Enriching the Freshman Experience with Juniors

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Abstract

Design teams consisting of three first year students and three third year students were created to design and manufacture a device to meet the entrance requirements for the American Society of Mechanical Engineers (ASME) student design contest. The first year students were enrolled in a course entitled "Introduction to Computer Aided Design and Manufacture" and the third year students were enrolled in a course entitled "Dynamic Systems Modeling and Control." The authors conceived of this combined course design project to improve the quality of the design projects in both courses. Although the project was not completely successful in improving the quality of the design project other important, if not anticipated benefits were observed. This project created social and professional ties between juniors and freshmen that lead to a higher level of enthusiasm for the engineering program. It also provided the freshmen an opportunity to observe junior level students including work habits/organization, use of calculus and other fundamentals and writing. The freshmen also benefited by being mentored by the juniors. The juniors benefited by getting some 'management' experience and reducing the total time required to fabricate their designs.

1. Introduction

The freshman year of our engineering program is mainly composed of non-engineering fundamental courses. In addition, our freshman year is offered on a campus separated from the engineering school. As a result there is a lack of contact between the freshman class and the engineering school in general. The faculty has observed some unfortunate effects of the separation. Some students lose interest because they spend a year or longer before they attend classes on the engineering campus. They also lose the benefit of associating with upper class students and seeing the activities they are involved in. This paper addresses an approach to overcoming this problem by having freshman and junior students work together on a design and build project. The project used was the ASME student design competition.

The project involved assigning teams of three freshmen to teams of three juniors. The juniors were responsible for the main design concept, mathematical analysis, the final construction and the overall performance. The freshmen worked with the team to identify one or more subsystems that they could design and build. In many cases this was a small wheeled cart. The freshmen were responsible for producing parts and drawings of their design.

1.1 Introduction to Computer Aided Design and Manufacturing, EGR 101

All engineering students who are qualified to take calculus take EGR 101, Introduction to computer aided design and manufacture. Topics covered include 3D solid modeling design techniques, computer aided manufacturing and hands-on experiences in computer-numerically controlled (CNC) milling. EGR 101 is a three credit class consisting of a two hour lecture and a 3 hour laboratory session each week. During the semester students work on four design and manufacture projects. The manufacturing is accomplished using bench top CNC milling machines. As the semester progresses the design projects become increasingly complex and open ended. The first project is the design and manufacture of a key chain and, in the last project student teams design and build simple products of their own choosing.

Although this approach has been very successful, the quality and complexity of the final projects have varied widely. Creative students with good ideas have produced impressive products like camera tripods, flashlights and folding remote control devices. Immature students without creativity have struggled to identify good projects and often produce disappointing results. These students become discouraged and are in danger of leaving engineering.

Exacerbating this problem is the fact that the freshman engineering courses are offered only on a campus separated from the engineering school. The campuses are ten miles apart. This distance isolates the first year students from contact with the upper class students. They do not see the Engineering lab spaces or the interesting projects and activities that are part of the engineering school experience. The faculty has observed some unfortunate effects of the separation. Some students lose interest in engineering and transfer to other majors.

1.2 Dynamic Systems Modeling and Control, EGR 345

Dynamic Systems Modeling and Control course (EGR 345) is taught to junior mechanical and manufacturing engineering students. In this course students learn to develop and analyze mathematical models of systems for design purposes. This course includes weekly labs and a final team design project. The project focuses on a creative design that is mathematically analyzed and then built. The final design is tested competitively against other students. In the past students have often complained about the time required to both analyze and then fabricate a design.

2. Methodology

To improve the situation the authors decided to assign a design project to teams consisting of both EGR 101 and EGR 345 students. The teams were assigned to design and construct an entry to the 2003 American Society of Mechanical Engineers (ASME) student design competition. The contest required teams to design and build a system to use the potential energy of an elevated bucket of water to transport rice up an inclined plane and dump the rice into a catch basin. Each team consisted of three freshmen students and three juniors. The juniors in EGR 345 were responsible for the main design concept, mathematical analysis, the final construction and the overall performance. The freshmen worked with the team to identify one or more subsystems that they could design and build. In many cases this was a small, wheeled cart. The freshmen were responsible for modeling, producing prints and other design documentation and manufacturing their designs. The freshman and the junior's contributions to the design effort were graded separately.

The authors intended four main benefits to the students. First the new approach gives the junior students an opportunity to mentor the freshmen students. First year students would work with the junior students and observe their work habits, use of calculus and other fundamentals as well as their writing and revising reports. It was hoped that this would provide a connection between the courses the freshmen were currently taking and the courses they would take in the future. Next the authors intended to improve the maturity of the EGR 101 projects. Within the ASME design contest, the freshmen would be required to design and manufacture a subsystem that had to work with the other parts of the system and contribute to the success or failure of the entire system. As envisioned, the junior students would give the freshmen specifications for their design and encourage them to produce robust designs. The combined project was also intended to improve the project management and mentoring skills of the junior students. Generally the junior students were responsible for dividing up the project tasks, assigning tasks to team members and keeping the project progressing forward. Finally, the project was intended to give all of the students practice working in teams.

3. Outcomes

All student teams produced an entry for the competition. The entries were demonstrated at least once. On the day of the competition, a majority of the designs were able to successfully achieve the goals. Teams that produced outstanding designs generally had thorough designs, completed construction early and worked well together. Teams that had difficulties on competition day typically disregarded instruction on the engineering design process. In those cases students came to recognize the value of the structured engineering design process. Although many of our observations are anecdotal, we were able to collect some quantitative data from the students.

Students were asked to review their teammates on five different criteria. The reviews were based on a five point scale with a score of five identified as "good performance" and a score of one identified as "poor performance". The criteria and how they were described to the students are shown below.

1. **Communication**: Did the teammate return e-mails and other forms of communication promptly? Could the teammate understand, explain and evaluate the technical aspects of the project in a clear and concise fashion?

2. **Team Work**: Did your teammate come to meetings on time? Did the teammate participate in all aspects of the project? How much did the teammate's efforts contribute to the overall success of the project?

3. **Ability to Meet Deadlines**: Did your teammate complete individual responsibilities on time? Did the teammate keep the project progressing forward in a timely manner with a consistent effort throughout the project, or was the teammate only available when the team was in trouble?

4. **Quality of Work**: Was your teammate willing to accept and carry out their individual responsibilities of the design project? How well were the individual responsibilities carried out? Did your teammate do his or her fair share of the work?

5. **Overall Rating**: Would you be happy to work with this person again? Would you give this person a job reference?

Table 1. Student peer evaluation outcomes.

	Juniors Reviewing Freshmen	**Freshmen Reviewing Juniors**	**Juniors Reviewing Juniors**
Communication	4.0 out of 5	4.2 out of 5	4.8 out of 5
Teamwork	4.0 out of 5	4.3 out of 5	4.8 out of 5
Deadlines	4.1 out of 5	4.2 out of 5	4.8 out of 5
Quality of Work	4.1 out of 5	4.4 out of 5	4.8 out of 5
Overall Rating	4.0 out of 5	4.4 out of 5	4.9 out of 5

The average results of the different groups reviewing each other are presented in Table 1. The high marks all around indicate that the teams functioned effectively. The relatively high marks given to the freshmen by the juniors indicate that the juniors valued the input and results of the freshmen members of the team. The even higher marks given by the freshmen to the juniors shows the respect the freshmen gained for the juniors. Finally, it is not surprising that the juniors evaluated other junior members of their teams higher than the freshman members of the team.

Additional indications of the success of the approach can be found in the comments students provided with their evaluations. Some comments from the junior students about the freshman show indications of the development of mentoring relationships.

"Always willing to go the "extra mile". The only thing he couldn't do was the calculations, and that probably wouldn't have taken long to teach him. An integral part of completing this project. Already asked my boss if we needed a summer intern."

"Matt contributed as much as I expected any of the freshman to going into the project.

He did a good job of communicating about meeting times. In addition, Matt completed all of the tasks that were asked of him in a prompt fashion."

"Zach did well overall with this project. For the most part he did what was asked of him. However towards the end he did not communicate well with the 345 students on whether or not he would be attending meetings. Zach had a lot of good ideas and was able to express them well."

Similarly some of the comments made by the freshman illustrated the presence of a mentoring relationship.

"Tom definitely knew what he wanted done from the start and communicated his ideas well. Tom was easy to work with and taught me a couple of things during the project. It was fun working with Tom."

"Ryan helped out all the time and was always there on time to help. Also he always brought lots of ideas and helped us out tremendously."

"Joel expected a lot from us, really wanted things to be perfect but in the end it helped us out to make a functional product."

The combined project was also intended to improve the managerial and leadership skills of the juniors. Again the comments were very instructive. Several of the freshman commented on the leadership abilities of the juniors.

"Dale took the real leadership role. He also did a lot of prep work."

"Paul was a very good asset to our team. He kept us up on all their progress via e-mail and was always helpful to our group. I think that Paul was extremely helpful to our team, a definite leader."

"He wouldn't accept some of my ideas until I proved they worked, and worked well. He did take on the role of someone in charge. Witch was good, it made sure things were done."

Of course some of the comments showed a lack of managerial and leadership skills.

"I barely saw him at most meetings and he didn't seem to give much input. The entire 345 half of the project wasn't started until the weekend before due date. It was like we were two separate teams."

The last goal of the new approach was to improve the maturity of the EGR 101 projects. The results exposed some opportunities for improving the sophistication of the systems that the EGR 101 and the EGR 345 students produced. A successful solution to the design problem did not have to be a "designed artifact." Many teams used easy to manipulate materials like balsa wood and paper to quickly fabricate workable solutions. Although this was an effective strategy, it reduced the need to use Computer Aided Design and Manufacturing software to design and fabricate precise parts. Assembly analysis and tolerance design were also not required. The authors believe that this problem can be overcome by selecting a different design problem. In the future a less constrained problem that requires more precise actions or results will result in more mature designs.

4. Summary and Conclusions

This paper discussed some anecdotes and student opinions arising from a joint project between freshmen and junior students. Overall the interactions were beneficial for both groups of students. The resulting project work will be improved in future years by refining the design problem and process based upon the initial offering. Some of the changes to be made are:

1. Require a single report from the combined team of students.
2. Stricter division of responsibility to both freshmen and juniors.
3. Refine the project to include an initial demonstration day before the final contest.
4. Redefine the project to require engineering level designs and production.
5. Provide more opportunity for informal student interactions.
6. Clearly communicate teamwork skills and expectations.

Biographies

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John Farris is currently an assistant Professor in the Padnos School of Engineering at Grand Valley State University (GVSU). He earned his Bachelors and Masters degrees at Lehigh University and his Doctorate at the University of Rhode Island. His teaching interests lie in the first year design, design for manufacture and assembly and interdisciplinary design.

Hugh Jack
Hugh Jack, Associate Professor of Engineering at Grand Valley State University graduated from the University of Western Ontario with a bachelors in Electrical engineering and a masters and Ph.D. in mechanical engineering. He is currently the graduate and manufacturing chair and actively researching open source software for manufacturing controls.