Faces on Design: A Student Perspective on Three Assistive Technology Projects

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***Abstract* – This paper describes three assistive technology projects that were undertaken by the student author. The first took place during the author's junior year and involved the design and fabrication of a wheelchair accessible crib and was done as an extracurricular project. The second project took place as part of the capstone design project and involved creating a piece of specialized physical exercise equipment for a disabled gunshot victim. The last is a project that was undertaken as part of a graduate mechatronic course and involved designing and prototyping a versatile lift for an elderly person. All three of these projects were created with a specific client in mind. With the exception of the last project (still under development), the prototypes were delivered and are being used by the intended client. The educational experience from the student perspectives are related in this paper along with the technical specifics of the projects.**

Index Terms – Capstone Design, Competition Design, Extracurricular Activities, Student Projects

INTRODUCTION

This paper describes three assistive technology projects that the author has worked on for the past 3 years. Through projects like The Stability Enhanced Autonomous Lift for the Elderly (SEALE), The Triceps Workout Station, and The Wheelchair Accessible Crib, the author was able to use the skills he has learned in class to grow with each of these projects and create a device to increase the quality of life for a number individuals.

These projects were each undertaken using a different approach. The first project was an extracurricular project called the Wheelchair Accessible Crib. This project laid the foundation for the author's design experience. The next project was the Triceps Workout Station, completed as a Capstone Design Project. Here the students were able to build upon the basic knowledge they gained from the first project and mid-level engineering courses. Finally the last projects was the SEALE, which was created for a design competition in the context of a graduate course.

THE BOTTOM LINE IS… DESIGN EXPERIENCES ARE REWARDING

A. Through three design experiences, the student has learned the rewards of working on assistive technologies.

I. Engineers are more than technical nerds

In some lights engineers are portrayed as people no more than dorky looking, pocket protector wearing individuals who crunch number on their TI-89 all day long but this does not have to be the case. Engineers are individuals who are design oriented. They are people who can take an idea and make it practical for use in everyday. The projects described in this paper show the design side of engineers, while still stressing the technical nerd side. They help foster growth not only in the educational background of an engineer but also in the creative side. Today companies are looking for engineers that not only crunch the numbers but also will bring fresh ideas to their companies. Student projects help engineering students present themselves as the creative and self-motivated individuals that employers always seek.

II. Engineers have the ability to change lives

Student engineering projects don't need to be created for the sole purpose of assigning grades. Projects can be designed to change the lives of the user. Engineers have the great gift of designing devices to make people's lives better. Students participating in meaningful projects will gain a sense of self worth. The three projects described in this paper brought positive changes to the lives of the intended client.

The first project was an extracurricular project in which a wheelchair accessible crib was designed for an expecting mom. This crib gave the mother a sense of safety and independence, knowing that she doesn't have to rely on someone else to do the simple act of placing her child in a crib. This device helped her overcome the challenges of child care which she faces every day.

The next project was a Capstone Design Project, where an upper body workout device was created for a person in a wheelchair. This device is called the Triceps Workout Station and is used to strengthen the triceps and shoulders of the individual. When confined to a wheelchair, upper body strength is needed to transfer oneself to and from their chair. By creating an easy to use device like this, the user is more self sufficient and not dependent on others around them. They can work at their own pace to achieve the final goal.

The most recent project was the SEALE. Students created a device to meet one specific need but in turn, created a device that can help many different people. The SEALE is a device used to assist a client off the ground after

he/she has fallen. Independence is one quality that people value at any age, especially the elderly. With the use of the SEALE, the client doesn't have to worry about being alone and she can live a more independent life style.

III. Learn the satisfaction of making the client happy

Normally in college, projects are just an ends to a mean, the students gets a project, completes the project, and then graduates. Many tend to miss a major component in this process, which is human interaction with customers and clients. All three of these projects had a face behind what was designed. The students are able to see the happiness on their faces when the projects are complete or the disappointment when they didn't succeed. The satisfaction of the client is a better motivation than any grade they will ever receive in school.

The Triceps Workout Station affected the author the most. The first time he saw the client use the device, there was a sense of shock and amazement that came over him. The client couldn't believe that a person he has only known for the past couple of months could have designed a device like this for him. The client acted as if opening a present that he has always wanted and just can't wait to play with. This satisfaction has led the author to participate in other design projects and he wishes other people can feel the way he has felt.

B. Tailor design projects to grow with the students

One major difference between these three projects is in the approach they were completed in. The Wheelchair Accessible Crib was the first project that was undertaken and was an extra curricular project. Extra curricular projects are good because they help teach the individual time management. Working forty hours a week or going to class fulltime is enough work by itself but by throwing on top a project like this, the students can learn what time management really is. There is no waiting until the last minute to complete this project when there are things to accomplish. There were a lot of times when it was tough for the author to get started on this project after working a full eight hour work day but he knew that he had to get it done, if he liked it or not.

Also, this was a simple project, in terms of design. Here the students could get their feet wet in the design process. They were able to start forming the engineering mind set and use the basic ideas they have learned in the first couple of years in school.

The Triceps Workout Station was the next project completed. This was a Capstone Design Project completed during the author's senior year. Capstone Projects are good because they provide a disciplined scheduled approach. They help teach the idea of completing smaller projects as milestones towards the completion of a larger one.

This project continued to grow with the team members. They started off with just a modification of a wood device to create a whole new design using metal and different joining methods. This team was able to use information from their higher level classes to create a more robust design.

The SEALE was the third and final project the author participated in. This project was done as part of a competition. Competitions are good because students learn the idea of streamlining to hit a deadline. There were things the team could have done to make the device better but that would mean taking more time and time is very valuable in competition. A balance between benefit and time consumption is needed to make the best possible device.

This project was the highest on the difficultly level of the three projects. Here the team took knowledge from two engineering disciplines and combined it to produce an intelligent device.

By tailoring projects to grow with the students they will be able to take more out of these projects. They will see the meaning behind the things they are learning and will have practical experience over this information.

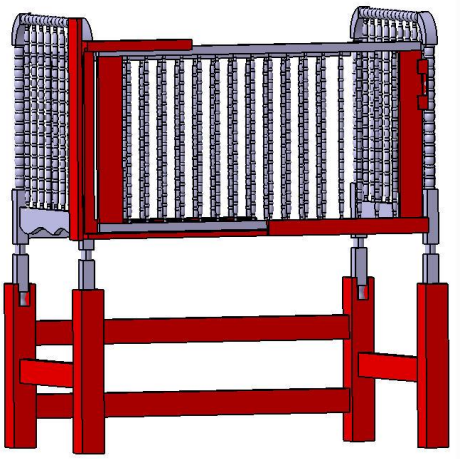
This article describes the author's experience on these three design projects.

PROJECT: HANDICAP ACCESSIBLE CRIB

The goal of this project was to provide a child care provider in a wheelchair with a suitable baby crib. A redesign of an existing crib was necessary because the majority of commercially available cribs have a vertically sliding front face. With this vertically sliding front, a child care provider in a wheelchair cannot safely reach to place a baby in the crib. The front of the crib drops part way in order to protect the mattress of the crib and a person in a wheelchair cannot get his/her arms over the rail to lay the baby down. A second problem concerns how close a person in a wheelchair is able to get to the crib. If that person tries to wheel straight up to the crib, the knees would obstruct him/her from getting close enough. If this user tried pulling up to the side, he/she cannot physically get one's arms over the side. These difficulties were all taken into account when conceiving the design for this wheelchair accessible crib.

Taking in to account all of these main concerns led to creating a horizontal sliding front faced crib that is raised 24 inched of the ground. By raising the crib off the ground, it allowed a wheelchair user to fit under the crib, just like sitting at a desk, and place the child in at a close and safe distance. With the horizontally sliding front face, the wheelchair user can gradually open the crib door and control how much it is open. The ability to manage the size of the opening is a critical safety function. A picture of the completed Wheelchair Accessible Crib is seen in Figure 1.

FIGURE 1
HANDICAP ACCESSIBLE CRIB



Two of those cribs were created. The first crib was created for a single mother living in Kalamazoo, MI. She used crutches when she wanted to walk, but could not walk and carry her baby at the same time. This meant that she needed a wheelchair to carry her baby around the house and a crib she can use while in the wheelchair. By the time that the crib was finished, she has had her child for a couple of months and already experienced how difficult it was to take care of a child when in a wheelchair. As a matter of fact, the baby had been sleeping in a car seat until the crib became available. The second client was a disabled mother from Ypsilanti, MI. As the design was already available, the crib was done and waiting for the baby when he came home from the hospital.

Creating and personally delivering and installing these two cribs meant a lot to the author and the rest of the team (the author was part of a team of students and faculty who were involved). The team felt that they were able to help someone in need of a much needed technology and to give a baby a safer and better start in life. One never knows, but these children might someday grow up to be future engineers and design devices for someone else, just like what this team did for them.

The experience of this work was very valuable from the author's point of view. This has been a very worthwhile and highly recommended extra-curricular activity. Even though these two projects seem the same, the experience was completely different. During the first rendition, the team was responsible for the actual design and building of the device. This provided important insight on what needs to take place for an idea to become a reality. Everyone can have a vision of what something should look like and how long it takes to design and build a product. However, it is a very different story when the work actually takes place. That is a critical and valuable experience.

The second rendition, which took place a year later, was a very different experience. In this case, a design already existed along with feedback from the first client and lessons learned. The author's role was primarily to document the redesigns and a builder's guide for the crib. The lessons learned from this activity involved the need to pay attention to details and to effectively manage time, especially in the absence of deadlines. Creating a builder's guide required looking closely at every aspect and detail and communicating these to the builder. Also, the work was very flexible and that gave the author more independence but required setting personal deadlines and motivating oneself to get it finished. There were no team members pushing to get the work done or even helping to get it finished. The author had to manage the personal time and energy after working a full day as a co-op. The motivation has always been the knowledge that there is a person who is counting on the work to greatly improve their lives.

Success in the real world means being to get things done without relying on direction and hand holding. Extra curricular projects like this can help teach the valuable skills of time management and motivation. There were many times that the author did not want to work on the project but having a picture of the disabled mother with a newborn was motivating. That encouraged the author to produce the best possible device.

PROJECT: TRICEPS WORKOUT STATION

The goal of this project was to create a device to strengthen the triceps and shoulders of a wheelchair bound individual. The client specifically wanted to strengthen his upper body because he wants to more easily transfer himself from his wheelchair to another chair.

The Triceps Workout Station began with a connection to the Michigan Rehabilitation Services and a dream from one man that someday he will have the opportunity to live a somewhat normal life. They came to the students with the task of designing a device that would help increase the marketability of this man to future employers or help him with everyday tasks.

The team's client was a male quadriplegic who has been confined to a wheelchair for the past several years. Having a specific user in mind they were able to ask him what he would like in a device. During the first meeting the team had a game plan in mind and already a prototype built to see his thoughts of the device. This device was almost immediately shot down but they didn't see this as a failure rather, this was more of a learning process. If you are designing a device you better go out and ask questions to your potential market base. In this case the market base was the client. He was the one who is going to be using the device.

After this initial meeting they were now able to design a device to meet the needs of the client. This device was the Triceps Workout Station in which the user would either back into the device or pull forward into it. They would then place their arms on the two padded lever arms and press down. These arms are connected to two shock dampers, which provide resistance for the user. Making them a standard part, we were able to obtain a variety of resistances for the user. The shock dampers and the lever arms are connected to the spine of the device. This spine has multiple pin locations to

adjust the height of the device. A picture of the completed Triceps Workout Station is seen in Figure 2.

FIGURE 2
TRICEPS WORKOUT STATION

By creating this device in a class setting over an eight month span this team was able to change the device many different times. In some respect this was good, with more than enough time to design it, build it and deliver it. In the author's mind this wasn't so good; this meant that the team had more than enough time to change the scope of our device multiple times. The constantly changing device reduced the overall time from eight months down to four months and it put pressure on the team to complete it. The first four months were spent on the design phase of the device. During this time, the team created deliverables such as QFDs, DFMEAs, and reports to focus on the areas of concern or assessments of designs that were abandoned. The author recommends the importance of exploring all possible areas and researching the market base before getting too much development time in one concept.

One of the many valuable things the author has learned from this project is how to follow a deadline driven and disciplined approach. Every step of the way, goals needed to be completed before the work can proceed. This helped the team stay focused on the plan ahead, and learn what it takes to complete a design project at this large a scale. Also, it made the end result a lot easier. There was no rushing around at the very last minute to complete a report as the pieces were already done and now simply needed to be put together.

PROJECT: THE STABILITY ENHANCED AUTONOMOUS LIFT FOR THE ELDERLY (SEALE)

The goal of this project was to create a device to lift an elderly individual who has fallen to the ground. This device is created to be an assistive device that will still rely on the strength of the user.

The SEALE started off from the prior experiences of the author and the team, an initial meeting with the client to figure out what she needs in a device. This client was an elderly lady who wanted to remain in her home and live by herself. She wanted this device to help her keep her sense of independence, knowing that she will be safe getting up on her own. Currently, the way she would get to her feet is by crawling to the basement stairs, throwing her feet over the steps and pushing herself up with the handrails. After hearing this description, the team agreed that she couldn't keep doing this because one day she might slip and fall down the stairs.

To address the needs of the client, the team created the SEALE. The SEALE is a lifting mechanism mounted to a standard medical walker. This walker has two DC Motors mounted on the sides. Attached to each motor is a harness with pressure sensors to sense the position of the user during the lifting cycle. In order for this device to work, the user will crawl to the walker and slide their bottom onto the harness. When in position, they would put their hands on the hand grip sensors to start the lifting process. Once the hands are released from these sensors or the harness has gotten to the top, the device will stop. A picture of the completed device is seen in Figure 3.

FIGURE 3
SEALE

One of the main reasons that the user is lifted from their bottom instead of their shoulder is from the input received from the initial client meeting. The client has two torn rotator cuffs and any force on the shoulders will cause pain. Without this initial meeting the team would not have known about this major problem. This is just one of the many reason that an initial client meeting it important to do in the design process.

The SEALE was developed as part of a competition. The hardest part was delivering a final product in the short amount of time. Competitions are a good way to learn the idea of streamlining a design and meeting deadlines. One has to realize how to plan and execute ideas in the best possible way. This experience showed the author that there are always things one can change on a device but one needs

to know what should be done and what can be done later. The author recommends students take part in competitions because they give the students a taste of what it might feel like in the real world. There are times when one is working for a company and you are pressured to finish the job in a less than ideal time frame.

CONCLUSION

Three design projects involving assistive technologies have helped the author grow as a student in the engineering field. The projects taught the author and the various teams the skills needed to succeed in the profession and in life. The author made the most of his experiences on these three design projects and is a better engineer as a result.

The author recommends that engineering students partake in three approaches to student design projects: extracurricular service based projects, capstone design course projects and advanced competition based projects. The extracurricular project taught the author the need for time management. The capstone design project taught the author the benefits of a disciplined and scheduled approach. This project showed the author that the best thought-out plans can fail and one has to know when its time to move on and change the scope of your project. The competition project taught the author to streamline his design to hit a deadline and to avoid the temptation of adding bells and whistles, since in reality there might not be enough time to finish the project.

Also, instructors should create design projects to grow with the students. This is seen in the projects the author has participated in. They started off as simple projects that beginning engineers can complete, and move to higher level projects in which knowledge from these courses can be used.

Each of these design approaches provided a different learning experience in which all these skills combine to produce a well rounded engineer. These experiences were very valuable and the author is very grateful that he had the opportunity to participate in these three design projects.

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