body motions and how the child leans either forward or backwards for speed and to either side to turn. The appearance of the device also held some sway on how well the device would do compared to other, and the device just needed to be aesthetically appealing and structurally sound to perform well in this category.

Finally the cost of the product is estimated to be the lowest of the designs therefore receiving the best scores within this area. This design is a significant improvement from the original GBG cars, where it would include a steering belt and harness for progressive speed control and safety respectively. The steering system for this design utilizes a belt that is attached to the steering mechanism and allows the child the ability to pull from either hand to steer the device. On the other hand, the harness in the car allows for protection increased protection from a sudden change in momentum from an impact. The harnesses run across the seat to hold the child in a safe position in the event of a crash. When the child sits, the harness is connected together in the front of the child to keep them steady despite changes in speed. Some of the benefits of the design include allowing smooth and easier turning of the car and is easier to use compared to joy sticks and steering wheels, low costs to install and maintain, and protection from the sudden change in speed.

6. PROPOSED DESIGN

Based on the client demands the requirements got changed to only designing a steering mechanism. The team plans to improve the current design of the GBG car through making operational changes to the steering mechanism. This mechanism will not be relying on hands, but shoulders for steering. There are different types of materials that will be required in order to implement the concept successfully. The materials include shoulder harness. A ride on car. In addition, the team will need a strap in order to connect the harness to the front wheel in order to be able to conduct the steering concept and miscellaneous tools in order to connect the strap. The structure of the design is represented in Appendix E, which will be incorporated into the current GBG car. The team members will work together and research the steps needed to complete this design and ask for professional help when extra questions. Other resources include the client, 3D printer, and the testing apparatuses. The budget will be split up into being spent on the current car set up, may need to buy shoulder harness, plastic sticks, glue, force pulling meter for testing purposes and the rope. These values are represented in appendix F.

This includes a miscellaneous amount for testing procedures and other supplies not yet known. The testing procedures will be conducted on the size and weight of the car, which includes a scale and a measuring tape. The team is in the process of constructing the first prototype but after feedback, they will construct a startup model. This model will be tested on force needed to steer the wheels and durability of steering mechanism.

7 Implementation

7.1 DOE

The first variable that we tested is the force needed to steer the wheel and that was accomplished by using a digital push pull force meter. The statistical results that we got is three to five pounds of force needed to steer the wheel and based on the average weight of a seven to ten years old a child can easily do it. Testing the force needed is important because a child might not have the strength to do it. The other variable is the durability of the steering mechanism and that was accomplished by pulling the harness multiple times and the results showed a strong mechanism. A design of experiment analysis can be found in Appendix G.

7.2 Manufacturing

Starting by attaching two U-shaped steel rods to two steel plates. Followed by attaching the plates to the front tires. After that use two six yards straps to attach each rod to the shoulder harness. Modifications can be added such as attaching two eye bolts to the frame of the car to prevent the strap from touching the frame and strap adjusters to adjust the strap. Based on the analysis three to five pounds of force needed to steer the wheel by thirty-five degree. The resources that we used are ride-on car for children that do not exceed sixty-five pounds, two six inch steel rods, forty-eight inch strap, plastic glue and two adjustable shoulder harness. These values are represented in appendix F.

8 Testing

There are two tests that we tested on the final product and those were the force needed to steer the mechanism and the other one was the durability of the mechanism. The equipment that we used was a pull force meter to measure the force needed to steer the wheels and for durability a naked eye can easily observe if the product was durable or not. the results are 3 to 5 pounds of force needed to steer the wheels and the mechanism is strong. Refer to appendix G to see the results.

9. CONCLUSIONS

9.1 Contribution to Project Success

The team made sure that the project's aims and objectives were in alignment with the goals and purpose indicated in the team charter. This allowed for effectiveness while working in order to arrive at the intended design. These goals and purposes allowed for the team to come up with a strategy that would be followed in ensuring that the end product meets all these goals. Based on the end product, the team completed the purpose and goals stated in the team charter.

The ground rules and coping strategies stated in the team charter were followed. Group members were expected to go to all group gatherings and be on time. Work was to be finished in an expert way and any issues ought to be tended to so as to decide another game plan and still entire the task in a convenient way. When we initially began off, I didn't believe that our group was not the average high-errand one. However, I think our gathering is special as it was that every group member has his/her own remarkable character and we really supplement each other. Albeit many would imagine that the group project would be more essential than the relationship segment, I think both are as similarly critical and supplement each other.

The strategy that worked the best was research and communication. The team members were quite effective in researching and communicating their findings. It was important for each team member to make sure that they completed the research assigned to them and then communicates their findings to the other team members. This worked effectively, which contributed to the team's success while working on the project. On the other hand, time keeping was a strategy that was difficult to keep up with. Most times, team members' schedules were clashing, where some team members were held up in one way or another at times when the team was expected to be meeting, which was a major hindrance to the success and effectiveness of the team.

The aspects that proved to be the most effective were teamwork and product quality. The team members were quite effective in working together as one unit. The team members made sure that they remained as one unit in completing the duties and responsibilities that were assigned to the team, which contributed to the team's success. In addition, the team member, due to their effectiveness in working together as one unit, managed to come up with the best quality end product. Through research, brainstorming, and effective decision making, the team's design was excellent.

Time management and manufacturing cost were the most negative aspects of the team's work process. The team was quite ineffective in a management of time. For example, some of the group members at times did not complete their assigned duties at times, which made the team to lag behind based on the time schedule that was set. Also, the times set aside for team meeting were not effectively managed since some individuals at times got late and at times the school schedules made it difficult to set a specific time for meeting due to classes and other school activities. Further, cost management was also a negative aspect, where we undervalue the cost of some products, which led to the team spending more than it had projected during the preparation stages.

9.2 opportunities for improvement

In future one organizational action that can be taken to improve the performance is having a corporate strategy and plan that builds commitment. An aggressive business methodology and strategic management increase the odds that an association will be effective and achievement fabricates duty. Likewise, if the arrangement and the procedure are clear and all around conveyed, will your workers be more propelled, as well as knowing the vital course will help them stay focused. Corporate qualities that are measured and compensated can likewise adjust conduct and fabricate responsibility. Another opportunity for improvement includes having a defined purpose for teams make roles clear. Each specialty unit and group needed to comprehend its part. Administrators and pioneers need to build up a reasonable and imparted reason that is both convincing and that makes individuals feel imperative. Comprehend that workers will probably be focused on the motivation behind the unit or group in the event that they are included in making it. A vague mission will bring about an absence of center and a low level of engagement and responsibility toward accomplishing it.

REFERENCES

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APPENDICES

Appendix A-- Customer Needs & Benchmarking

Go Baby Go Universal Control Project		
Customer Requirements:		
Date:	9/21/2016	
	Customer Requirement	**Ranking**
	life span	3
	Easy Instructions Manual	5
	Easy to use	3
	Easy to build	5
	Safe	5
	12V Power	4
	progressive speed control	4
	Steering For Upper and lower Body limited Mobility	3
	Delicate appearance	2
	Low cost	3

Project: Go Baby Go Universal Control			
Benckmarking			
	Basic Frozen Car	Frozen Car With Joystick	Barbie car
life span	/	/	/
Easy Instructions Manual	/		/
Easy to use	/	/	/
Easy to build	/	/	/
Safe	/	/	/
12V Power		/	
progressive speed control			
Steering For Upper and lower body limited Mobility		/	
delicate Appearance	/	/	/
Low cost	/		/

Appendix B- HoQ and Email Confirmation from Dr. Oman

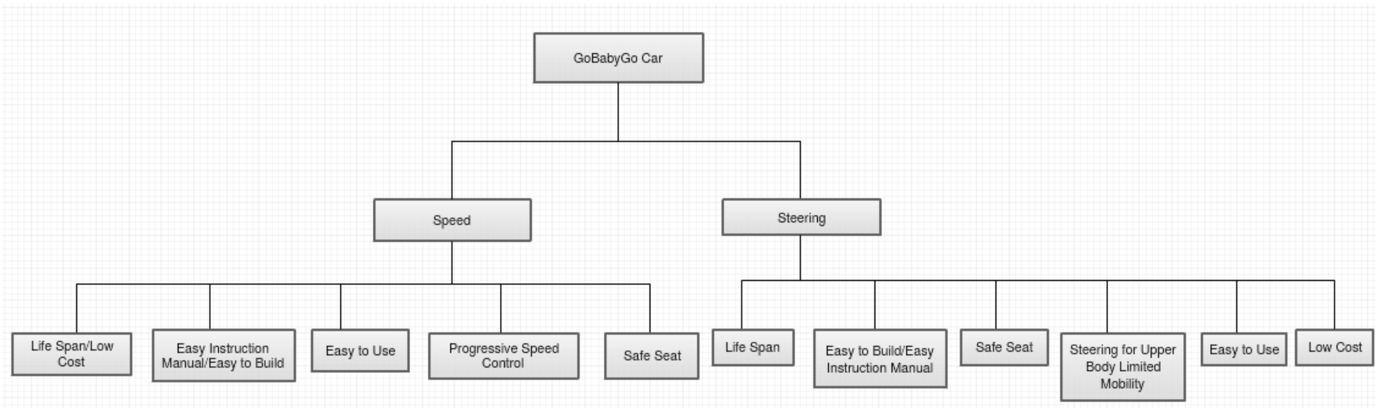
	Customer Needs	Customer Weights	Long Life Battery	Clear & Simple Instructions	Easy to Make	Easy to access materials	Speed control	Seat belt	12V battery	Low use of limbs	Weight	Cost
			Engineering Requirements									
1	Life Span	3	9				3	6	3			
2	Easy instruction manual	5		9	6	6				3		
3	Easy to use	3		3	9			1		3		1
4	Easy to Build	5		6		9		1		3		
5	Progressive speed control	4			3		9		3	6		3
6	Safety	5	3					9				1
7	12V power	4					6		9			3
8	Steering for upper body limited mobility	3	3		6	1				9		
9	Weight	2	3								9	1
10	Low Cost	3	3		3				1	6		9
	Technical Requirement Units		hour						Volts		lb.	$
	Technical Requirement Targets		>5						12		100	200
	Absolute Technical Importance		66	84	96	78	69	71	60	108	18	61
	Relative Technical Importance		7	3	2	4	6	5	9	1	10	8
	Testing Procedures (TPs)		Run until dies	Average Parent reads it	Time how long it takes to make	Check at store	Accelerometer	Test with dummy	Multimeter		Scale	Keep reciepts of material to see expenses
	Design Links (DLs)		Incorporated in all Designs	Incorporated in all Designs	Incorporated in all Designs	Incorporated in all Designs	Harness Design	Incorporated in all Designs	Incorporated in all Designs	Belt Design	Incorporated in all Designs	Incorporated in all Designs

Sarah Kay Oman Sep 26 (2 days ago)

to Salman, me, Mohammad, Sydney

What information do you need from me? The CNs in the attached document look fine along with the weightings.

Appendix C- Functional Decomposition Flow Chart

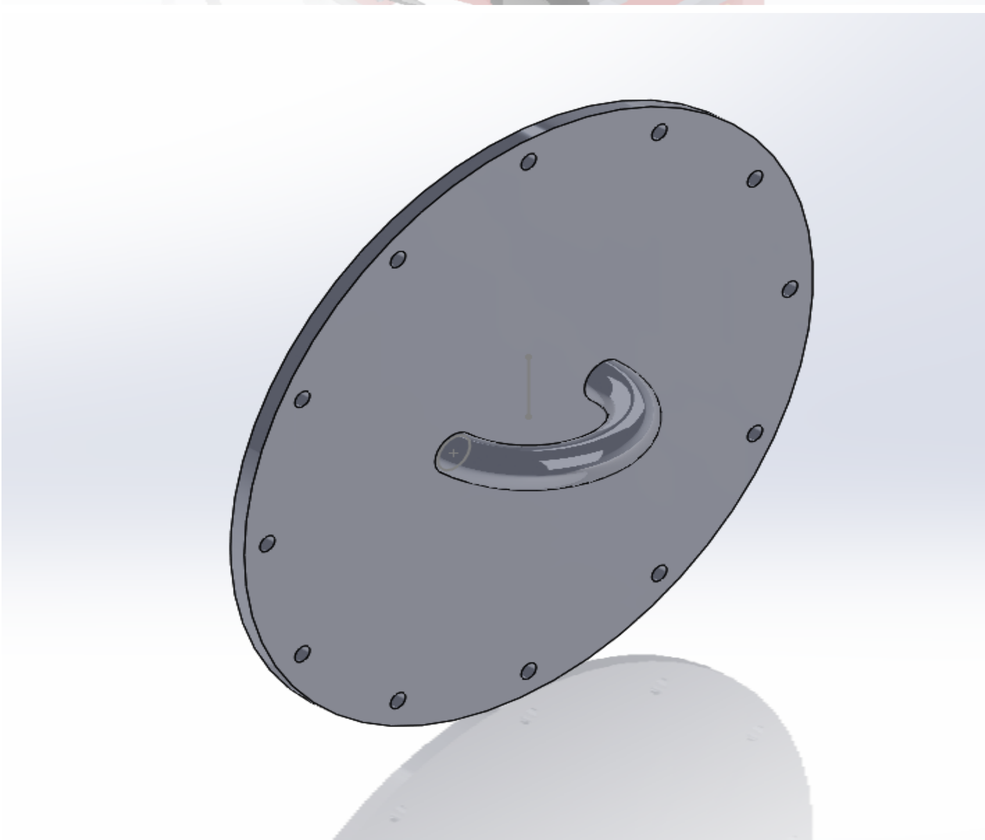


Appendix D- Decision Matrix and Pugh Chart

Go baby Go B Decision matrix				
Option	Weight Out Of 100	Harness and Belt	Electronic Tablet	Fan Bio Inspired
Life span	8	8	8	8
Easy Instructions Manual	15	12	9	11
Easy to use	8	8	5	8
Easy to build	15	13	7	14
Safe Seat	15	15	12	10
12V Power	10	10	10	10
progressive speed control	10	8	9	7
Steering For Upper and lower body limited Mobility	10	8	4	8
Appearance	5	5	5	5
Low Cost	4	4	2	3
Score	--	91	60	84
Ranking		1	3	2

	1	2	3	4	5	6	7	8	9	10
	Horse Ranes Bio Inspired	Solar Bio Inspired	fan Bio Inspired	Horns Bio Inspired	Kangroo Bio Inspired	Belt & Harness Brain Ball	Foot Pads Brain Ball	Rotating Chair Brain Ball	Joy Stick 635	Electronic Tablet 63
Life span	-	S	S	+	S	+	D	S	S	S
Easy Instructions Manual	S	-	-	-	S	+		-	-	S
Easy to use	S	S	S	-	-	+		S	-	-
Easy to build	-	-	-	-	-	S		-	-	+
Safe Seat	+	S	+	S	+	+	A	-	S	+
12V Power	+	-	+	-	-	S		S	S	S
progressive speed control	-	-	+	-	+	+		-	-	-
Steering For Upper and lower body limited	+	S	-	+	-	+		+	-	+
delicate Appearance	-	-	+	S	S	S	T	+	+	+
Low cost	-	-	-	S	S	-		+	+	+
S+	+3	+0	+4	+2	+2	+7		+3	+2	+5
S-	-4	-5	-4	-5	-3	-1	U	-4	-5	-2
S	-2	-5	0	-3	-4	6		-1	-3	3
Ranking	5	8	3	6	7	1	M	4	5	2

Appendix E–A SolidWorks Drawing Of Final Design (Harness & Belt Design)



Appendix F- BOM & Budget

GoBabyGo B

Part #	Part Name	Description	Qty	Vendor	Cost
1	Fabric Strap	A strap to attach the shoulder harness to the steel rods.	1	Jo-Ann Fabric And Craft	$ 25.34
2	Bolts & Screws	Bolts & screws to attach the steel plate to the tires	6	The Home Depot	$ 2.97
3	Steel Rods	A rod that is attached to the steel plate.	2	The Home Depot	$ 5.77
4	Shoulder Harness	A strap that is attached to the rope for steering	2	Amazon	$ 14.99
5	Ride-on-Car	A ride on car that is not designed for disabled children	1	Amazon	$ 239.94
6	Plastic glue	A glue that is used to attach the pipe to the wheel	1	Walmart	$ 3.12
7	scissors	An instrument that is used to cut the rope	1	Walmart	$ 14.97
8	Steel Plate	An instrument that is used to cut the rope	2	The Home Depot	$ 16.99

Budget		
Materials	Quantity	Cost
Steel Rods	2	$5.77
Bolts & Screws	6	$2.97
Steel Plate	2	$16.99
Ride-on Car	1	$239.94
Shoulder Harness	2	$14.99
Fabric Strap	12 Yards	$25.34
Swivel Hook	2	$8
Plastic Glue	1	$3.12
3D Printed Prototype	2	$13.95
Prototype (Toy)	1	$12
Testing Materials	4	$100
miscellaneous		$100
	Total:	$543.07

Appendix G–DOE

Project:	Go Baby Go B			m =	2	experiment levels
DOE				n =	2	number of factors or design variables
Recorded:	4/23/17			Fraction =	1	fraction of full factorial experiment
				N =	4	number of experimental combinations/trials
				r =	2	number of replicants
		Force Needed	Durability			
	I	x1	x2	y1	y2	ybar
1	1	1	-1	1.93	1.96	1.945
2	1	1	1	1.88	1.6	1.74
3	1	1	1	1.74	1.74	1.74
4	1	1	1	1.72	1.53	1.625
5	1	-1	1	1.52	1.53	1.525
6	1	-1	1	1.31	1.58	1.445
7	1	-1	1	1.4	1.36	1.38
8	1	-1	1	1.23	1.32	1.275
Effects		0.7125	4.3925			
ß's	1.5844	0.35625	2.19625			
					ybarbar	1.5844
Variable Actual values						
		low (-1)	high (+1)	units		
x1		5	3.5	lbf		
x2		Weak	Strong	in		

Appendix H – Final Product