Team Victory Lap Design Brief

Problem Statement

The Meyer family is in need of a customized adaptive tricycle for their daughter Fiona, who has agenesis of the corpus callosum (ACC). This condition affects her motor skills, strength, speech, and coordination due to lack of communication between the two hemispheres of her brain. Currently, Fiona has limited coordination, which makes it difficult for her to ride her current tricycle; she struggles to keep her feet on the pedals and steer on her own. The family would like a tricycle Fiona can use to improve her strength and coordination, while participating in a recreational activity with her family.

The adaptive tricycle must be attachable to any standard bicycle with minor modifications. It must be stable, safe, and able to be controlled by the supervisor. It should be adjustable to provide maximum therapeutic benefit and adaptable to Fiona's growth and development for at least three years. The device should be able to be used on flat, paved surfaces.

Methods/Approach/Solutions Considered

As a team, we followed the design approach outlined in our Senior Design class. This class runs throughout the entire school year. The design approach was split into five phases.

The first phase, problem definition, includes creating the customer needs statement and requirements, researching and benchmarking the defined problem, and identifying the specifications our design must meet. We began by working with our customers, the Meyer family and Fiona's physical therapist, Dr. Sara Needler. Through discussions with the two parties we are able to define Fiona's needs for an adaptive tricycle. Our design team performed research into current adaptive tricycles on the market, laws governing such products, Fiona's disorder, and the biomechanics of those with ACC. With knowledge gained from the discussions and research, we worked together with project mentors and our customers to finalize our design specifications.

The second phase, conceptual design, included patent research, concept development, and then narrowing down the concepts based on feasibility and our design specifications. Patent research provided insight for several of our brainstorming sessions. From these brainstorming sessions, we created five concepts. Through several decision matrices, we were able to develop a concept based on the best components and subsystems, as well as the feasibility of the design. From these decisions, our plan was to build a custom frame, manufacture custom adaptive pedals, add removable handlebars, and use a removable tow bar attachment.

The goal of Phase Three was to further develop the overall concept by forming a detailed prototype design. During this phase, we performed several forms of analysis on our design including DFMA (Design for Manufacturing and Assembly), FMEA (Failure Mode Effects Analysis), and Value Added Analysis. During this phase, and through our DFMA and Value Added Analysis, we determined ways to make our design more feasible. We decided that purchasing a bicycle frame and a complete rear axle assembly provided higher reliability,

lowered overall design costs, and reduced possible failure modes compared to designing and building our own frame. While in this phase, we also created and proposed a budget to continue with material purchases to begin prototype production. During this time, we purchased major components, such as the complete rear axle conversion kit and a suitable bicycle frame for Fiona.

The design finally comes to life during Phase Four, prototype construction and testing. In this phase, the prototype design is tested and retested until a fully functioning prototype is produced. During this stage, we worked as a team to convert the bicycle into a tricycle. Upon completion of this task, the team met Fiona and her family to test the unit, making notes and measurements of current and future adjustments to produce a highly adaptive tricycle for Fiona. Other refinements were made, such as modifications to the components we ordered that made them more adaptable or user friendly. Through four separate test sessions, we were able to work with Fiona to produce an operational prototype that is fully adaptable to Fiona and her growth potential over the next three years. Also, during this stage, we worked diligently to write a user manual that provides adequate instructions for using and maintaining our prototype.

The final phase of the process, Phase Five, involves documentation, demonstration and evaluation. This includes updating the design specification sheet that was determined in Phase One, evaluating the performance of our final prototype relative to the specifications, and creating a Manufacturing and Assembly Plan. We are also finalizing our estimates for the overall cost of building our prototype, including material costs and labor involved. Upon completion of these tasks, the prototype will be delivered to Fiona and the Meyer Family for their use and enjoyment.

Description of Final Design/Approach

Our final design combines a properly sized bicycle frame selected by Fiona, and a tricycle rear axle. Purchasing these major components instead of manufacturing them enabled us to allocate the majority of our time to making the tricycle more adaptable for Fiona. Adaptations include an extended, ergonomic handlebar, quick-change back rests, and full foot support pedals. The handlebars were welded in a configuration that allows Fiona to comfortably reach and use them to steer the trike. They are attached to the original handlebars using clamps so that the adaptive handles can be removed if necessary. It was necessary to incorporate two different backrests: one provides lower back support for independent riding, the other full back support with a harness for when Fiona is being trailered. The new pedals included toe straps and heel cups to hold Fiona's feet in place.

Other adaptations include a trailer arm that allows the Meyers to tow Fiona while they are riding their own bikes. It lifts the front wheel of Fiona's trike off the ground and locks out the front wheel, turning the handlebars into a rigid support Fiona can use for balance and stability. The trailer arm can be attached or removed using quick release pin connections, and it can be stowed on the adult bicycle when it is not in use.

Outcome/Feedback

Based off initial feedback from the Meyer Family, they are overjoyed with the prototype that has been built. During our teams' Demo Day presentation, Fiona's father, Lenny Meyer,

spoke about the importance of the project to the family and the long term impact that this will have for Fiona and her development. This prototype will give the Meyer family the opportunity to enjoy recreational activities together and allow Fiona to continue her physical therapy exercises, which aid in the development of muscle strength and coordination.

Cost

We have provided an estimation of the overall costs related to building prototype. We have separated the costs based on material and labor costs.

Table 1. Material Costs related to building the prototype.

Item	Qty.	MSRP	Shipping/Tax	Total Cost
Tricycle Rear Axle Assembly	1	$329.00	$50.00	$379.00
Bicycle	1	$229.00	$0.00	$229.00
Bicycle Tow Bar Material	1	$150.00	$0.00	$150.00
Lower Back Support Bicycle Rest	1	$73.50	$0.00	$73.50
Full Back Support Bicycle Rest	1	$42.98	$9.95	$52.93
Push Bar	1	$50.00	$0.00	$50.00
Schwinn No Pressure Bike Seat	1	$19.99	$5.88	$25.87
Basket	1	$18.18	$10.00	$28.18
Handlebar	1	$71.42	$0.00	$71.42
Pedals	1	$59.08	$0.00	$59.08
Total				$1118.98

Table 2. Costs related labor including design, fabrication and assembly.

	Design	Assembly	Fabrication	Testing
Total Time	120 hr	15 hr	10 hr	10 hr
Labor Rate	$35	$15	$19	$35
Overhead Factor	2	2	2	2
Equipment Factor		0.5	0.5	
Total				$ 10,081.25

Based on these calculations, the overall cost estimation to produce a single prototype is $11, 200.23. The $10,081.25 for labor costs represents our team's contribution to creating a customized adaptive tricycle that will be donated to the Meyer family, while we gained a valuable learning experience.

Significance

The purpose of building a tricycle for Fiona was to develop her mobility and allow her to ride with her family on the Athens bike path. Since Fiona requires a specialized device for her condition, creating a tricycle that allows her to enjoy a simple pleasure that is often an important part of childhood is incredibly meaningful to her and her parents. Our team has learned more than we ever anticipated through our interactions with Fiona and the process of building a tricycle specifically designed for her. Working with a customer that has limited communication taught us to pay attention to minor details, like her body mechanics and reactions to different adjustments we made.

We also think it is important to point out that several of the adaptations we made to Fiona's tricycle could be implemented in various applications by different users, such as the trailer arm for users who are unable to control their own device, or custom handlebars for riders who struggle to reach or effectively use existing handlebars. They could also be modified and personalized to meet the needs of other patients.

Acknowledgements/References

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We would finally like to thank Fiona and the Meyer Family. It has been an incredible opportunity to work with them throughout the year. We appreciate all of the support and time they have given us to help us bring our design to life. It has been an incredible pleasure for our team to witness Fiona's joy when riding or being pulled on her tricycle.