University of Connecticut Biomedical Engineering

Standing Gardener and Snow/Sand Wheelchair Project Proposal

Team 2

Peter George, Fryderyk Karnas, and Robert Knapp

Client Contact:
Brenda and Sean Stenglein
34 East Howey Road
Ashford, CT 06278
Phone: 860-429-1059
Executive Summary

Sean Stenglein is a ten year old boy with cerebral palsy. A standing gardener and a snow/sand wheelchair will be constructed to make it possible for him to perform a greater variety of activities with his family. The goal of this project is, in the case of the standing gardener, to take an existing and fairly expensive product and modify it so that it can be adjusted to accommodate Sean while he grows and aid him in gardening. In the case of the snow/sand wheelchair, the goal is to modify an existing wheelchair so that it can easily traverse both sand and snow. The main criteria for both of these devices is to keep Sean safe while keeping the devices as light weight and cost effective as possible.

Introduction

1.1 Background of Client

Cerebral palsy is a disorder which is caused by lack of oxygen to the brain at birth. The affected part of the brain is the cerebrum. Sean Stenglein is 10 years old and struggles with motor operations due to his disorder. This includes loss of control in his legs which causes him not to be able to stand on his own or walk on his own. Along with not being able to control his legs Sean has trouble controlling other parts of his body as well, including his arms and mouth, making it difficult for him to pick things up and talk.

Sean has a speech therapist trying to help him to be able to talk. He is capable of talking when his body is under control and his muscles are relaxed. However, sometimes when Sean gets excited and tries to talk he cannot control just the muscles around his mouth and moves his whole body instead.
Sean also has a physical therapist, Steve Moran, who is vital to any progress Sean makes toward gaining control of his body. Mr. Moran knows all of Sean’s current capabilities which include the ranges of motion of all parts of his body. It is very important that Sean exercises so that he does not lose muscle mass. If Sean were kept in a wheelchair for his whole life he would never be able to walk, but exercise brings hope. A very important exercise for Sean is being held in a standing position which is another reason the standing gardener is so vital for him. Sean must get used to being in a standing position even if it is uncomfortable for him. A good way to help get his mind off of being uncomfortable is to have him be able to pot plants with his parents while remaining in the standing position.

1.2 Purpose of Project

1.2.1 Standing Gardener

As of now Sean is able to be involved using his current stander, a Leckey Free Stander size 2 shown in Figure 1. Sean is still growing however and needs a new standing device which will be able to grow with him so that Sean’s parents will not have to buy him a larger stander.

The standing gardener’s main purpose is to aid Sean in standing to help strengthen his muscles. But it is also to allow Sean to be able to pot plants while he is in the standing position. This will allow Sean to support his own weight on his legs, while at the same time be supported by the frame of the gardener. This project will be better than any other product on the market for Sean because it will adjust to whatever size he needs. It will also be designed specifically for what Sean is using it for: gardening. All of the parts that would typically become too small when Sean grows larger will grow telescopically with him. The purpose of this is to have one generic device, as opposed to having specific sizes that are completely separate and are sold separately.
1.2.2 Snow/sand Wheelchair

Regular wheelchairs work very well on flat, relatively smooth terrain, such as pavement or tile. However, the problem comes when a handicapped person in the wheelchair has to be mobile during the winter when there is ice or snow on the ground outside. The person also cannot go on the beach because the wheelchair would sink in the sand when he tries to propel himself. The goal of this part of the project is to design a wheelchair device such that a handicapped person, such as Sean Stenglein, can be mobile on sand, ice, and snow.

1.3 Previous Work
1.3.1 Previous NSF designs

There have been previous designs made to aid people with standing. One such device is the Child Stander which was a NSF project done at the University of Alabama at Birmingham. This device has a table for the subject to work on and wheels. The subject would stand with his feet on the ground and be stabilized by the device. The reason the subject would stand on the ground was because previous devices suspended the user one foot off the ground making him or her taller than his or her peers. Being so much taller became an issue with interaction.

Also the Posture-Right Walker was an NSF project done by students at Arizona State University. This device was intended to allow the user to be stabilized when he walked. There is no table which could be used as a workspace however which Sean needs to have.

In terms of the Snow/sand wheelchair, there was an “All Terrain Wheelchair” completed by the University of Toledo in Ohio in the year 2005. This project had a third wheel that came out in front of the wheelchair frame to give the wheelchair more stability. In 1994, the University of Hawaii designed a
wheelchair with wheel adapters and casters so that the wheelchair can go on sand. In 2000, The University of New York in Buffalo designed a wheelchair accessory platform that the wheelchair strapped on to and could be propelled to give the rider more options to conquer different kinds of terrain.

1.3.2: Products on Market

The Leckey Freestander is a product on the market being sold now. It comes in three sizes which can be a problem for Sean and his family. They want a device which they can telescope to fit Sean perfectly. The Leckey Freestander sells for about $1,200 to $1,500 which is quite expensive to have to buy one of each size. The Leckey Freestander can be seen in Figure 1. The design of the standing gardener will be based off of this device.

![Figure 1: Leckey Freestander](image)

There are a few manual off-road wheelchairs on the market today (like the Lasher Sport, Llc BT-Trail), but the far majority of them are electric. Since the motor adds a considerable amount of weight
to the device, we believe it would be a better option to go with a manual wheelchair. However, there are none on the market that have a satisfactory design. A picture of the Lasher Sport can be found in Figure 2.

![Lasher Sport Trail Wheelchair](image)

**Figure 2: Lasher Sport Trail Wheelchair**

### 1.3.3 Previous Patents

A Mobile Standing aid was patented in 03/07/1989 by Jesse Owens. Owens’ device is much like the Leckey Freestander with the exception that Owens’ design includes wheels to make the stander mobile. The wheels were able to be propelled by the users arms with two cranks on either side connected to pulleys which drive the wheels. Also unlike the Leckey Freestander Owens design did not have a table in front of it to do work on. Owens design was made just for the purpose of being mobile in the standing position.

An all terrain wheelchair was patented (US Patent 5427398) to convert an existing wheelchair into an all terrain vehicle by Steven L. Weybrecht on October 29, 1993. The design is unlike the design proposed because it doesn’t have tread-like belts that go over the front and back wheels, increasing the surface area in contact with the ground. A picture of Weybrecht’s design can be found in Figure 3.
Project Description

2.1 Project Objective

2.1.1 Standing Gardener

The standing gardener will be designed to keep Sean in a standing position. To do this it will have a place to strap Sean’s shoes for stability. Knee pads which will extend to the sides of the knees will keep Sean’s legs in place and be soft for when he spasms his knees will not be hurt. Also a waistband will strap Sean to the device to make sure he does not fall backwards. There will be a table in front of him to be used as a workspace for potting plants along with a holster which Sean can hang the hose onto when he needs to water the plants. The whole standing gardener frame will be on caster wheels so it can be easily moved throughout the greenhouse. There will also be a holster for a water bottle for Sean.
2.1.2 Snow/Sand Wheelchair

The snow/sand wheelchair will be unique in that it will encompass the technology of belt treads into the design of a wheelchair. The wheelchair must be lightweight so that it can be easily moved. This criteria implies that the wheelchair has to be a manual one, meaning no electric or gas motor is used in the propulsion of the device. The handicapped subject will propel himself on his own.

The snow/sand wheelchair will be much like that of a normal manual wheelchair, in that the basic concept will be the same for self-propulsion. However, the main difference is in how the wheelchair device moves. The addition of belt treads around the modified wheels will allow for more surface area to be in contact with the ground. This will provide more stability and traction when it comes to moving across terrain that otherwise proves to be difficult to move across in a normal manual wheelchair.

The device will also have short skis mounted on the bottom of the frame of the wheelchair with a manual jack that can raise and lower the frame of the wheelchair. In doing this action, the amount of force on the wheels can be varied for different levels of ice, snow, and sand. This would make it much easier to propel one’s self on this device.

2.2 Project Methods

2.2.1 Standing Gardener

The purpose of creating a new stander for Sean is to make things as easy as possible for him while he is gardening. This can be done by adding features to the stander that his current stander does not have. The proposed stander will be able to telescope to whatever size Sean likes so that he can do his work in the most comfortable position. To make this possible, certain parts of the gardener will be able to slide and lock into place to make the gardener grow or shrink. One problem with this is Sean's
center of gravity. If Sean uses the gardener in a tall position it will lead to the stander being less stable. By adding extra supports which increase the area of the base we can avoid this problem.

Since Sean’s current stander was not meant for gardening in particular it makes it difficult for him to pot plants on it. A tray will be available on the side of the gardener for plants which need to be transplanted. Once Sean has the plant ready to be out in the pot he needs to put more soil in. However Sean’s disability causes him to have very little control in his arms leading to erratic movements. This makes it hard for Sean to transfer the soil from the table into the potting plant. The proposed stander has a designed workspace which will have a spot to stabilize the three types of pots Sean will be using. Next to that there will be a soil table which is slightly elevated above the pot where Sean can easily slide the soil off the table and into the pot. When Sean is finished potting the plant he can easily grab the hose which will be attached to the gardener by a clip. When Sean is done watering the plant there is a place for him to put all of his finished plants. The design layout can be seen in Figure 4.

All of the parts that support Sean’s weight will also be telescopic, meaning they can grow in length as Sean grows in size. The purpose of this feature is that Sean never outgrows the device. The hip supports, side hip supports, and height of the device will all be able to telescopically lock into place and can become longer or shorter if the need presents itself.
Figure 4: Design of the Standing Gardener
Certain positions help Sean in maintaining control of his limbs. When Sean’s elbows are kept at a 90 degree angle and closer to his body he has the most control of his arms. Therefore by having this device be able to change its size Sean will be able to work in whatever position he finds to be most comfortable. Also by adding the extra features such as the water hose holder, the adjustable pot holder, finished potted plant holder, and needed to be potted plant holder, Sean will be able to do his work with as little frustration as possible.

Each stabilizing component for holding Sean will be as comfortable as possible in that they will each prevent erratic movements as much as possible. This idea will be carried out by having pads which will snuggly fit to Sean’s hips and legs. For Sean’s feet there will be straps to hold them in place. These will be adjustable to fit whatever footwear Sean has on at the time. The base attachments are also very important for Sean’s safety making sure the whole device does not tip over while in use. Wheels on the base will help increase ease of movement for Sean’s parents. These wheels will have the option of locking also for Sean’s safety.

2.2.2 Snow/Sand Wheelchair

The Snow/Sand wheelchair will start with the modification of an existing wheelchair frame. The front axle where the front wheels attach will have to be extended so that the front and back wheels are in side alignment. All four wheels will be modified so that the treads can interlock with wheels so that there is no tread-wheel slip. This will maximize the efficiency and power output by the subject to the wheels and treads.

Short skis will be attached to the wheelchair’s frame via a manual jack. The purpose of this jack is to raise or lower the frame, and wheels/treads, relative to the skis. This would adjust the amount of force on the wheels, making it easy to control how much grip and weight the treads actually have on the ground.
The wheelchair would be self-propelled like a normal manual wheelchair. A propulsion wheel will be added on the outside of each of the back wheels which will allow the subject to control his speed and direction. An outline of the design can be found in Figures 5 and 6.

Figure 5: Snow/Sand Wheelchair Design (Side View)
Figure 6: Snow/Sand Wheelchair Design (Front View)

The wheelchair will also be coated with an anti-corrosion treatment to allow for a longer life and more rigorous usage.

**Budget**

Products currently available on the market which serve a similar function as the proposed designs tend to be very expensive. Standers range in prices from just over $1,000 to more than $5,000. Despite these high prices, the devices are typically limited in function. Standers typically come in three different sizes (small, medium, large) with limited telescopic abilities. For this reason, as a person grows he will usually require three separate standers to accommodate his height. Clearly, this can get very expensive. Similarly, multi-terrain wheelchairs typically cost around $4,000 and usually do not have the possibility of self-propulsion.

Many different options were explored to minimize the cost of the proposed designs. The possibility of buying factory made pads for the foot support, knee support, and waist support was
evaluated. It was quickly refused due to high expenses. Foot supports on their own cost roughly $250 while full waist and hip supports each roughly $500. Correspondingly, the design team decided to make all parts for the standing gardener from raw materials.

An inexpensive wheelchair was found and it was decided that modifying an existing wheelchair would be much more cost efficient than building a wheelchair from scratch. The design team is still looking into the possibility of having someone donate a wheelchair to the design project in order to reduce total expenses. However, for the time being, such a possibility is not available. Table 1 describes the materials the design team intends to use as well as the lowest cost located for these materials.
<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Cost (U.S. dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 304 Stainless Steel Full Bars</td>
<td>- 1.5” Diameter Steel Bar, Cold Finished and Annealed</td>
<td>$173.80</td>
</tr>
<tr>
<td></td>
<td>- 1.5” Inner Diameter/1.9” Outer Diameter Pipe, Cold Finished and Annealed</td>
<td></td>
</tr>
<tr>
<td>- 304 Stainless Steel Round Pipe</td>
<td>- 48” x 24” Steel Plate, Cold Finished and Annealed</td>
<td>$179.68</td>
</tr>
<tr>
<td>- 304 Stainless Steel Plates</td>
<td></td>
<td>$80.00</td>
</tr>
<tr>
<td>High Density Flexible Polyurethane Foam</td>
<td>- 78” x 64” x 2” Premium Medium Firmness Foam from eFoamStore.com</td>
<td>$214.00</td>
</tr>
<tr>
<td>Nylon/Polyester Double Coated Vinyl Fabric</td>
<td>- 72” x 75” Roll of Extra Heavy Duty Fabric</td>
<td>$68.95</td>
</tr>
<tr>
<td>Wood</td>
<td>- Plywood Sheets</td>
<td>$25.00</td>
</tr>
<tr>
<td>Wheel Chair</td>
<td>- Invacare Veranda Standard Wheelchair</td>
<td>$129.00</td>
</tr>
<tr>
<td>Rubber Treads</td>
<td>- Black 4” Wide Robotic Rubber Treads</td>
<td>$150.98</td>
</tr>
<tr>
<td>Skies</td>
<td>- K2 ESCAPE PRO R SKIS 2004</td>
<td>$69.90</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>- Nuts, Bolts, Velcro, Straps, Wood Treatment, Hinges, Hooks, Metal Supports, Metal Car Jack, Metal Clips</td>
<td>$150.00</td>
</tr>
</tbody>
</table>

**ESTIMATED TOTAL COST:** $1241.31

The estimated cost is $1241.31. Even though this is the best estimate possible with currently available prices, this value may slightly increase or decrease as design modifications are made, and material prices change. Considering a low grade stander which sells on the market for $1,000 and a
normal grade multi-terrain wheelchair which sells on the market for $4,000, the proposed designs will cost only about 25% of the total $5,000 value.

**Conclusion**

By keeping in contact with Sean and his family, a good understanding of Sean’s abilities was obtained. An understanding of what options and features will maximize his comfort and production was gained. We hope by making this project Sean’s duties in the greenhouse will be much easier and more enjoyable. Not only do we want Sean’s experience to be more enjoyable but we want his parents’ to be also. Not only will this device cause Sean to be able to do more planting on his own, it will allow his parents to be able to do more gardening not having to help Sean with his gardening.

Since we are modifying an existing wheelchair into a design that is not on the current market, the outcome should be a positive one. The materials that are being used to build both devices are relatively inexpensive, when compared to what products are already on the market that accomplish similar tasks, the cost of these designs is a fraction.

The key criteria of this project is that Sean is safe and is supported while accomplishing the things he needs to complete. These devices will allow Sean to grow, both physically and mentally, in ways that he would be unable to otherwise. The standing gardener will literally grow as Sean grows and will allow him to support his weight on his feet, while giving him stability. The snow/sand wheelchair will give Sean mobility in during the winter and summer months in a way that he wouldn’t have otherwise.