BME Senior Design and Freshmen Engineering

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Abstract
This paper reports the results for a senior-freshman teaming event that took place during the fall quarter 2004. It describes the rational for the event, the design leadership required of the seniors, the structure of the design environment, project reports, student reactions, and the event evaluations.

This is the second year that our biomedical engineering seniors have been coupled with our engineering and computer science freshmen on a joint design project. The first year results were promising enough to continue doing it the second year. The second year had improved expectations for the seniors coupled with more time to interact with the freshmen. Seniors gained valuable experience leading a design team while the freshmen gained experience teaming and interacting with upperclassmen. This event was possible as the director of the freshman engineering and computer science program was also the professor for the initial course in BME senior design. Over all this has been a win-win effort.

Introduction
Our BME senior design program consists of three courses taught over three quarters. The fall quarter introduces the students to principles of design. By the end of the quarter the students have been divided into teams and assigned a final project to work on during the next two quarters. The spring quarter involves designing a device to meet the specific project and during the third quarter the students build and deliver a working device.

In the fall quarter the students practiced design from initial concept to final specifications. This involved the client statement, problem definition, conceptual design, preliminary design, detailed design, design communication, and final design. During this period they learned to use design tools such as objective trees, function-means trees, morphological charts, and Gantt charts. As the quarter progressed they were placed in teams and assigned to develop solutions to problems assigned in class. Here they learned about team dynamics: forming, storming, norming, performing, and adjourning. The text used in the first quarter provided the students with a good resource for studying these concepts [1]. By the middle of the quarter the seniors were beginning to learn the design concepts but needed something more practical to practice on than in-class problems. For this the seniors were coupled with a freshman team.

Our freshman engineering and computer science program is a one quarter course offered each quarter of the freshman year. All freshmen in the college are required to take it. The course integrates a lecture and two labs each week. There are also a number of team events which

cumulates in a final team project. It was with this final team project that our BME seniors were coupled. The way we did this coupling appears to be unique.

There are reports on freshman design teams and the benefits they have in the education of an engineer[1]. In one case it was reported that the freshmen were encouraged to seek out senior students for advice but no specifics were provided [2]. We reported on our first year's effort coupling freshmen with seniors [3]. This first year's effort established the logistics involved and gathered some feedback from the students. The seniors' response varied from dislike to enjoyment. The freshmen reported in increased interest in engineering due to the interaction with the seniors.

Methodology
The overall goals for this teaming effort were:

1. Provide the seniors an opportunity to practice team leadership skills
2. Have seniors apply design tools learned in class to an actual problem
3. Meet the senior writing across the curriculum requirement through the project report
4. Provide the freshmen with upper classmen contact on a project
5. Expose freshmen to the design process

At week six the freshmen were introduced to their final project and divided into teams so that each senior could be assigned as the team leader. The freshmen were allowed to form their own teams with a restriction on the number of team members. The seniors are assigned to a team by the course instructor and the teams were listed on the freshman WEB site. It is fortuitous that the senior course instructor and the freshman course instructor were the same person as this simplified the coordination of the two courses. There were 86 freshmen divided into 27 teams for fall quarter 2004. There were 24 teams of three and 3 teams of four.

From week 6 through week 9 the freshmen learned enough basic electronics to design simple circuits using batteries, switches, resistors, LED's and integrated devices such as the 555 timer, decade counters, flip-flops, and AND-gates. Most of this was done using breadboards. There was one lab devoted to learning how to solder a printer circuit. With this knowledge the freshmen could tackle the final project.

There were two options for the final project:

1. Design a device based upon a winter theme. It must have motion, at least six individual flashing light events, and play a tune. Motion meant that something had to move around. Individual light events meant that there were at least six lights going on and off in sequence.

2. Design an environmental control unit for an individual with severe disabilities who can only use a single switch. The unit was to provide selection for and operate at least two battery operated items.

The final projects were presented on the last Saturday of the quarter. Each team was required to:
1. Provide a two minute power point presentation which ran automatically
2. Demonstrate their device
3. Total time allowed per team - five minutes

Points were given to the freshmen for:
1. Meeting design requirements (50pts)
2. Creativity (25 pts)
3. Presentation (25 pts)

The seniors' role was to lead a team of freshman students through the design process resulting in a working device. In doing so, they were expected to serve as a resource for locating materials, proper construction methods, and provide guidance in solving problems. It was their task to keep the project on schedule, assure that team meetings were attended, and see that the work load was evenly divided among the team members.

This team effort was 20% of a senior's grade and was based upon 150 possible points using the following metrics:
1. Meet with their team at least three times (30 pts)
2. Maintain an engineering notebook on the project (10 pts)
3. Be present at the project presentation to introduce the team (10 pts)
4. Produce a project report at least 12 pages long consisting of the following: (100 pts)
    A. Heading (5pts)
    B. Problem definition with objectives, requirements, constraints, and functions (15 pts)
    C. Include an objective tree, a function means tree, a morphological chart, and a Gantt chart (15 pts)
    D. Describe their initial contacts with the students and what stages of group formation they went through (10 pts)
    E. Provide a description of each meeting including who attended, what was discussed, assignments given, actions, taken and if any ethical issues occurred (20 pts)
    F. Provide a drawing of the physical project including circuit diagrams (10 pts)
    G. Provide a copy of the power point presentation and photo of the project (15 pts)
    H. And as a final paragraph, provide their thoughts on this event, how it worked as a teaming effort, how the freshmen responded to it, what made it fun and what made it difficult, and suggestions on how to improve it for the next class. (10 pts)

The senior's writing across the curriculum requirement is based upon generating at least 1500 words that can be graded on a pass or unsatisfactory basis. The project report requirements easily met the word count.

The freshmen were asked to fill out a form, as follows, which helped capture their impressions of the teaming effort.
1. What was the name of your senior team leader?
2. How many times did you meet with your senior team leader?
3. Did your first meeting include your senior team leader?
4. How much time did your team leader put on the project?
5. Did the senior team leader help you in developing your teams design?
6. Was the senior member an effective leader? Give an example.
7. In interacting with your senior team leader what did you learn about objectives, functions, morphological charts, and Gantt charts – have a good idea about it, heard about it, unfamiliar with it.
8. Was working with your senior team leader a good experience? 1 thru 10
9. How soon after your team was formed did you first meet?
10. How many ideas did your team consider?
11. Did all members of the team participate equally?
12. Did everyone accept their responsibilities?
13. Was there any resistance to the division of duties?
14. Did everyone attend each team meeting?
15. Did the team grow while you worked together?
16. Did you notice better team interaction as time went on?
17. How many times did you meet with your team?
18. What is your honest evaluation of your personal contribution to the team? %
19. What suggestions do you have for future teaming activities?

Results
The senior's reports on this project provided many insights on how they perceived the event. Additionally, it provided the professor with good feedback on how well they learned the course material. The presentations showed the teams working together and the freshman teaming questions gave insight on their interactions with the seniors.

The Seniors Perspective
  Twenty three seniors reported that they enjoyed the experience. Four did not mention it. The interaction with freshmen and the opportunity to apply what they had been learning was the main reason given. Two examples were:
      "Actually seeing the design process at hand, and actually being in control of it was a priceless experience."
      "Working with freshmen made it a lot of fun --"

  Leadership skill development was mentioned eleven times. Some comments were:
      "This introduction to teaming showed me that I *can* implement leadership skills when forced to."
      " -- even though people are suppose to be adults they still need to be told what to do."
      " -- if you can teach someone what you have just learned then you understand what you have been taught."

That this was a good teaming experience was mentioned fourteen times. Here are some examples:

"I actually gained some real-world knowledge about teaming, not the least of which was: don't count on freshmen to be timely or thorough."

"It allowed the seniors to get the design team experience and also allowed the freshmen to interact with a senior to see what lies ahead."

" -- get a taste of what the real world is like."

The most mentioned difficulties were getting the teams started and arranging meeting times. Ten suggested making the assignment sooner.

There were four comparisons of when seniors were freshman and had to do the same assignment without interacting with a senior. All four felt that having the senior-freshman interaction was much better.

There were several comments that reflected the seniors primary reactions to this experience.

"I am thankful for being afforded the opportunity to experience such a wonderful program."

"It would be great if other courses can include similar learning techniques."

"It was perfect as is.".

The Freshmen's Answers (Three of the teams did not turn in any teaming questions)

1. All knew their team leaders name.
2. The seniors were tasked to meet with the freshmen at least three times. The freshmen reported that ten teams did just that. Seven met 4 times, two 5 times, and one 6 times. The senior's reports indicated that often the freshmen met without the senior present to work on assembly.
3. Twenty two of the teams reported that the first meeting included the senior team leader.
4. Some of the seniors put in as much time as the freshmen. One provided only 5% on the actual project with the mean being 70%.
5. Seventeen teams received direct help with the project and four reported no help.
6. Twenty teams reported that their senior was an effective leader. The following are comments from different teams:
   A. "He contacted each of us immediately and really got us together quickly. He worked around our scheduled and really made the whole process go smoothly."
   B. "If we had questions he would answer them and he gave suggestions."
   C. "He helped out when we had problems creating the circuit."
   D. "Gave us tasks to do by the next meeting."
   E. " If we would come upon a problem in the building process, she stepped up to lead in the direction we needed to go."
   F. "He forced us to develop >6 ideas."
   G. "She was able to tell us exactly where to go to get every thing we needed. Always available for consultation."
   H. "She put up with me being late and helped out a lot with the project."
7. From the question involving basic design tools 19 teams reported knowledge about objectives and functions, 7 had heard about them, and none had knowledge about morphological or Gantt charts.

8. The ranking on working with the senior team leader as a good experience was answered by 22 teams as follows: 9 tens, 4 nines, 5 eights, 1 six, 1 five, 1 four and 1 three.
9. For the first meeting, ten teams met the 1st week of the assignment and the rest by the 2nd week
10. The teams reported considering from 1 to 6 ideas. Eight considered 1, nine 2, five 3, and one 6.
11. Two teams reported problems with accepting responsibilities.
12. Two teams reported problems with team participation.
13. No team had resistance to the division to duties.
14. Sixteen teams had 100% attendance at their meeting.
15. Twenty-one reported increased team growth
16. Twenty-two experienced improved team interactions as time went on
17. They reported meeting with their teams from two to twelve times with a mean of 4.3
18. Their own evaluation of their participation varied from 30% to 100% with most in the 90% to 100% range.
19. There were five suggestions for the future. Four were complaints about having to meet on a Saturday and the other one said "Keep it going, it was fun".

The Presentations

   The first 15 minutes of the presentation period was spent filling out the freshman questionnaire and some other administrative matters. Prior to the presentations the teams' power point presentations were consolidated onto a CD. The order of presentation was randomized. As each team came forward to set up, their power point presentation was launched and ran automatically. They then introduced themselves and demonstrated their project. The audience was asked to evaluate if they met the requirements and the professor kept notes. The whole process took 3.5 hours. While it was planned to hold the process down to 5 minutes per team, the positive interactions occurring with the audience caused slippage.

The Professor's Perspective

   This event served well as a learning tool. All of the seniors had a real life experience that served to emphasize the course objectives. Their reports showed a good grasp of design tools and were very informative about the teaming process they experienced. The students appreciated having project requirements laid out in detail. All met the requirements and the reports were fun to read. In particular, the details about their meeting showed that they were experiencing first hand the problems team leaders have in getting team members together and proceeding with a design. Their attention to detail in using the design tools was excellent and the fact that 19 of the team's freshmen reported knowledge about two of the tools was a good indicator that the seniors involved had mastered the concepts. The five goals were met in that the seniors did have practice as a team leader, they did apply the design tools they had learned in class, the writing across the curriculum requirements were met, the freshmen did have contact with an upperclassman, and the freshmen did have exposure to the design process.

Conclusions
This is the second year that our seniors were teamed with the freshmen on a project. The first year served as a feasibility test. This year, the students were provided more detailed written requirements and the opportunity to provide feedback. Overall the effort was a success. This was

reflected in the seniors' written reports, answers to the questionnaires and the enthusiasm present during the project demonstrations. The seniors had a real life experience being a team leader and honed their skills using the design tools taught in the course. From the freshmen comments it appears that a few of the seniors were not as diligent working with their teams as the others. This will need to corrected for the next senior-freshman event. Most of the seniors enjoyed the experience and the freshmen responded well. One senior's final comment sums it up,
"Overall, it was a joy working with these freshmen."

References

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Biographical Information

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