Illinois Institute of Technology
Inter-Professional Project

FINAL REPORT

Section 312:
Exercise Technology for Disabled People

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Introduction

At this point in time, exercise technology for people with disabilities is a burgeoning field. Handcyles are among the most popular as a result of their versatility, being used for both recreational as well as racing purposes. Although handcycle designs vary greatly, a common factor for all is the fact that they accommodate only a single rider. For this reason, IPRO Section 312 is focused on creating a functional tandem handcycle designed to accommodate people with and without disabilities. The handcycle is meant to be used for recreational purposes and could possibly be marketable at some point in the future.

The IPRO Team consists of eight members, coming from the Illinois Institute of Technology MMAE, MBB, CHE, and ECE Departments as well as the Institute of Design. The team worked together using their varied backgrounds to design and build the tandem handcycle. This reports serves as the documentation of the semester's progress.

History of IPRO

Exercise Technology For Disabled People is an IPRO that first started in the spring semester of the year 2000. The original goal of this IPRO was and still is to investigate the technical and market feasibility of the concept for a new exercise technology. This technology represents an innovative extension of currently available handcycle systems. The unique aspect of this new concept was the potential to involve people with disabilities and those without disabilities in a common exercising experience

at the same time. This would lead to developing a prototype and testing it with the intended user populations. Unfortunately, all the work that was completed in the first semester was lost which made this IPRO quite a challenge for the next semester's students.

The fall semester students came into this IPRO facing many problems. Their immediate goal was to design and create a working prototype for the first tandem handcycle. One of the first considerations for this group was the frame of the bike. They debated and researched all that they needed to in able to find a supportive, inexpensive and efficient way to build the frame; taking in all the considerations of weight, aerodynamics and resistance. The group decided on a three-wheeled tandem handcycle: one wheel in front, two in the back. The prototype used a front chain drive. By the end of the semester, the group accomplished their goal and finished the first prototype of the tandem handcycle. However, the current IPRO students have chosen to go in another direction with the design and the first prototype serves as step towards attaining the final goal.

Problem and Objectives

During the first few weeks of the IPRO the definition of the problem was an evolving one. Originally, the plan was to design and construct the entire handcycle from scratch, however this is an incredibly significant task and unreasonable to expect to accomplish. Also, the initial research performed led the group to decide that the ideal of building a tandem handcycle that couldn't be broken down for easy transport and storage wasn't the best design. Therefore the original objective was revised to focus on the

design and creation of the hitch and the tandem attachment for the handcycle. The comfort and safety of the design was also taken into account through behavioral testing, research and hands on experience. Focusing on these issues and concentration points, our ultimate goal for the semester was to design and build a functional prototype attachment for a pre-made handcycle.

Approach

The entire group worked together to fulfill the tasks set forth on the original timeline. Meetings were scheduled for once a week as a full group, with weekly goals being set and progress reported. At the midpoint of the semester, it was decided that sub-groups be formed to focus on both design issues and behavioral modeling. Each group's progress is described in detail in the following sections.

Behavioral Group

The members of the behavioral group were focused on researching the different aspects of the design from the user's perspective. This included performing ergonomic research, riding different types of handcycles, interviewing distributors as well as riders of handcycles, and finally creating a behavioral prototype to test different design possibilities.

Over the course of the semester, the members of the behavioral prototyping group visited a bike shop specializing in handcycles as well as attending an adaptive sporting event. To understand the structural design and general mechanics of handcycles and other tandem cycles, the behavioral group attended an event at Great Lakes Naval Base.

This event hosted different bikes from Creative Mobility, a store specializing in wheelchairs, adaptive bikes, and bike equipment.

Many different types of bikes were featured at the event. Each bike had a unique design, and these designs were noted so we could incorporate it into our finished product. To get a good design for our tandem handcycle, different tandems were ridden to feel the comfort level and positioning of the body. The group noticed that the level of control changed depending on whether one was in the front or in the back of the bike. The tandem designs were also helpful in designing both the placement of the gears and a better hitch for the finished product.

The group also got to experience riding the different designs of handcycles. Each handcycle was different in the way the body had to be positioned to turn around corners and adjusting to the seat. We had to take in consideration, that depending on the type of disability, one might have more control of certain parts of their body than others and was used for the ergonomics study. We found that the handcycles that were closer to the ground felt safer. The steering also played an important role in what was more comfortable for the rider. By not having to move much of one's body to turn the bike felt safer and the handcycle was much easier to ride.

The information gathered at this event was brought back to the full group and incorporated into both the engineering designs issues as well as the behavioral prototyping session.

After testing out different bike designs, it was decided that a behavioral prototype would be built and tested in an effort to ascertain the range of comfort levels of potential users. This prototype was built from wood and mounted upon a wheeled cart. Its design

allowed for changing the yaw movement and inclination of the seat in order to determine the best design for the prototype. Testing and interviews were conducted following Institute of Design standards and policies. Seven individuals were tested with varying levels of success. The people tested for the most part felt relatively unstable and unsafe when seated on the prototype. It was difficult to safely lean into the turns and this made the prototype difficult to accurately test. The information gained was taken into consideration when deciding upon the final design.

Engineering Group

First and foremost, we had to figure out what the objective of our group was going to be. We knew that our goal was to build a tandem hand cycle, and that it had to meet the expectations of our advisors. The group decided that the best approach would be to start from scratch. The prototype from last year's group could then be used for parts in making our design.

The final design was a culmination of many things. The behavioral group gave us insights as to what was comfortable and appealing in the ergonomics aspect of the design. A few different designs were brought up to the group. Designs came from both the behavioral sub-group and the engineering sub-group.

As a group we then went over the pros and cons of each design. Some designs had too many engineering problems associated with them, and others were not what the sponsors had in mind. The group debated on which designs should be implemented. The group came up with some general design concepts that should be applied to the prototype.

Some designs ideas were voted down. One was where the wheel would be placed. We thought about putting the wheel in front of the rear rider, but we felt this

would cause too much stress in the back end. Another idea that did not make it into production was that the pedals would be located under the rider. The sponsors felt this was a bad idea since it would cause using the same muscles as that of a wheelchair. One last thing that did not make the cut was a single drive connecting both the front and back wheels and drives. The chain routing would be too complicated and unreliable.

On the other hand the following made it into the final design. The back end of the cycle would be attached using a hitch so that radial and torsional movement will be allowed. This was decided so that the person in back would feel comfortable and in control of the rear end. The group decided on a simple pin hitch for now to save time. Later designs may have a ball hitch.

Also for comfort the seat should be set at a forty-five degree angle for the back and it will be mounted on springs. The angle of the seat was found to be the most comfortable by the behavioral group. The springs will allow the back rider to lean into the turns like the front rider. This makes the rear more comfortable and safe.

Other considerations that went into the design were the geometry of the rear frame, placement of the back tire, and location of the center of gravity. The group decided that the center of gravity for both the front and rear should be the same. Therefore there are less engineering problems to run into. The placement of the rear wheel was debated for a while but we finally decided on a behind the seat placement rather than in front of it. The geometry of the frame is almost a reverse image of the front. The seat to pedal distance and the pin to wheel distances are exactly the same as the that of the front part.

The engineering group then took all of these concepts and modeled the whole hand cycle on AutoCad. This 3D model was then placed into a stress analysis program to see if the design was sound.

With the help of a professor this was all accomplished. We then optimized the design and altered some geometry until the design was safe and practical. This is the design that we modeled for this presentation.

Final Design

Future Considerations

During the semester, the hitch design was focused upon the most. Thus issues still remaining for future IPRO semesters are those of gears, brakes and improved steering to name a few. Another consideration is the marketing aspect of the design. Although the goal at this time is to create one functional product, it could easily be marketed to a larger population. Turing the IPRO into an Entrepreneurial Professional Project (ENPRO) is one possibility. Research has shown that a patent for the design does not exist at this time and this could be the objective of an ENPRO group.

Conclusions

Appendices

ATTACHMENT A.

The following serves as a timeline for the IPRO as the semester progresses.

Project Timeline

Generalized Time Line:

Week 1: Begin Project Plan
Week 2: Finalize Project Plan
Weeks 3-8: Research and Development
Weeks 9-11: Make 2nd prototype
Weeks 12-13: Complete final report and presentation
Week 14: Practice and Perform presentation

Detailed Time Line:

Week	
1: 1/15 – 1/21	▪ Work on Project Plan ▪ Price parts for tentative budget ▪ Find storage for 1st prototype
2: 1/22 – 1/28	▪ Continue Project Plan, set goals for semester ▪ Visit Creative Mobility to test handcycles
3: 1/29 – 2/4	▪ Begin Research and Development

	▪ Order handcycle for second prototype ▪ Complete and turn in Project Plan
4: 2/5 – 2/11	
5: 2/12 –2/18	
6: 2/19 – 2/25	
7: 2/26 –3/4	▪ Progress Report Due
8: 3/5 – 3/11	
10: 3/19 – 3/25	▪ Begin prototype #2
11: 3/26 – 4/1	
12: 4/2 – 4/8	▪ Finish prototype #2
13: 4/9 – 4/15	▪ Write report, abstract, and create presentation
14: 4/16 – 4/22	▪ Finish report, abstract, and presentation
15: 4/23 – 4/29	▪ Practice Presentation ▪ Give Presentation: April 27, HUB
16: May 4	▪ Final Report due