

## Using Assistive Devices for the Disabled to Teach Design in a Freshman Engineering Course

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An effective freshman design project must meet several criteria: motivate students, provide a clear model of the design process, give adequate opportunity to practice the various skills being taught in the freshman year and fit within a limited time and financial budget. In the Design, Technology and Communications (DTeC) program at SUNY-Binghamton, we have used a series of design projects to meet these goals. Of particular importance is the Assistive Device Design Project (ADDP) which the students undertake in the second semester of their freshman year.

Professor Culver has had previous experience with junior mechanical engineering students on similar projects, but the spring of 1996 was the first time we asked freshmen to meet this challenge<sup>1,2</sup>. The results were better than expected. A total of 23 projects were undertaken and virtually all were completed satisfactorily. While most were not as demanding as those attempted by the juniors, the completion rate was higher.

The design activities were closely tied to the writing and group work exercises presented in the Communications component of DTeC. The structure of DTeC is designed to accommodate approximately 100 students who meet as a total group in a General Session of 20 minutes three times a week. At the end of the General Session, 1/3 of the students go to Graphics and Design, 1/3 to Communications, and 1/3 to Computers; by the end of the week students have attended each two-hour lab. The skills taught in each lab revolve around the current engineering design project, in this case, the ADDP. In Communications lab, students were required to write a series of memos, one at each stage in the design process, to document their work. Their logbooks were periodically reviewed and were graded at the end of the semester to emphasize their importance in engineering practice. Each student team was required to give a fifteen minute formal presentation about the overall project.

There are several advantages of using the ADDP in the freshman year. It gives the students the opportunity to learn and practice the basic skills used by the practicing engineer, thereby expanding the students' understanding of the engineering profession and strengthening their commitment to obtain their degree in engineering<sup>3</sup>. The scope of this project also guides the students through all of the project objectives:

- Understand the elements of a standard design methodology and be able to apply them to a poorly defined problem;
- Have confidence to handle an ill-defined problem;
- Work effectively with a client to determine the real problem and develop an effective solution;

Analyze a proposed design for ergonomics and safety, as well as economic and construction factors;

Work effectively as a member of a project team;

Write an effective technical report and make an effective presentation;

Be proficient in using hand tools for fabrication of a mechanical device.

Experience with design projects indicates that students prefer to work with a real live client with a problem, which the students can address. The assistive devices provide this opportunity. Our freshmen students responded enthusiastically to this challenge. They were introduced to real life problems that exist for the disabled and became aware of the world of people with disabilities. They realized that each client had unique needs, which makes every individual situation a unique design problem. The design of an assistive device immediately leads to consideration of such factors as safety, aesthetics, liability and cost.

Many of the commercially available assistive devices are high priced and poorly designed. Adaptation of a toy can add \$75 to its cost. Wheelchairs and other mobility aids start at about \$500 and can cost several thousand dollars. While insurance and governmental programs cover many of these devices, the medical costs of people with disabilities leave little money for nonessentials. Thus, these projects are of great help to both the clients and their health care providers. Students take pride in the fact that they can provide a needed device to a client at an affordable price.

The fact that there is a client puts significant demands on the structure of the design project, the students, and the instructor. Once a client has been identified and the students have met the client, there are expectations that a useful device will be created, taking into consideration the safety, aesthetics, and liability issues. Not only should it function correctly, it should be aesthetically pleasing and delivered at the assigned time, usually at the end of the semester. Because the client can really use the device if properly completed, there is more impetus for the students to carry the project through to completion than in projects where the only motive is to get a good grade.

To find potential clients, Professor Culver called several agencies with whom he had worked before. As in the past, several agencies and private therapists responded positively with problems that might be appropriate for the freshmen. These health care professionals visited the Communications Lab and presented their various problems while describing their clients. Students then discussed in their teams what project they were interested in and chose three. They submitted their requests to the Communications and Design instructors who assigned final projects based on student preference. Soon after this visit, the students met their respective clients and talked about the problem, described the course, made measurements, and established a working arrangement.

The 23 freshman projects chosen in spring 1997 were:

1. Bath Steps for Dwarf Child – Plastic steps which allow dwarf child to safely enter /exit bathtub on his own
2. Bath Steps for Child without legs— Plastic steps which allow child whose legs were amputated at the knees to safely enter /exit bathtub on his own
3. Head Pointer for Communication - Stick pointer was replaced with battery-powered laser pointer, which attaches to baseball cap
4. Wheelchair Repair Lift – Table with pivoting legs which sits on floor at an angle so wheelchair can be loaded and then is lifted through an arc to raise wheelchair to desk level for repair.
5. Adjustable Key Board Stand – Stand, which holds computer keyboard, can be adjusted for height and angle.
6. Wheelchair Extension Bar – Adjustable frame attaches to child’s wheelchair to aid tall adults in pushing the wheelchair.
7. Barbie Doll Dresser – A pivoting tabletop frame holds the Barbie doll for one-handed dressing. Covers for hands and feet aid in placing clothes on doll. Hook pulls skirt, pants on and off torso.
8. See-and-Say Handle/Switch – Extension handle and tabletop frame make one-handed operation of see-and-say toy possible.
9. Portable Ramp – Ramp which children can slide down on stomach or coaster for physical stimulation.
10. Supine Stander – Pivoting frame which supports child at various angles. Straps hold child on frame. Removable tray provides workspace.
11. Tabletop Folding Easel – Easel which sits on table can hold large books and provides drawing surface.
12. Trifold Jig/Mail Cart – Trifold jig holds sheet of paper for one handed folding. Wheeled cart used for mail delivery provides support for user.
13. Wheelchair from Hell – Electric wheel chair had several modifications to make it serve user better. Control switch, seat frame attachment, seat release were all modified.
14. Bookcase/Table – Special table to support microwave oven and magazines for elderly woman.
15. Shaking Hand Control – Frame to make vegetable slicer accessible for one hand operation.
16. Kneeling Table – Activity table with adjustable height legs for children to kneel around.
17. Stair Exerciser – Six-foot high collapsible frame with stairs, platform, ladder and ramp for children.
18. Balance Beam – low level balance beam for physical stimulation of children
19. Feeding Spoon - Spoon with large handle and offset extension for person with limited dexterity.
20. Toilet Seat Splash Control – Removable plastic urine splash guard which attaches to toilet seat.
21. Neck Moisture Absorber – Moisture-absorbent pad which attaches to neck collar to remove saliva.
22. Hand Assembly Box – Activity box with various locks and handle billiards game
23. Built-up Handle for Keys – device which holds key to aid in insertion into keyhole.

To manage the projects and lead the students through an effective design methodology, each team submitted a series of status memos:

1. problem definition
2. design alternatives
3. proposed design
4. project schedule
5. detailed design
6. final report
7. final presentation

In a one-semester course where the ADDP takes place for only half of that semester there is little time for modification and rebuild. The role of the instructor as project supervisor and consultant on the design process is extremely important and sensitive. Frequently, the instructor can see a “better” solution to the problem than the one the students select and must decide whether to intervene. The instructor also has to make sure that the client understands the goals of the course and allows the students to develop alternative solutions to the problem selected in order to pursue a rational optimization process. Students in the class help solve this problem by critiquing each other’s projects. During a formal review process, they suggest alternative designs and raise questions about the effectiveness of a given solution, reducing the instructor’s need to control the design and fulfilling the team/group work objective of the course.

Team building exercises practiced in previous team projects help the ADDP project team establish a healthy operating norm. Students are assigned to the teams by the instructors to insure balanced talent and experience in each group. During the early phase of this project, the groups meet the client, refine the problem statement, and create solution alternatives. But once they are involved in construction, activities other than progress reports are seen as a distraction rather than contributing too the course.

The process of actually building the designed product is a critical part of the lesson. It is easy to come up with a conceptual design. During construction, students learn the importance of material selection, the role of fasteners and joining methods and decisions on build-versus-buy of sub-assembly components. Decisions which require judgment by the students, can teach a valuable lesson in design optimization and the need to weigh the relative importance of product functional quality, cost, and time.

The projects were constructed in two shops. The engineering machine shop was used for devices made from PVC tubing, plastic or metal. The wood projects were built in the scene shop in the Theater department. Funds to purchase the material came from an NSF REU grant held by Professor Culver.

The students showed a great deal of pride in their projects, regardless of the level of complexity. They performed a service that bettered a specific community. They learned many of the basic skills used by the practicing engineer and what it is like to develop a product for a client. It became apparent as the project progressed throughout the semester that they were learning many

lessons about humanity and the importance of caring, ultimately learning more about themselves than they expected. This effective freshman design project met the criteria put forth and will be repeated in the spring of 1997.

### References

1. Culver, R.S. *Design and Construction of Adaptive Devices for the Disabled: Design Education with Marker Potential*. Proc. – Frontiers in Education, 1994, San Jose.
2. Culver, R.S. *Lessons Learned on Using Adaptive Devices for the Disabled to Teach Design*. Proc. – Frontiers in Education, 1995, Atlanta.
3. Landis, Ray, *Studying Engineering - A Road Map to a Rewarding Career* Discovery Press, Burbank, CA, 1995.