Session 2428

Freshman Design Course at IPFW

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Introduction

Indiana University – Purdue University Fort Wayne (IPFW) is the sixth largest public university in Indiana with an enrollment of 12,000 students. Typically a commuter campus (although residence halls open in the fall of 2004) the students are a mix of part and full time students, as well as one of traditional and non-traditional types (who have been out of school for several years). The School of Engineering, Technology and Computer Science (ETCS) comprises of five departments, that of Engineering and Computer Science and three Technology departments. All engineering majors are required to take an introductory course on engineering design. The course that was offered during the fall of 2003 had students that were majoring in mechanical, electrical and computer engineering, and also a few undecided majors. This paper outlines some of the novel approaches adopted in this course. Some of the concepts were: (a) use of student teams to study a number of actual case histories at different stages of instruction as well as to perform a number of classroom activities, (b) introduction of a hands-on team project, (c) implementation of a design project in which the student teams apply the engineering design process to conceptualize a real world design problem, and (d) introduction of case studies to teach engineering design.

Classroom Team Activities

The classroom activities comprised of a student-centered collaborative learning approach. The role of the instructor changed from the so-called "sage on the stage" to one of "guide on the side." The students were grouped in teams of three at the beginning of the course. This structure of teams was retained throughout the duration of the course, and the same teams were also used to perform team projects. Initially a number of activities were introduced to build up the student teams. This included an exercise on coming up with strategies for survival in a problem situation. Also included were a number of brainstorming exercises given during the class, in which the different teams came up with sets of solutions to open-ended problems, and the instructor compared and critiqued their solutions.

In addition, the student teams performed customer surveys on specific engineering products and participated in a number of exercises such as statistical analysis and also cost analysis. The student teams were also involved in mock-up situations requiring the application of engineering ethics. As a part of instruction the student teams were assigned to present specific case histories covering different aspects of design process. This consisted of engineering successes as well as failures from the accounts of case histories [1]. These realistic situations from the case histories were used to illustrate and reinforce the interdisciplinary nature of engineering design. The student teams would come prepared and present before the class the case histories and what were the lessons learned from them. The entire class participated in asking questions and critiquing the presentations. Prior to the student team presentations, the instructor would outline the major design theme contained in the case histories.

The instruction and the presentation of the case histories by the student teams followed the sequence of the engineering design process, namely that of (a) definition of need, (b) problem analysis, (c) problem synthesis, (d) the search for a solution, and (e) the implementation of the specific solution. The student teams appreciated the oral presentations and a number of shy ones were able to overcome the barriers of personality and were able to communicate well with the class. In fact quite a few displayed humor in their presentations and kept the whole class entertained. The amount of preparation required for the presentation was not extensive and the students who were primarily commuters would find time to work in teams. They in fact found it a welcome change from the predominantly lecture mode of presentation typically experienced in their other classes.

Minor Design Project

This was a hands-on design project, which was assigned early on in the course. The student teams were asked to design and build a contraption that would launch ping-pong balls to a specific location 2 meters away after clearing a height of 1 meter placed halfway between the launch site and the delivery site (See Figure 1). The teams were required to design and build in three weeks' time. All the student teams built the devices, and quite a few teams were successful in their launches. This was particularly gratifying when we see that the most of the students are working full or part time and yet found time to work together in groups. Most of the devices that the student teams came up with were spring actuated and all the student teams displayed a great amount of interest.

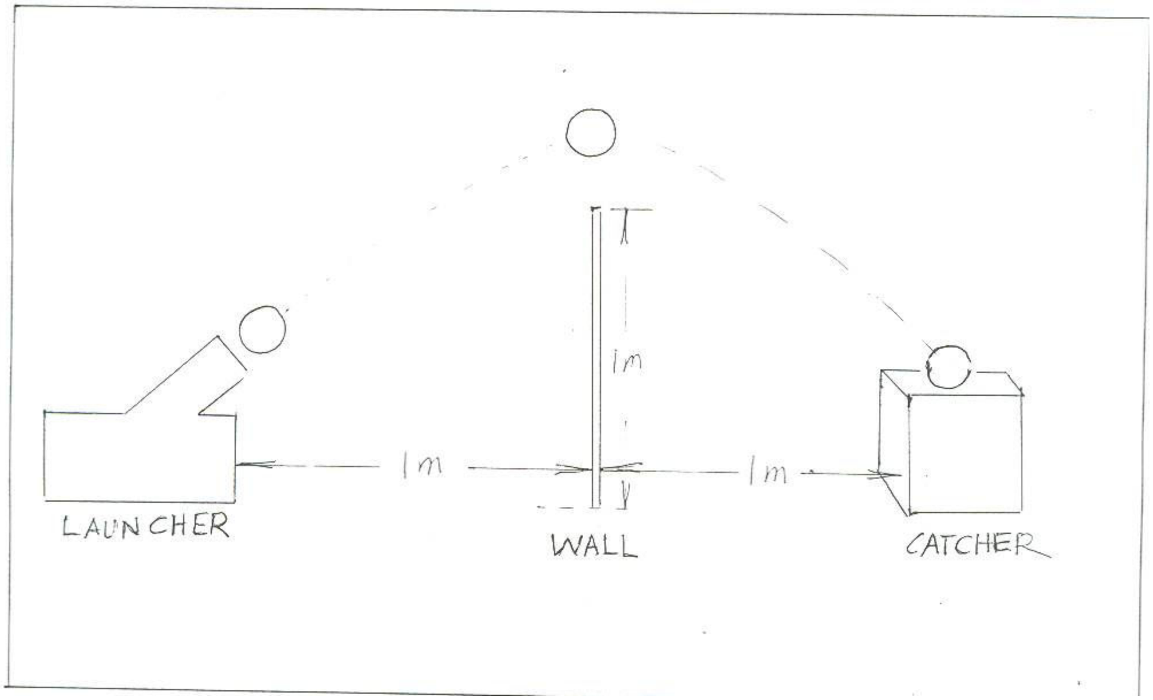

Figure 1 Setup for Minor Design Project

The aspect of competition was downplayed in this exercise and the student teams were rewarded with generous points for simply building the device. In addition, the teams had to prepare a detailed report documenting their designs, with an engineering drawing (using CAD) and all calculations supporting their designs. Typically the calculations would involve determining the initial velocity of the ping-pong ball and the angle at which it would be thrown to meet the constraints of the design. Some of the teams employed an iterative approach to determine the angle of the projectile. Some went into the detailed consideration for the design of the ejector spring. A handful of designs successfully launched the pin-pong balls to the delivery basket in three tries. Overall it was an enjoyable and exciting campus event.

Major Design Project

The projects were announced two weeks after the start of the course. The student teams were asked to pick projects from a list provided by the instructor. Once the projects were picked the teams were required to turn in a proposal, which would define the problem, the possible solutions and their planned activity in terms of a Gantt chart. In addition the student teams were required to maintain a journal and to turn in weekly progress reports. Table 1 lists the projects picked by the student teams. It was interesting that out of the 11 student teams, there were 4 teams that picked wheelchair as the theme for their designs (although their designs were differently conceptualized). Although the instructor encouraged meetings with individual teams, not too many of those meetings took place because of the time constraints of the individual students.

Table 1 Student Design Projects

1. **Sleepy Driver: How Sonic Waves Can Help**
2. **Optical Landmine Hunter**
3. **Chainsaw Safety**
4. **Propane Fuel for the 21st Century**
5. **Thrust Chair**
6. **Improvements in Step Ladder**
7. **Stairs and Chairs**
8. **Automatic Pet Feeder**
9. **Running with Scissors**
10. **Wheel Chair Mobility Improvement**
11. **Climachair ™**

It was not judged practical to set aside class times for those meetings because of the class time that was required to cover other activities including the lecture presentation. In a way the philosophy was to build the concept of design across the curriculum and to prepare the students early on for the ultimate design experience, namely that of the capstone design project in their senior year. The teams were required to present their designs in form of a design report (with specified format to include all the relevant sections and CAD representation) and to defend the design through oral presentations using PowerPoint. The design presentations were scheduled the week before the final examination week, with each team allowed about ten minutes between the presentation and the Q&A sessions. The presentations took two class periods and there was adequate time for the students to present the material (each team member had to present a portion of the material) and to defend the questions from the audience, which of course included the instructor.

Since the teams worked on their projects in the limited time that was available in a typical commuter campus, and the fact that they worked pretty much without the guidance and intervention of the instructor, the results were mixed. Some of the presentations were fairly detailed touching on every aspect of the design process reflecting the interest and motivation level of the students. The others were sketchy with some last minute efforts. This was particularly revealing in the 4 projects that were centered on the wheelchair design (Projects 5, 7, 10 and 11 in Table 1). The problem was to come up with a design that would be effective for the wheelchair to climb an eight-inch curb. One team (Project 5) decided to employ rocket-like thrusters for their design despite requests by the instructor to keep the design cost-effective. The other team (Project 7) came up with an extremely simple yet impractical solution. One team (Project 10) came up with a highly innovative solution as shown in Figure 2. The last team (Project 11) came up with a solution that was quite creative but there were some questions regarding its implementation. The lessons learned for the instructor was that his intervention in the design stages was absolutely essential in spite of the obstacles presented in a typical commuter campus.

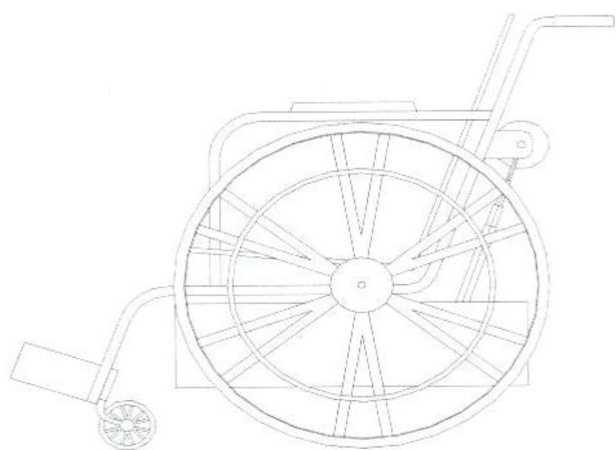

Figure 2 Wheelchair Design

In the written reports the teams were specifically asked to include the concept of the house of quality [2]. The House of Quality diagram for the Project 5 is shown in Figure 3 as an illustration.

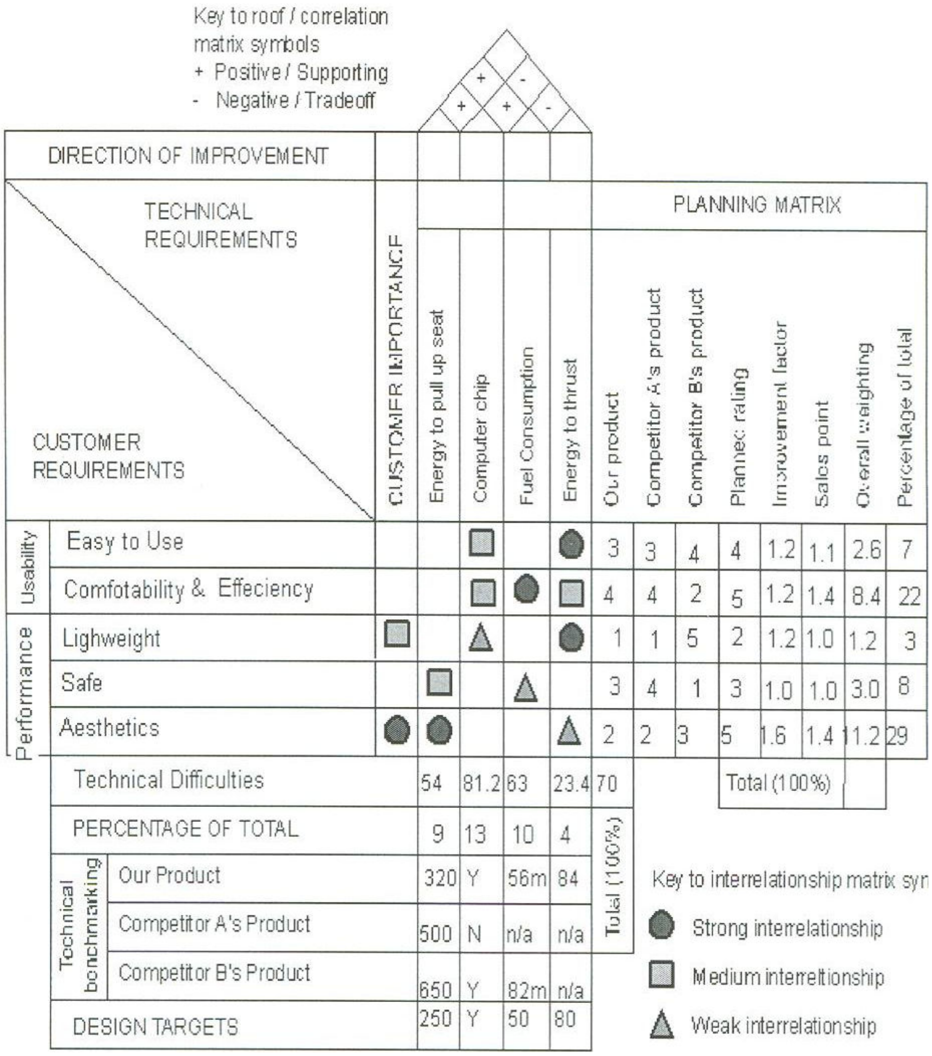

Figure 3 House of Quality for a Student Team Design Project

Case Studies

The method of instruction using case studies was first introduced in 1870 at the Harvard Law School and later practical case studies became a part of the curriculum for the Harvard Graduate School of Administration in 1908. A case is typically a record of a business or technical issue which actually has been faced by engineers and managers in a technical organization. It includes the surrounding facts, opinions and prejudices that form the bases of the decisions of the engineers or managers. Raju and Sankar [3] have recently produced a text that introduces engineering concepts through case studies. In fact we have used two of the case studies authored by them in our class. The first one involved Della Steam Plant [4] and the problem was whether or not the turbine in the plant should be shut off. The other one involved Crist Power Plant [5] which required strategic decision making while planning for a maintenance outage.

The 11 teams in the class were split with 6 teams working on the Crist Power Plant and 5 on the Della Steam Plant. All the students were provided with the texts on these case studies through a generous contribution from the Dean of the School of ETCS at IPFW. The 6 teams working on the Crist Power Plant were assigned one of the six alternatives presented to them and defend their specific alternative. Each of the alternatives involved different costs and other aspects associated with it. In addition, the teams were to suggest innovative methods to solve the problem. The 5 teams working on the Della Steam Plant were assigned as follows:

Two teams would assume the roles of the manufacturer representative for the turbine-generator and that of the maintenance supervisor respectively and defend their recommendations. One team would defend the role of the plant manager and decide between the two recommendations. The two remaining groups would assume the roles of new technology groups and discuss technologies that could be used in future to solve such problems.

Two weeks were devoted to these case studies with mixed success. A number of students thought that these case studies were not relevant to their majors and thus unimportant. Some simply failed to grasp all the concepts that were needed to come up with effective decisions.

Conclusions

The classroom exercises associated with the freshman engineering design course were reasonably effective and collaborative learning approach was achieved with great success. The minor design project that the students worked in teams was also quite successful. A number of teams working on the major design projects did a fairly good job, while some others were not very effective. This aspect could be improved greatly with increased instructor's guidance. The case study method could have been more successful if simpler cases were employed in the instruction. The student responses from these activities and projects were quite favorable.

Bibliography

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