Abstract – First year design courses face several obstacles. The students have little or no design experience and only a high school background. A strategy was developed to address these issues. The course rapidly built design experience by emphasizing case studies and reverse engineering activities. The development and use of design specifications were also emphasized. The course project was to design and build a prototype of a sensory stimulation table for an adult man with profound mental retardation. The class was divided into 8 groups of 4-5 students. Required weekly progress reports ensured timely completion of the project. Several students continued to work on advanced prototypes after completion of the course. With proper project selection, service learning projects can be successfully introduced into first year design courses.

Index Terms – assistive technology, design projects, first year courses, service learning

INTRODUCTION

Many entering students choose to study engineering because they have a strong interest in design. However, the first year is often nearly devoid of design activities. First year design courses face several obstacles. First, most students have little or no prior design experience and at best limited hands-on experience. Second, teaching the design process via projects requires not only that the topics be exciting and interesting but also that they can be successfully completed by relying almost exclusively upon the student’s high school background.

In past years our first year Introduction to Engineering course (ES 1020) focused on the development of skills such as using software to solve equations, plot data, create drawings and write reports. WPI organizes the academic year into four 7 week terms. ES 1020 is offered in the 1st term and is open to all entering students. In 2004, ES 1020 was revamped into a project based course that focuses almost exclusively on design. The major course project developed a device for a person with a disability. We had prior experience in using design projects related to assistive devices in higher level courses [1], however, this was our first attempt at using this strategy in a first year course.

COURSE CONTENT

The new format rapidly built the students’ design experience through the use of a text that emphasized case studies [2]. There were a number of lectures on design methodology based upon material from a variety of sources. Several classes were devoted to the process of developing and weighting design specifications. Reverse engineering activities were used to develop hands-on experience as well as an understanding of the role of components in achieving a design objective. In one laboratory activity the students were required to disassemble an outdoor faucet and then write a report describing the function of each component. Another laboratory session was devoted to brainstorming. The class of 34 students was divided into 5 groups. The groups were given 30 minutes to generate multiple possible solutions for raising 70 lb. bundles of shingles from the ground to staging that may be 10 to 40 feet above the ground. As constraints, the strength and size of the workers as well as the accessibility and physical features of the location were highly variable. Statistics were introduced using anthropometric measurements (height) of each class member. These data were used to develop class statistics which were then compared to published data bases. The centerpiece of the course was a 4 week design project that culminated with oral and written reports. Each project team was required to develop and evaluate at least a crude prototype of their solution. For the oral presentations, each student was required to provide a thoughtful evaluation (3-4 sentences) of each of the other group presentations.

THE DESIGN PROJECT

The design project was developed through a network of agencies providing services to persons with disabilities [3]. The project centered on the needs of a 46 year old man with profound mental retardation that limits his mental capacity to that of a two year old. His daily activities in a residential facility provide only minimal sensory stimulation and he is at risk for developing institutional depression. The project was developed by the clinical psychologist at the facility. He proposed that the students design and build a sensory stimulation table that would provide the man with a broad variety of sensory related activities and/or components. The sponsor spent one class period introducing the problem to the
students and was available to the students by phone or email during the execution of the project.

The class was divided into 8 teams of 4-5 students each. Three weekly written progress reports were used as a means to set weekly objectives and assure timely completion of the project. The objectives for each week were:

- Week 1. Identification of the need, final problem statement and preliminary design specifications.
- Week 2. Completion of background research, finalization of design specifications, development of distinct preliminary designs and selection of a final design.
- Week 3. Detailed analysis of the final design.

Eight distinct prototypes were produced. Two prototypes were high quality portable devices: a 12"x12"x12" cube with sensory stimulation activities on 5 of the 6 sides (Figure 1) and rotating pyramid shaped device with sensory activities on each of its 4 sides. The remaining 6 prototypes were less developed and utilized tabletop designs where specific areas contained different types of activities. The student groups employed a wide variety of methods to achieve tactile, audio, visual and olfactory stimulation.

![Sensory Stimulation Cube](image)

**FIGURE 1**

SENSORY STIMULATION CUBE

The project sponsor was very impressed with the student generated designs and felt that combining several of the design features might be more appropriate. Upon conclusion of the course seven students volunteered to continue working on more refined prototypes that could be tested with the client. Three prototypes were delivered in December 2004 for a one month period. These included the two portable designs from the original class plus a new tabletop design based upon a combination of class design concepts. While many of the design features were highly regarded by the project sponsor, very few of the features were able to withstand the strength of the 46 year old man. A second (modified) version of the tabletop design was developed and evaluated during March 2005. This version solved the durability issues. A third and final revision of the tabletop design is scheduled to be delivered in September 2005.

**DISCUSSION**

Responses to open ended questions on course evaluation forms indicated that the class project, hands-on activities and the emphasis on case studies were well received by the students. The opportunity to create a design that would make a real difference in a person’s life appeared to be a highly motivating factor. This was clearly evidenced by the number of students desiring to continue working on the project after the course had ended.

Considerable care must be taken in utilizing and selecting design projects for first year courses. The course must include mechanisms for rapidly building student experience in design. Our emphasis on case studies and reverse engineering activities appeared to meet this objective. Additional reverse engineering activities will be added to the course in the fall of 2005. Proper project selection is perhaps the most critical component. Students come to the project with only a high school background. Thus a well posed design project will likely involve assembling and organizing existing ideas, devices and technologies but still involve all of the design steps up through creating and evaluating a prototype. The weekly progress reports were quite successful in keeping the groups progressing at an acceptable rate. However, we found that additional emphasis needs to be placed on how to integrate this material into a final written report. Overall, it appears that service learning projects provide an excellent vehicle for introducing first year students to engineering design.

**ACKNOWLEDGMENT**

We acknowledge the contribution of Dr. Tommy Stoddard, Clinical Psychologist, for the Massachusetts Department of Mental Retardation for suggesting the design problem. This work was conducted in association with the national Engineering Projects In Community Service (EPICS) program.

**REFERENCES**

