Enhancing the Design Experience by Developing Projects for Special Needs Children

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ABSTRACT

This paper describes how projects for special needs children enhance the design experience while providing a valued service to the special needs children. Teams of students in the Mechanical Systems Design course at the University of Wisconsin-Platteville (UWP) worked closely with the occupational and physical therapists from the Platteville K-12 school system to design various adaptive devices for children with special needs. Seventeen adaptive devices were designed and built in the past two semesters. This paper includes descriptions of three of these: a redesign of a bicycle for a child with cerebral palsy, a learning center for a child with spina bifida, and a visual light activity box for a child recovering from pilocystic astrocytoma brain tumors. The learning center project was a continuation of a similar project from the previous semester. Some of the specific benefits of these projects to the children include: building of self esteem and confidence, providing an improved learning environment, and redeveloping of motor skills. A formal design process as described in this paper was used to determine the final design for each team. A prototype was then built and the projects were presented to an audience of parents and friends of the special needs students, the therapists and the course instructor. The prototypes shown in this paper have been successfully used by the children at school for the past semester.

INTRODUCTION (DEFINING THE PROJECTS)

This paper describes three special needs projects that students designed and built this past semester at UWP. These projects demonstrate the design process and how they have enhanced the design experience. Initial discussion took place between the occupational and physical therapists and the instructor of the Mechanical Systems Design course to create a need for projects that could be designed and built in one semester for special needs children in the school system. The projects were then presented by the therapists to the students with explanations of the children's disabilities. These adaptive-type devices would have to motivate the children to use the devices and benefit the children by enhancing their self confidence. Upon use of the devices, the children should also improve in the following typical ways: improving motor skills and self-esteem for the child with cerebral palsy, assisting in placement of learning materials for the child with spina bifida, and recovering lost motor skills for the child recovering from brain tumor surgery.

METHOD OF SOLUTION – FORMAL DESIGN PROCESS

Teams composed of four to six students were created to match up their interests as best possible. The student individual teams then met with the special needs child, along with the therapists and classroom instructor. At this meeting, the special needs children, with insight provide by the therapists, demonstrated their abilities and needs.

Need Statement or Problem Definition

Based on a standard design process, a formal need statement was developed by each team. The need statements for the projects described in this paper were as follows:

- There is a need to redesign and modify a bicycle adaptable to a child with cerebral palsy so the child can participate with other bicycle riders.
- There is a need to design and build a learning center to allow a student with spina bifida to participate in the classroom learning experience.
- There is a need for a device to stimulate a student's eye-hand coordination to regain their normal use of upper body motion skills.

A Gantt chart was then created to assist in planning and scheduling of the project.

Background Information

Based on the defined need and information gathered during the initial visit with the special needs child, the teams then obtained background information on the particular disability of the child and began searching for existing devices that might meet the need.

Problem Constraints

Through information from their background research, from suggestions made by the therapists, and based on observed motor skill behavior and gathered physical data of the children, the teams then identified problem constraints or task specifications. Some significant constraints for the projects included:

- For the redesigned bicycle:
  The bicycle must be ergonomically designed and modified to account for the special needs of the child, including an adjustable seat with supporting back, adjustable pedals with straps, and adjustable handlebars (actually reversed from normal position) all to make sure the bicycle is safe and stable to ride.
- For the learning center:
  The learning center must have easily adjustable moving parts.
  The center must have sufficient supporting arms to hold books, notebooks, and computer.
- For the visual light activity box:
  The visual light activity box must have proper dimensions to be transportable. The orientation of the peg/light holes must be laid out to cover a sufficient area to increase the student's peripheral vision, but not be spread out too far to cause the student to over-reach.

Possible Solutions

Possible or candidate solutions were generated with each team required to generate two to three possible solution concepts. These concepts were then evaluated based on various weighted criteria in a decision matrix often including such criteria as ease of assembly, product functionality, ease of use, safety, quality, and cost. Decisions on material selection and manufacturing process, sometimes dictated by the client, also were of significant importance in the design process. These concepts were presented to the therapists. Often concepts were demonstrated using rough models of wood or cardboard or CAD animations, as appropriate. The final design decision was based on numerous iterations with input from the therapists. A typical decision matrix for the learning center is shown in Figure 1.

		Ergotron - Design 1		**Square Tube – Design 2**	
	Weight factor	Score	Value	Score	Value
Time to Produce	**0.05**	**10**	**0.5**	**5**	**0.25**
Reliability	**0.2**	**10**	**2**	**5**	**1**
Material cost	**0.1**	**8**	**0.8**	**6**	**0.6**
Manufacturing cost	**0.1**	**9**	**1**	**9**	**0.9**
Low complexity	**0.1**	**9**	**0.9**	**9**	**0.9**
Ease of Assembly	**0.05**	**10**	**0.50**	**8**	**0.4**
Ease of adjustability	**0.2**	**9**	**1.8**	**7**	**1.4**
Ease of maintenance	**0.2**	**9**	**1.8**	**9**	**1.8**
Total	**1**		**9.30**		**7.25**

Figure 1 – Typical decision matrix for learning center for special needs child

Proposed Solution

The final design concept was then selected consistent with the best scored possible solution. This solution was detailed with the aid of computer-aided software. Appropriate engineering principles and equations were included to validate the soundness of the designs. A prototype was then built by each design team. The final prototypes of the three designs described in this paper are shown in Figure 2. These prototypes, along with an oral presentation and a written engineering report were presented to the therapists. The oral presentation was also attended by the parents and relatives of the special needs child, and other interested parties from the university, including the Associate Dean, and Chair of the Mechanical Engineering Program.

(a) (b) (c)

Figure 2 – a) Child using his redesigned/modified bicycle, b) child positioned at her learning center, and c) light activity box showing arrangement of peg holes

ENHANCEMENT OF DESIGN EXPERIENCE

From these projects for special needs children, we observe how the design experience for the students has been enhanced as follows:

- Solve real life problems with a sponsor or client.
- Introduce, interact, and serve students with special needs.
- Design unique and challenging projects for special needs.
- Provide a needed device at an affordable price.
- Increase student's enthusiasm.
- Enhance team working skills.
- Enhance communication skills.

It is emphasized that the same design process is used for special needs devices as with developing products used by the general public. Projects incorporate design considerations, such as scheduling, project management, and team working skills, working within interdisciplinary settings, working with vendors and creating a bill of materials, safety, ergonomics, aesthetics, societal concerns, liability, and cost.

CHALLENGES AND RECOMMENDATIONS

Some challenges working with special needs projects include:

- Expectations that a working useful device will be created that is aesthetically pleasing;
- Variability of degree of difficulty in projects;
- That the device will be built and delivered at the assigned end of semester time;
- Follow-up logistics to observe if the actual criteria have been met;
- Lack of assurance to modify or have continuity to improve on a project from one semester to another to meet client recommendations, (In the case of the learning center, numerous changes were made by encouraging feedback to suggest improvements from one semester to the next. These changes resulted in an excellent professional functioning working solution for the high school student using the learning

center. Fortunately, the course has been taught in continuous semesters and by the same instructor for the past two years to make this possible.)

Recommendations include ways to ensure follow-up of the projects to observe if they are meeting the needs of the special needs children and continuity in course teaching and its requirements so that improvements can be made to previous projects as necessary.

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