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In the Pursuit of Assistance: A Team's Desire to Not Let a Congenital Amputation Get in a Young Boy's Way

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families. The benefit of serving at the ReStore is both to one's own learning and service to the community. You have the ability to see firsthand how a donation center runs and know that you are playing a role in reducing housing instability. Before volunteering at the ReStore, I would advise students to research housing instability and what it means for the people involved. I would know the ReStore's mission before volunteering, as it will help direct your service.

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In the Pursuit of Assistance: A Team's Desire to Not Let a Congenital Amputation Get in a Young Boy's Way

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Student Author Bio Sketches

Carl Russell III is a second-year student at Purdue University studying Biomedical Engineering with a concentration in premedical studies and a minor in chemistry. He is currently participating in a co-op education experience at Zimmer Biomet. He has participated on the Biomedical Engineering EPICS team for two semesters.

Gavin Loucks is a first-year student who began his work with project partner William Sevick on the BME EPICS team in the fall of 2019. Currently, he is completing the first-year Engineering program at Purdue, but he will soon be transitioning to a major in Civil Engineering. He is passionate about the environment, and eventually hopes to work on improving hydroelectric power systems across the United States.

Kirsten Wozniak is finishing her second year of undergraduate studies in Biomedical Engineering. She is also active in programs such as Timmy Global Health and Purdue University Dance Marathon. Her career goals for the future include cross-cultural engineering in the global health field to assist in needed areas of the world.

In this article, they discuss the team's collaboration and impact with their project partner, William Sevick. The article also mentions other opportunities with the EPICS team and projects that are currently ongoing.

Introduction

The Biomedical Engineering (BME) team in EPICS is a service design team dedicated to assisting community partners through addressing medical problems and providing biomedical education. They are a small portion of the over 500 students in EPICS at Purdue University (Teams, n.d.). EPICS is a program run through the Purdue College of Engineering to foster design and teamwork skills while also providing for those in the community. There are currently 22 students on the Biomedical Engineering team (EPICS: BME, n.d.).

The BME EPICS team started at Purdue in the spring of 2017. One of the groups in the BME team is dedicated to designing assistive devices for a six-year-old boy named William. The partnership started with the help of his neighbor, Karen Hubbard, a Purdue Biomedical Engineering student, who approached the BME department with an interest in having a project dedicated to helping William with his disability. The BME EPICS team was a good fit for the project. The group has currently designed two devices for William with the hope of improving his life: a playing card holder (Figure 1) and an assistive bike device (Figure 2).

Students of various levels of education, from freshman to seniors, with various experiences and academic disciplines make up the team. They work with William to develop these assistive devices and make everyday activities easier.

Figure 1. A group picture with William and the spring 2019 BME EPICS team, taken after one of the team's design reviews. William is posing with his new card holder. Image from Shannon Sevick.

Figure 2. William and Gavin Loucks posing with a prototype of the bike attachment. Image from Shannon Sevick.

Community Partner Description

William Sevick is a six-year-old boy from Indiana who loves the Avengers®, playing video games, and riding his bike. He lives with his mother, Shannon; his father, Frank; and his sister and brother, Trinity and Brenner. He has a congenital arm amputation that allows him the use of his upper arm and some of his forearm. He is the main stakeholder of the team and the designs are all made with the intention of making the things that he does every day easier and more efficient.

The vision of the team is to provide assistive devices for William so that he may live his life to its fullest potential. One of the cornerstones that is critical to the success of that vision is the constant collaboration with William and his parents. The first step of the design process with William is to address a need or a struggle that he has in his day-to-day life. His parents communicate this to the team, and they get to work. The team makes sure to talk with the parents to see how to address his needs specifically and not to pursue their own vision of the project. William's needs are the foundations of future projects. For now, there does not seem to be need for future projects. However, if a need does arise, the team will be there to assist William.

Impact

Throughout the time the team has been partnered with William and his family, they have designed multiple devices that assist William in his daily life. The first device that was designed for William was a prosthetic arm (Figure 3), which was modeled on an existing design called The UnLimbited Arm v2.1—Alfie Edition (Thingiverse.com, 2016). This was created with the intention of testing William's comfort level with wearing a prosthetic. Following this, William's parents told the team that William had some problems eating and drinking during his meals. So, the team set out to create some prototypes that they thought would help him. They ended up designing several prototypes that would help him with tasks such as drinking water, eating with utensils, and eating a sandwich or hamburger. The only prototype that William seemed to find the most useful was the attachment that helped him eat a sandwich. He, his parents, and the team then moved on to other aspects of his life.

When figuring out how to better affect other aspects of William's life, the design team pivoted to address some of his other interests. At that time, in the middle of winter, William loved to play cards with his family. His mother said that his favorite game was UNO®. The team decided to focus their next design in that direction.

Figure 3. William tries on the prototype of the modified Alfie arm while holding a cup. Image from Karen Hubbard.

To assist in creating a successful design, the team employed use of the EPICS design process, a standard process that all EPICS teams use to ensure the creation of a well-made design while still working within the specifications defined by the project partner (Figure 4).

Initially when playing cards, William would hold his cards with the support of his chest. This would allow only a minimal view of the cards in his possession. To alleviate these problems, the team created a prototype card holder that would attach to the existing prosthesis previously designed by the team. This proved to be a successful approach and William enjoyed playing cards with this new assistive device (Figure 5). With their prototype complete, the group shifted their efforts to work on a project that was on the back burner: to help William ride a bike.

The bicycle prosthetic was intended to sit comfortably against William's arm and allow him to ride a bike smoothly and be able to pull his arm out of the device in case he fell. The device consists of three main components, each presenting its own challenges to overcome (Figures 6 and 7). It was made of a clamp that would grip the bike handle, a joint piece that would allow rotation while being durable enough to sustain constant pressure, and a sleeve piece that allows for comfort while not being too tight. The sleeve, joint piece, and clamp were fabricated with ABS plastic from a dual extrusion 3D printer. The designs were modeled in Autodesk Fusion 360®. This 3D printer allowed for a tolerance of ± 0.005 in. or ± 0.0015 in. per inch (whichever is greater) of specified measurements (Stratasys,

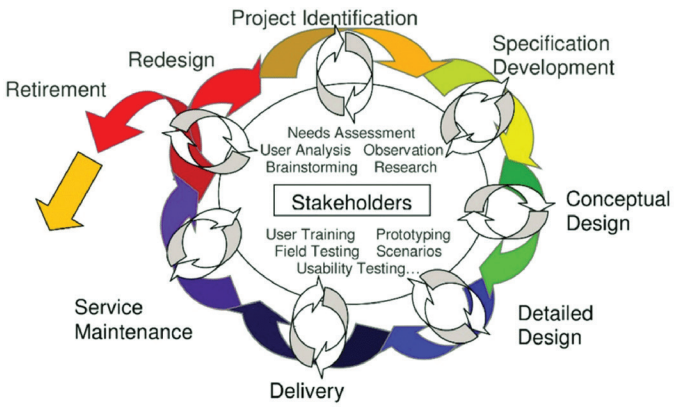

Figure 4. The EPICS design process flowchart. Image from EPICS—Purdue.

Figure 5. During a visit with the BME team in the spring of 2019, William tries on a prototype of his cardholder. Image by Carl Russell.

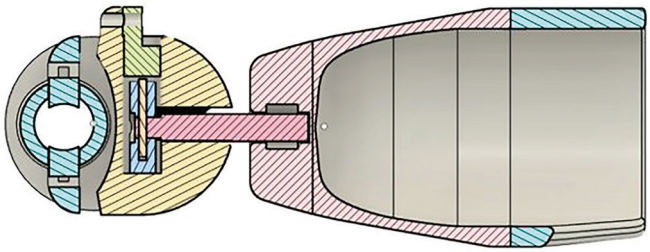

Figure 6. Cross-sectional view of the bicycle prosthetic. Image by Carl Russell.

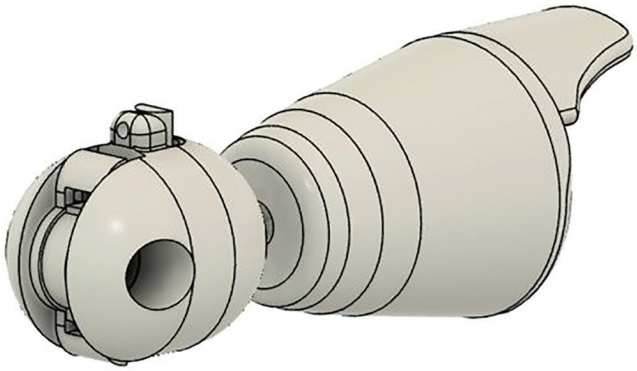

Figure 7. Angled view of the 3D rendered prosthetic device. Image by Carl Russell.

2013). To ensure the sleeve had a proper fit, the team measured the dimensions of William's residual limb and the distance needed to match the reach of his other arm. The team also made sure that the sleeve allowed William to have a natural range of freedom while riding the bike. The metal pin that connected the joint piece and the sleeve was manufactured using wrought aluminum in a 5-axis mill with the CAM programming being completed in Autodesk Fusion 360®. The 5-axis mill allowed adjustments in increments of 0.001 inches of desired dimensions (Haas Automation, 2020). The metal pin was originally designed to be an ABS 3D printed joint; however, during force simulations, the largest number of failure points were found to be at the pin location.

The prototype that was proposed at the end of the fall 2019 semester was a 3D printed clamp, joint, and padded sleeve (Figure 8). Upon initial validation with William in December 2019, the clamp was found to be too loose. However, he and his parents seemed to like the design and are looking forward to the final prototype.

Figure 8. William trying on a prototype with the assistance of Kirsten Wozniak during a visit to Purdue in March 2020. Image by Delaney Sunbury.

Opportunities

At the current moment, the team is due to deliver the finalized bike attachment prototype to William and his family in the middle of the fall 2020 semester. They plan to have improved the clamp design and to have finalized the aesthetics to William's liking. Once completed, delivery will mark the conclusion of the project and future teams will be responsible for future remediation. There is always the potential for more work for William. However, much of the work in the future will be with the other projects on the BME EPICS team.

Currently, there are three alternate projects on the EPICS team. One team is developing an automated CPR device to support first responders in underserved communities in Ecuador to provide effective CPR during long transits. Another team is developing a child-resistant weekly pill-minder device that also provides easy access for the prescription user. The third is creating a game modeled after Flappy Bird (Flappy Bird, 2013) that takes inputs from muscle contractions. Each week it is expected that a team member commits to a two-hour lab with two hours in outside lab work. Team members are also expected to document details related to their personal contributions to the project. If any of these projects happen to be of interest, contact the EPICS office at epics@purdue.edu.

Reflection

Carl: Working with William has been an amazing experience. He and his family have been so kind and open to new ideas. I have enjoyed contributing my own ideas to the designs that he uses. Working on this team has brought unique and difficult challenges. It has exposed me to new skills, experiences, and opportunities that I would not have had without this opportunity. I encourage anyone who is interested in design, project management, and medical applications to seek opportunities like this. It is a unique approach to service, and you can learn skills that can apply to future endeavors.

Kirsten: As a sophomore in Biomedical Engineering, I was interested in William's team from the beginning. This is now my fourth semester on the team and second semester as design lead. From an engineering perspective, this project has given me the insightful experience needed to help me achieve my future goals in the medical field of engineering. Working with William and his family has been a wonderful experience in learning about human-centered design while meeting the needs of those in our very own community.

Gavin: In the time that I've worked with William, I can count on both hands the number of times I've seen students, faculty, and staff alike watch in awe as they see him riding his bike with the biggest grin on his face. This project is the perfect example for showcasing just how impactful the work of EPICS can be on the lives of community partners. Not only has the project had a positive impact on William, but it has also been impactful in so many ways to all of those who have worked with him. Personally, working with William gave me valuable experience in working on a collaborative engineering team, as well as experience in communicating with community partners. When I began working with William, I had little to no experience in anything engineering related, but the skill I found to be most useful during the project was perseverance. Hardship is inevitable on engineering projects, but it is in overcoming those hardships that incredible things can happen.

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