# FRESHMAN-SENIOR COLLABORATION IN A CAPSTONE DESIGN COURSE

John I. Hochstein, William S. Janna

Department of Mechanical Engineering
University of Memphis
Memphis TN 38152

## ABSTRACT

An innovative capstone design course titled "Design of Fluid Thermal Systems," involves groups of seniors working on various semester-long design projects. Groups are composed of 3, 4 or 5 members that bid competitively on various projects. Once projects are awarded, freshmen enrolled in the "Introduction to Mechanical Engineering" course are assigned to work with the senior design teams. The senior teams function like small consulting companies that employ co-operative education students; e.g., the freshmen.

One objective of building this collaboration is a desire to increase the retention rate of the freshmen by involving them with the seniors in what appears to be interesting design work. Additionally, the seniors benefit by developing the ability to communicate their ideas to a non-technical, educated audience as their design work progresses.

The Freshman-Senior Collaboration program began in Fall 2001. At the end of the Fall 2001 semester, the seniors were given assessment forms to complete, and among other things, the seniors recommended that the program be continued in the future. The program was continued in 2002, 2003 and 2004. The seniors and the freshmen both assessed the program in Fall 2002, and in 2004.

In Fall 2004, a number of those who were freshmen in 2001 are now seniors. As seniors, they are now working with freshmen "co-ops." At the end of the semester, the freshmen and the seniors were again given assessment forms to complete, and the following conclusions were drawn:

- Overall, the seniors and the freshmen perceived the freshman-senior interaction as a rewarding experience
- The seniors perceived their freshmen partners as able to make useful contributions.
- Both the freshmen and the seniors gained an appreciation of the practical aspects of management through coordination with their partners.
- The seniors were able to provide many experiential insights to the freshmen to enhance the freshmen design experience.
- The seniors and the freshmen recommended that the program be continued in the future.

Results of several specific design projects are highlighted, and the freshman-senior interaction is described.

## BACKGROUND

"Design of Fluid Thermal Systems" is a senior-level, capstone design course at the University of Memphis. Students in this course are divided into groups of 3, 4 or 5 members who work together as a team on a design project. Selected projects are presented to the design teams who must bid competitively on three of the projects. The design team with the lowest bid is awarded that particular project to work on for the entire semester. (See the text listed in the Bibliography for information on the bidding process.) Design teams function like companies and as such, each



*Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition*
*Copyright © 2005, American Society for Engineering Education*

group chooses a company name and designs a company logo. Titles of projects worked on in Fall 2004 are provided in Table 1. Some groups developed web sites for their companies. More detailed project descriptions are provided in the Appendix of this paper.

**Table 1.** *Project titles and company logos.*

| Title | # of Engrs | Student Designed Logos |
|---|---|---|
| **Bicycle Dynamometer** | 3 | |
| **Fireplace Heat Recovery** | 3 | |
| **The Cat's Meow: Design of a Cat Washer** | 4 | |
| **Vacuum System for Cleaning Buses** | 3 | |
| **Analysis of Source of Noise in a Nesbittaire Cooling Unit** | 5 | |

Each group elects a Project Director who meets with the course instructor on a weekly basis. The Project Director works with the group members to identify a list of tasks to complete in order to finish the project by the end of the semester. The list of tasks includes, for example, sizing and selecting a pipe to convey a specific fluid; sizing and selecting a pump; selecting a heat exchanger; predicting system performance; and writing a report about the design of the system.

Table 2 is an example of a task planning sheet for the Fireplace Heat Recovery Project. The plan shows a completion date selected for each task. By the end of the fifth week of the semester, for example, a CAD model is to be developed. Also included in the task planner (although not shown in Table 2) is the name/initials of the individual responsible for completing the task.

Each group member maintains a notebook or diary of all tasks completed for the project. The diary contains any and all details of the work done by that particular member on the project. This would include something as short as a phone call, or as detailed as calculations to predict when a pump will cavitate.

The Project Director meets with the course instructor on a weekly basis, and brings his/her group member's notebooks. The instructor checks to be sure that the group or company is working on schedule. If so, the "company" earns a satisfactory performance evaluation for the week. If not, the company's performance is deemed unsatisfactory and repeated unsatisfactory evaluations will


*Copyright © 2005, American Society for Engineering Education*

affect the group's final grade. A student who continually fails to perform satisfactorily is "fired" from the company by the instructor.

**Table 2.** *List of tasks to be completed for the Fireplace Heat Recovery Project.*

| | Week Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Activity** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Research existing fireplaces | ■ | ■ | | | | | | | | |
| Select fireplace | | ■ | | | | | | | | |
| Suggest Heat Exchanger designs | | ■ | ■ | | | | | | | |
| Decide on HX design & optimize | | | ■ | ■ | | | | | | |
| Optimize blower | | | | ■ | | | | | | |
| Do cost analysis | | | | ■ | ■ | | | | | |
| Develop CAD models & parts | | ■ | ■ | ■ | ■ | | | | | |
| Write Report | | | | | | ■ | ■ | ■ | | |
| Write oral presentation | | | | | | ■ | ■ | ■ | | |
| Finalize Report | | | | | | | | | ■ | |
| Finalize oral presentation | | | | | | | | | ■ | |
| Present & submit reports | | | | | | | | | ■ | ■ |

## COOPERATIVE EDUCATION

Once projects are awarded, student companies begin their work. The first thing to work on is the task planning sheet. Tasks must be identified and the individual responsible for finishing each task is assigned.

A series of two courses were introduced into the Mechanical Engineering curriculum at the University of Memphis beginning with the Fall 1998 semester. Among other things, these courses serve as an introduction to Mechanical Engineering and will hopefully aid our retention efforts. One of the ideas tried in Fall 2001 and carried through to Fall 2004 was to get the freshmen involved with the seniors. Seniors can provide valuable insights to the freshmen and provide them with a perspective about the University that faculty cannot provide. The seemingly ideal way to do this was to have the senior design teams take on freshmen as part of their companies. Thus, the design "companies" were assigned "co-op" students.

Certainly freshmen are not expected to be able to size pumps or to make engineering-based decisions on materials to use for specific jobs. There are, however, things that freshmen can do to work credibly with the seniors.

For example, one company in Fall 2001 was assigned the project of designing a pneumatic freight pipeline. The pipeline would use a high volume flow rate of air to convey raw or frozen peas from a feed hopper to a cyclone separator. The students were to select a pipe size, a suitable blower, a feed hopper, and a separator. In addition, the students were to consider economic, environmental, health, and safety issues, as well as determine the cost (initial plus operating) of the entire system. The properties of peas were needed in order to size the pipeline. The freshmen were assigned the task of measuring the properties of peas, and to do so with some statistical significance (e.g. the density of peas is 1 410 kg/m$^3$, and the diameter of the "average" green pea is 0.23 in.).

In Fall 2004, one group was assigned the project of designing a Cat Washer. This apparatus would be used by large commercial pet stores, such as "PetCo." The Cat Washer is a device that will wash a cat with water and liquid shampoo, apply up to two post-wash water soluble additives such


*Copyright © 2005, American Society for Engineering Education*

as conditioner/ deodorizer/flea killer, remove loose hair from the cat's coat, and dry the cat. The freshmen did much of the leg work for this project including but not limited to: investigating whether such devices are currently marketed; designing and constructing a harness to hold the cat while it is in the washer; and, determining appropriate water temperature for washing the cat.

In Fall 2004, there were 8–10 freshmen assigned to each company; thus seniors had at least 8 freshmen co-op students to work with. The seniors (technically experienced persons) had to communicate their ideas to the freshmen (non-technical audience) as the design work progressed. Freshmen were to attend weekly planning meetings with the seniors, and so were able to observe and participate in the interaction that typically exists in technical meetings. In most cases, freshmen were present during much of the planning and design phases of the projects.

Near the end of the semester, the freshmen were required to submit written reports describing their experience and to give oral reports to their classmates regarding the work that they had completed as co-ops. Freshmen were asked to describe the project they worked on, and explain how they contributed to its overall completion. Seniors were required to attend the presentations, and in all cases the seniors helped the freshmen prepare their reports.

## FALL 2001 ASSESSMENT

At the end of the Fall 2001 semester, the seniors were given an assessment instrument in the form of a quantitative/qualitatively-based survey which measured results in the following areas:

- program objectives as related to the mechanical engineering department's Program Outcomes
- course management
- appropriateness/relevancy of prerequisites
- enhancement of technical communication skills
- interaction/experiences with freshman students

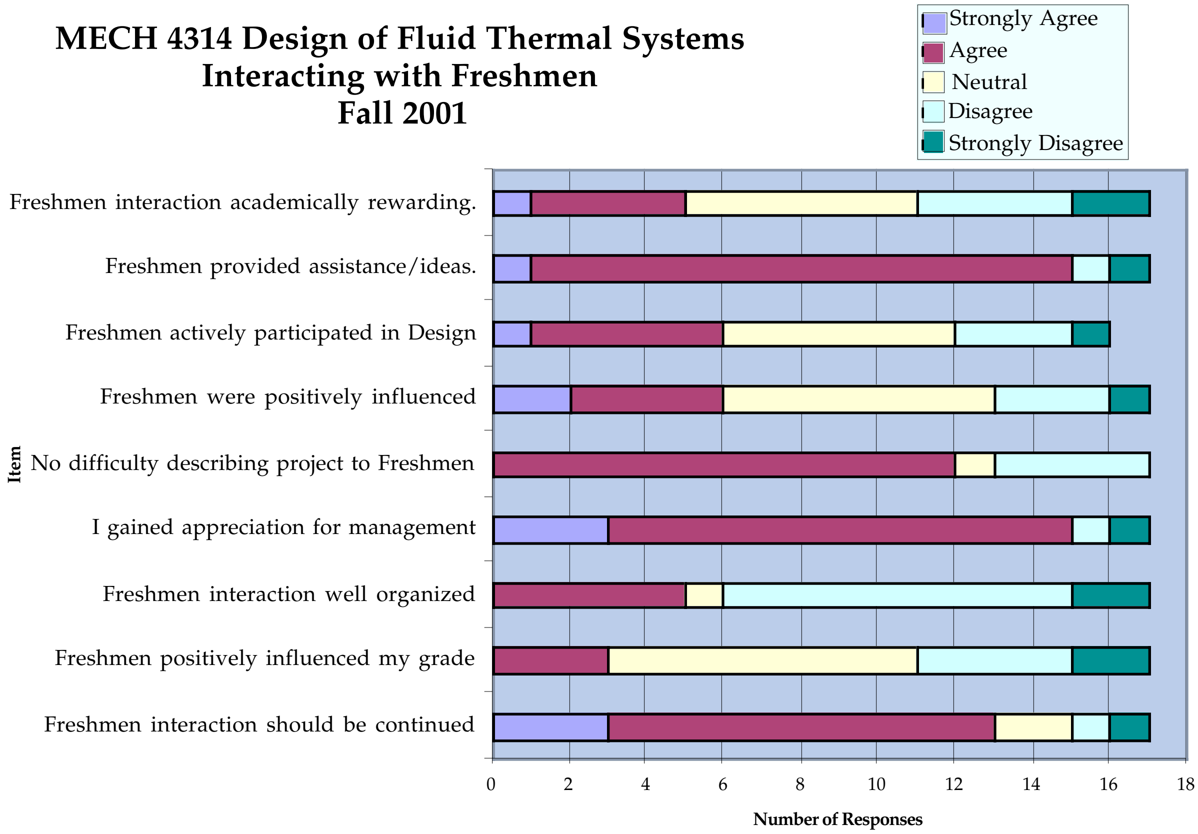
The focus here is on their opinions regarding their interaction with freshmen. Figure 1 displays graphically the seniors' responses. As indicated in the legend, a purple color means "Strongly Agree," a red color indicates "Agree," yellow means "Neutral," green signifies "Disagree," while cyan indicates "Strongly Disagree." The colors in the legend are arranged purple to cyan—top to bottom. In the chart, purple to cyan is arranged left to right. A preponderance of purple and red at the left edge is considered highly favorable.

**(a) Interacting with the freshmen was an academically rewarding experience.**
The response to Item a indicates that interacting with freshmen was not particularly rewarding for 6 out of 17 seniors, although 5 of 17 thought it was.

**(b) The freshmen were able to provide our group with assistance/ideas.**
Despite the response to Item a, Item b shows that 15 of 17 seniors believed that freshmen were able to provide some assistance to the overall design effort. Every group was able to have the freshmen work with them in some capacity.

**(c) The freshmen were able to participate actively in the design process.**
Item c shows that freshmen participation in the actual design phase was rather limited, due to their inexperience with engineering fundamentals. It was, however, desired to have the freshmen gain an appreciation for engineering design.


*Copyright © 2005, American Society for Engineering Education*




**(d) I believe I was able to positively influence the freshmen to want to stay in engineering.**
One of the objectives of building this collaboration was a desire to increase the retention rate of the freshmen by involving them with the seniors in design work. Item d shows that the seniors perceived that they had no positive influence on making freshmen want to stay in engineering.

**(e) I had no difficulty in describing our project to the freshmen.**
Item e indicates that the seniors believed they had little difficulty in describing their projects to the freshmen. Developing the student's ability to communicate technical ideas to a non-technical audience is one of the seldom mentioned objectives in this course.

**(f) By working with freshmen, I gained some appreciation for the effort involved in managing engineers.**
Item f shows that 15 of 17 seniors gained some appreciation for the effort involved in managing engineers.

**(g) I thought that this entire exercise of involving freshmen in senior design projects was well organized.**
The seniors felt that this venture was not well organized, as indicated in Item g, which is something that can occur with any new idea. In another part of the survey, several students made suggestions as to how to minimize some of the organizational problems encountered.

**(h) Interacting with the freshmen has had a positive effect on my grade in this course.**
Item h shows that seniores believed that interacting with the freshmen did not have a positive effect on the grades received by the seniors.


*Copyright © 2005, American Society for Engineering Education*

**(i) The practice of using freshmen to interact with the senior design groups should be continued.**
Item i asks the seniors about continuing the practice of involving freshmen in senior design projects, and the responses here were among the most positive in this portion of the survey. In the comments section, one senior wrote that interacting with freshmen was a good idea and should be continued.

In summary, at the end of the Fall 2001 semester, the seniors appeared to view their experiences with the freshmen-senior collaboration experiment in a mildly positive light. The most positive response elicited by the survey indicates that the 15 of the 17 seniors believe the experience gave them some appreciation for the challenges faced by managers of technical projects. Close behind, 13 of 17 seniors believe the collaboration to have been a worthwhile experience and that it should improved, not scrapped.

## LESSONS LEARNED FROM FALL 2001 ASSESSMENT

The survey instrument yielded information to be applied to the freshmen-senior collaboration project. Discussions with seniors, freshmen, and faculty provided additional data. Information gained from these sources helped to identify areas that needed improvement; the process was continued next time the senior design course was offered.

It was noted that the freshmen classes and the senior classes were offered at different times of the day, so there were problems in scheduling meetings in which freshmen and seniors could both attend conveniently. A group of seniors subsequently made very creative suggestions for eliminating this problem.

After both the Freshman and Senior courses were completed, and grades assigned, the faculty involved in this experience met to formalize their assessment of the freshmen-senior collaboration experiment and to plan accordingly for the future. Every faculty member was in agreement with the seniors that the experience was worthwhile and that the collaboration should be repeated in future offerings of these two courses.

It was also painfully clear that there was considerable room for improvement! Although a long list of lessons learned and specific actions to improve the experience was assembled, space limitations dictate discussion of only the two most salient lessons. First, the quality of the experience varied considerably from group to group. Clear definition of the ways that the freshmen and seniors should interface should be distributed to all parties at the very beginning of the semester, and faculty must ensure compliance as the semester progresses. Second, although some interesting work was accomplished by almost all freshmen, as a whole they were not as involved in the design process as had been hoped. The task plan developed by the seniors must explicitly show a Preliminary Design Phase, with an anticipated completion date, in which the freshmen can actively participate in a meaningful way despite their limited technical expertise.

## LESSONS LEARNED FROM FALL 2002 ASSESSMENT

It was believed that implementation of the aforementioned ideas and other corrective actions would lead to a more rewarding experience for all involved in the Fall 2002 Freshman-Senior Design Collaboration.

In Fall of 2002, the program was again instituted. The seniors and the freshmen were given assessment forms. The senior responses were quite similar to those just provided for Fall 2001. (See Reference 3 for more details.) The freshmen responses are provided here.


*Copyright © 2005, American Society for Engineering Education*

The freshmen assessment instrument was a quantitative/qualitatively-based survey which measured their reaction to the freshmen-senior interaction/experiences which is the focus here.

Figure 2 displays graphically the freshmen responses. As indicated in the legend, a purple color means "Strongly Agree," a red color indicates "Agree," yellow means "Neutral," green signifies "Disagree," while cyan indicates "Strongly Disagree." The colors in the legend are arranged purple to cyan—top to bottom. In the chart, purple to cyan is arranged left to right. The statements were worded such that a preponderance of purple and red at the left edge is considered highly favorable.

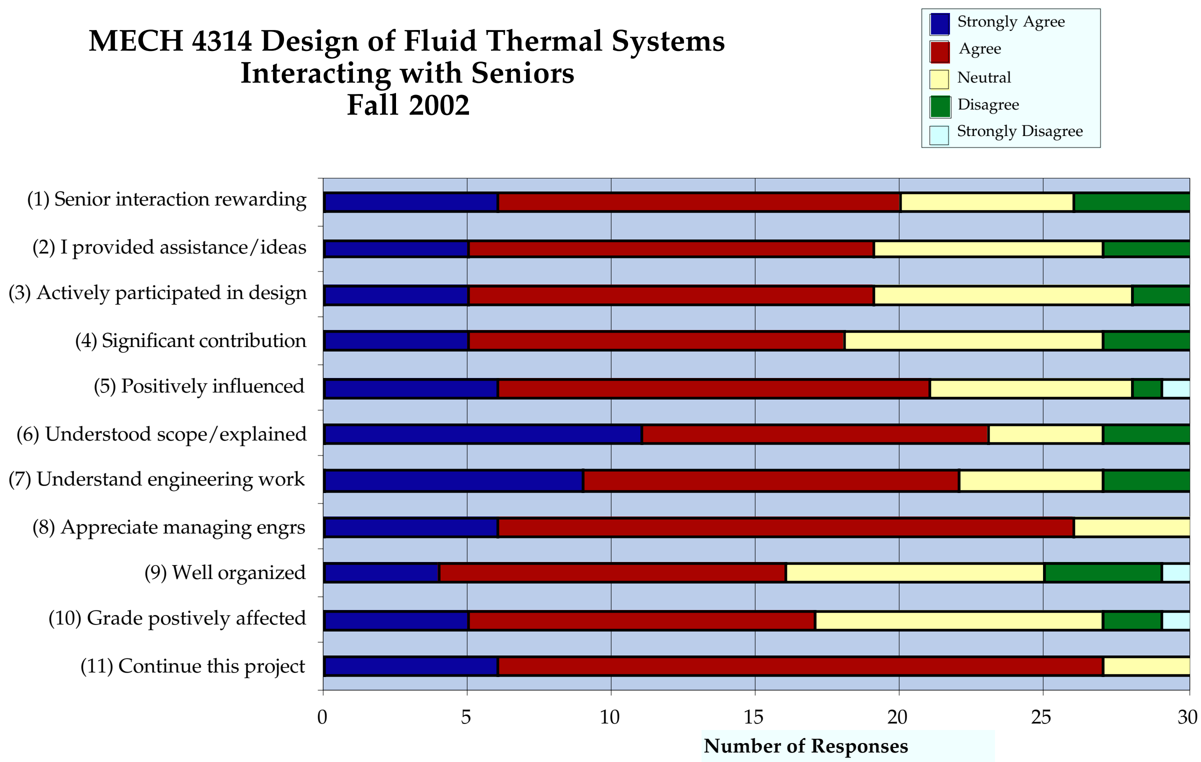



**Figure 2**. *Results of freshmen responses to questions about senior/freshmen interaction.*

**(1) Interacting with the seniors was an academically rewarding experience.** The response to **Item 1** indicates that interacting with seniors was perceived as rewarding for 20 out of 30 freshmen, although 4 of 30 thought it was not. Six students neither agreed nor disagreed with this statement.

**(2) The freshmen were able to provide the senior group with assistance/ideas. Item 2** shows that 19 of 30 freshmen believed that they were able to provide some assistance to the overall design effort.

**(3) The freshmen were able to participate actively in the design process. Item 3** shows that 19 of 30 freshmen strongly agreed or agreed that they actively participated in the design process, and only 2 of 30 did not. As mentioned earlier, freshmen participation in the actual design phase is rather limited, but this was not perceived as so by the freshmen as indicated by their response. The freshmen believe they have indeed gained an appreciation for engineering design.

**(4) I believe that I made a significant contribution to the overall design project.** 18 of 30 freshmen agreed with this statement, while 9 expressed no opinion, and only 3 disagreed. The freshmen apparently felt that their participation in this collaboration was worthwhile.


*Copyright © 2005, American Society for Engineering Education*

**(5) The seniors were able to positively influence me to want to stay in engineering.**

One of the objectives of involving freshmen with seniors was to increase the retention rate of the freshmen, or at the very least, to have seniors favorably impress them. **Item 5** shows that 21 of 30 freshmen were positively influenced; 7 expressed no opinion, and only 2 disagreed or strongly disagreed with this statement. Again, this was one of the stronger outcomes of the current experiment, and one of the primary drivers for conducting it.

**(6) The seniors had no difficulty in describing the scope of their project to us freshmen.**

**Item 6** indicates that 23 of 30 freshmen basically had little difficulty in understanding the descriptions of the projects. Four students expressed no opinion, while 3 disagreed. Developing the student's ability to communicate technical ideas to a non-technical audience is one of the seldom mentioned objectives in this course.

**(7) My participation in this design project helped me to understand what an engineer would do to complete a project in the workforce.**

**Item 7** shows that 22 of 30 freshmen gained an idea of what engineers do when working on a project in industry. Five students had no opinion and 3 students disagreed.

**(8) By working on the project, I gained some appreciation for the effort involved in managing engineers.**

Referring to the comments made by the seniors, we see that in **Item f,** 15 of 22 seniors gained some appreciation for the effort involved in managing engineers, while 4 did not. With regard to the comments made by the freshmen, we see that in **Item 8,** 26 of 30 students gained this same appreciation, while 4 expressed no opinion. This item appears to provide the most positive outcome of the entire freshmen/senior collaboration.

**(9) I thought that this entire exercise of involving freshmen in senior design projects was well organized.**

We see from Figure 2 that 16 of 30 freshmen felt that this project was well organized, but 5 of 30 felt it was not, and 8 students neither agreed nor disagreed. The freshmen were more positive on this issue than were the seniors.

**(10) Interacting with the seniors has had a positive effect on my grade in this course.**

**Item 10** shows that 17 of 30 freshmen felt that interacting with the seniors did have a positive effect on the grades received by the freshmen. Only two disagreed, and 10 were neutral.

**(11) The practice of using freshmen to interact with the senior design groups should be continued.**

**Item 11** asks the freshmen about continuing the practice of involving freshmen in senior design projects, and the majority of the responses (27 of 30) are positive. Three students expressed no opinion. More freshmen than seniors (12 of 22) think this collaboration should be continued.

**Comments.** The freshmen were also asked for the recommendations for improvement in the course, and they were far more talkative than the seniors. Comments from freshmen regarding the senior/freshmen interaction were as follows:

> *I felt that from the start my group didn't really work together. I would have had a better opportunity to learn being in the other cooling systems group. Also the seniors kept emphasizing the project we were supposed to make, I felt they could have done more explaining of the system.*
>
> *Talk more about the systems and make sure everyone is working together.*




*Copyright © 2005, American Society for Engineering Education*

*The organization on "The Presentation" on Power Point was poorly executed. I ended up doing all the work for my freshman group.*

*[Name of senior] group were very polite and very helpful when it came to do the presentation. Two thumbs up. Thanks.*

*I didn't receive help with non participating team members on the freshman group from senior team leader when I asked for help. Seniors should be more active with freshmen groups.*

*Should not classify groups such as seniors, freshmen, etc., [identify students] by their course.*

*Some groups did not give the freshmen much to do.*

*I think this program should be done with sophomores.*

*I didn't learn any details from our seniors. I just knew what their project was and that was about it.*

*Make responsibilities of freshmen more defined, so they can't use "I didn't know" as an excuse for not showing up, participating, and doing their fair share.*

*Sometimes I felt that the total involvement of freshmen in the group was not need[ed]. I felt that I was just coming to class and listening to a prof. lecture.*

**FALL 2004 ASSESSMENT BY SENIORS**

The following graph presents student opinions regarding this Freshmen/Senior collaboration, which is now in its fourth cycle. As indicated in the legend, a dark blue response means "Strongly Agree," etc.

The response to Item a indicates that interacting with freshmen was rewarding for 11 of 16 seniors who completed the questionnaire. In previous years, the freshmen-senior interaction received less favorable reviews. Two students had no opinion, and 3 thought it was not rewarding.

Item b shows that 12 of 16 seniors believed that freshmen were able to provide some assistance to the overall design effort. Every group was able to have the freshmen work productively with them in some capacity.

Item c shows that 14 of 16 seniors strongly agreed or agreed that the freshmen actively participated in the design process, and 2 of 16 had no opinion. The goal of having the freshmen gain an appreciation for engineering design is believed to have been met.

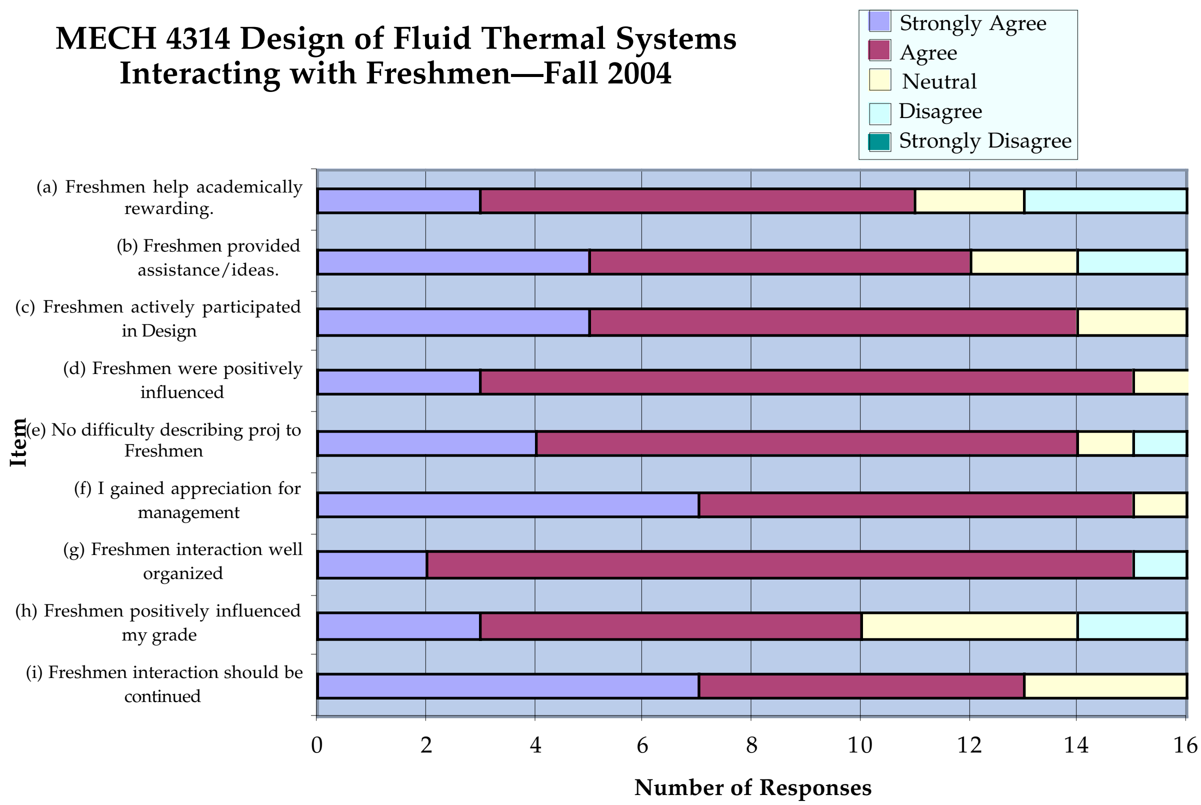
Item d shows that 15 of 16 seniors perceived that they had a positive influence on making freshmen want to stay in engineering. One senior had no opinion.

Item e indicates that 14 of 16 seniors believed they had little difficulty in describing their projects to the freshmen.

Item f shows that 15 of 16 seniors gained some appreciation for the effort involved in managing engineers, while 1 expressed no opinion.

In Fall of 2001, the seniors felt that this venture was not well organized. After making several changes for Fall 2002, Fall 2003, and Fall 2004, we see in item g that 15 of 16 seniors felt that this project was well organized, and 1 felt it was not. In previous years, the students were evenly divided on this issue.


*Copyright © 2005, American Society for Engineering Education*




Item h shows that 10 of 16 seniors felt that interacting with the freshmen did have a positive effect on the grades received by the seniors. Two disagreed, and 4 were neutral. Over the years, seniors in general did not feel that their grades were improved by the presence of freshmen on their design teams.

Item i asks the seniors about continuing the practice of involving freshmen in senior design projects, and the majority of the responses (13 of 16) are positive. Two of 16 thought had no opinion.

## FALL 2004 ASSESSMENT BY FRESHMEN

The following graph presents freshmen student opinions regarding this Freshmen/Senior collaboration. As indicated in the legend, a dark blue response means "Strongly Agree," etc. The response to Item 1 indicates that interacting with seniors was rewarding for 32 of 33 freshmen who completed the survey. One student thought it was not rewarding.

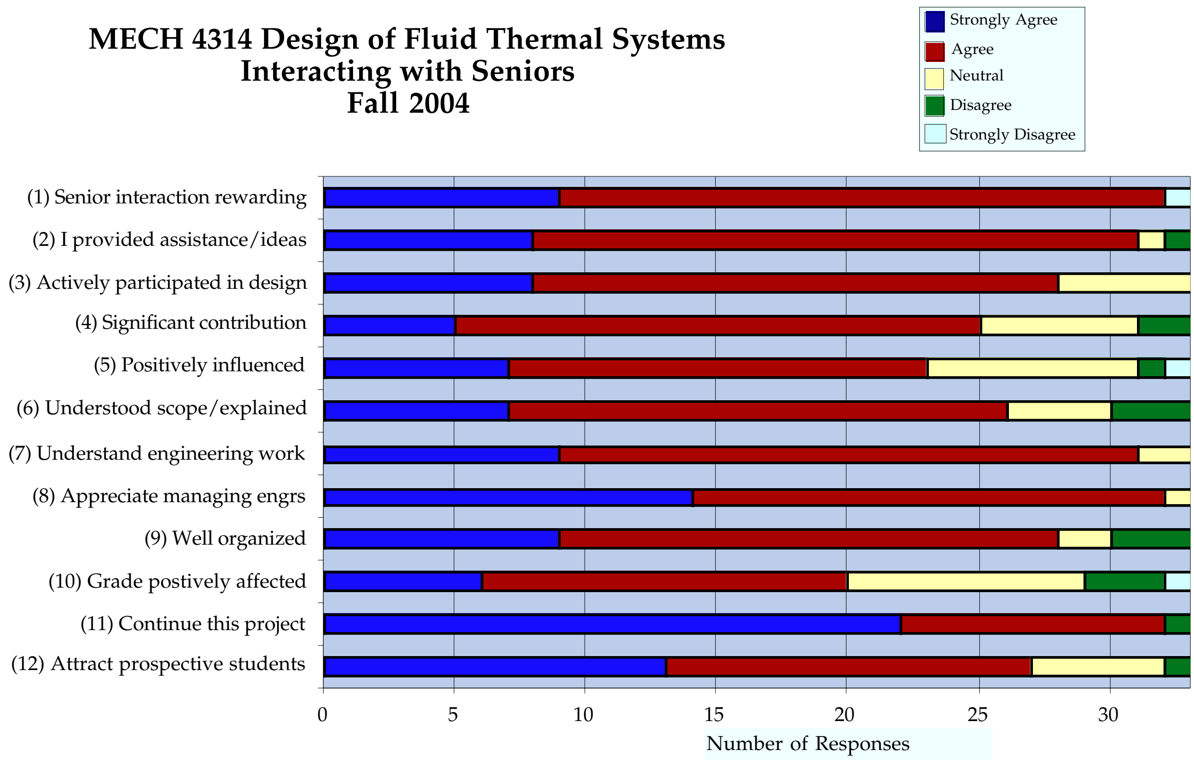
Item 2 shows that 31 of 33 freshmen believed that they were able to provide some assistance to the overall design effort.

Item 3 shows that 28 of 33 freshmen strongly agreed or agreed that they actively participated in the design process, and 5 had no opinion.

Item 4 shows that 25 of 33 freshmen perceived that they made a significant contribution toward completion of their respective project. Item 5 indicates that 23 of 33 freshmen were positively influenced into staying in engineering. Item 6 shows that 26 of 33 freshmen had little difficulty in understanding the scope of their projects as described by the seniors.




*Copyright © 2005, American Society for Engineering Education*




Item 7 shows that 31 of 33 freshmen gained some understanding of what an engineer would do to complete a project in the work force. Item 8 shows that 32 of 33 freshmen gained an appreciation for the effort involved in managing engineers, while 1 expressed no opinion.

Item 9 indicates that 28 of 33 freshmen felt that this project was well organized; 2 had no opinion and 3 felt it was not.

Item 10 shows that 20 of 33 freshmen felt that interacting with the seniors did have a positive effect on the grades received by the freshmen. Four disagreed, and 9 were neutral.

Item 11 asks the freshmen about continuing the practice of involving freshmen in senior design projects, and the majority of the responses (32 of 33) are positive. One of 33 disagreed.

Item 12 asks the freshmen about whether this freshmen senior collaboration would be something that would have a positive influence on prospective students. Twenty-seven responded strongly agree or agree, while 5 had no opinion and 1 disagreed.

The plan is to continue this project for many more cycles. Freshmen in Fall 2001 who served as co op students were seniors in Fall 2004. This uniquely experienced group provided assessment data that leads one to believe that the freshmen senior collaboration should continue. With the 2005 Fall offering of classes, additional structure will be added in MECH 1307 (the freshman class) to more closely track freshmen activities in an effort to improve the value of this experience for both freshmen and seniors.

## INTERVIEWS WITH SENIORS

Many of the seniors in this course during Fall 2004 were freshmen in Fall 2001 and have thus witnessed both sides of this collaboration. Interviewing them provided invaluable insight into the


*Copyright © 2005, American Society for Engineering Education*

program, and what could be done to improve it. Below is a summary of comments made by seniors:

1. Seniors should continue to hold regularly scheduled meetings with the freshmen.
2. Include the freshmen in a lot of activities.
3. Seniors should have more interaction with the freshmen
4. Making it fun for the freshmen would cause the freshmen course to be particularly attractive.
5. Plan activities to allow the freshmen to get to know each other better.
6. Seniors and faculty should provide lots of support.
7. Seniors should give the freshmen portions of the project to work on; give deadlines, and if a freshman does not complete his/her assignment, exclude them from attending a meeting.
8. Seniors should be assertive and firm with the freshmen to give the freshmen some discipline and structure.
9. Seniors must use the input provided by the freshmen.
10. Seniors and freshmen should brainstorm together.
11. Freshmen can get insights from seniors.
12. Have freshmen write short reports and have them present their results to the seniors.
13. Freshmen are required to give final reports in the freshman class. These reports should be worked on with the help and guidance of the seniors.
14. Faculty should periodically sit in on meetings with the seniors and freshmen.
15. Seniors and freshmen should meet at least once per week.
16. Seniors and faculty must be strict on getting the freshmen to attend meetings.
17. Let the freshmen do their own research and provide guidance as needed.
18. Seniors should be required to grade the freshmen on their participation on the project.
19. If a freshman does not participate, his name is to be removed from any reports.
20. Actual mentoring is to be practiced by the seniors.
21. Give the freshmen nicknames to make them feel as if they are in a friendly environment.
22. The interested freshmen is to be rewarded and the disinterested freshmen should be failed.
23. Seniors liked this experience.
24. It should be continued.
25. The interaction should be fun.
26. This program should continue.
27. Great experience for the seniors in managing engineers.
28. The freshmen that did not drop out of engineering worked out well.

**Differences between Fall 2001 and Fall 2004 that improved the collaboration**

1. A time to meet was formally scheduled.
2. There were no schedule conflicts; at least one meeting time per week was set.
3. Seniors in 2004 spend far more time with the freshmen compared to 2001.

## COMPARISON OF SURVEY RESULTS

It is interesting to compare results between the collaborations. Here we compare the results obtained from the seniors in Fall 2001 to those obtained in Fall 2004. Table 3 provides a summary of the results, showing only the positive responses (red and blue in the charts). Table 2 provides a comparison between the Fall 2002 and Fall 2004 freshmen, again showing only the positive responses.


*Copyright © 2005, American Society for Engineering Education*

**Table 3.** *Comparison Fall 01 to Fall 04 responses by* ***seniors*** *to survey.*

| QUESTION | FALL 01 | FALL 04 | % CHANGE |
|---|---|---|---|
| **(a) Interacting with the freshmen was an academically rewarding experience.** | 5/17 | 11/16 | + 39% |
| **(b) The freshmen were able to provide our group with assistance/ideas.** | 15/17 | 12/16 | – 13 |
| **(c) The freshmen were able to participate actively in the design process.** | 6/17 | 14/16 | + 52 |
| **(d) I believe I was able to positively influence the freshmen to want to stay in engineering.** | 6/17 | 15/16 | + 59 |
| **(e) I had no difficulty in describing our project to the freshmen.** | 12/17 | 14/16 | + 17 |
| **(f) By working with freshmen, I gained some appreciation for the effort involved in managing engineers.** | 15/17 | 15/16 | + 5.5 |
| **(g) I thought that this entire exercise of involving freshmen in senior design projects was well organized.** | 5/17 | 15/16 | + 64 |
| **(h) Interacting with the freshmen has had a positive effect on my grade in this course.** | 3/17 | 10/16 | + 45 |
| **(i) The practice of using freshmen to interact with the senior design groups should be continued.** | 13/17 | 13/16 | + 4.9 |

## SUMMARY AND CONCLUSIONS

Beginning with the 2001 Fall semester, students in the freshman "Introduction to Engineering" course have been assigned to work with design teams formed by seniors in a capstone thermal/fluid systems design course. The model for this interaction is very similar to that of a student intern or a co-op student in an industrial setting: motivated and intelligent but technically immature individuals work with more knowledgeable and experienced individuals to form a team focused on producing a design to meet a perceived need.

This paper, being written at the conclusion of the 2004 Fall semester, has documented the evolution of this collaboration through its first four iterations. Toward the end of each semester, seniors and freshmen have been asked to assess the experience from many different perspectives. A continuous improvement process, using these assessments in concert with anecdotal information and informal communications, has guided the instructors in addressing shortcomings and in enhancing the experience for both the freshmen and the seniors.

With every iteration, the level of success in achieving the pedagogical objectives of the collaboration has increased. Although many factors influence student retention, it is clear from student opinions that this exercise has a positive influence on freshmen perceptions of the program and the profession. The 2004 Fall collaboration is the first time that senior members of the design


*Copyright © 2005, American Society for Engineering Education*

team had also experienced this collaboration as freshmen. Many of them were determined to do a better job of mentoring the freshmen than had been done for them when they were freshmen. There is no doubt in the authors' minds that this motivation has helped to make the 2004 Fall collaboration more successful than any of its predecessors.

**Table 4.** *Comparison Fall 2002 to Fall 2004 responses by* ***freshmen*** *to survey.*

| QUESTION | FALL 02 | FALL 04 | % CHANGE |
|---|---|---|---|
| **(1) Interacting with the seniors was an academically rewarding experience.** | 20/30 | 32/33 | + 30% |
| **(2) The freshmen were able to provide the senior group with assistance/ideas.** | 19/30 | 31/33 | + 31 |
| **(3) The freshmen were able to participate actively in the design process.** | 19/30 | 28/33 | + 22 |
| **(4) I believe that I made a significant contribution to the overall design project.** | 18/30 | 25/33 | + 16 |
| **(5) The seniors were able to positively influence me to want to stay in engineering.** | 21/30 | 23/33 | – 0.3 |
| **(6) The seniors had no difficulty in describing the scope of their project to us freshmen.** | 23/30 | 26/33 | + 2.1 |
| **(7) My participation in this design project helped me to understand what an engineer would do to complete a project in the workforce.** | 22/30 | 31/33 | + 21 |
| **(8) By working on the project, I gained some appreciation for the effort involved in managing engineers.** | 26/30 | 32/33 | + 10 |
| **(9) I thought that this entire exercise of involving freshmen in senior design projects was well organized.** | 16/30 | 28/33 | + 32 |
| **(10) Interacting with the seniors has had a positive effect on my grade in this course.** | 17/30 | 20/33 | + 3.9 |
| **(11) The practice of using freshmen to interact with the senior design groups should be continued.** | 27/30 | 32/33 | + 7.0 |

The Freshman/Senior Collaboration on design projects supports many of the mechanical engineering program's ABET-related Program Outcomes and all of the program's Program Educational Objectives. As measured by student assessments and by the opinion of instructors, the level of success in all aspects of the interaction is growing with experience. Therefore, the authors plan to continue integrating the Freshman/Senior Collaboration on design projects into the mechanical engineering program for the foreseeable future.




*Copyright © 2005, American Society for Engineering Education*

## BIBLIOGRAPHY


1. Janna, W. S., John I. Hochstein, Michael Racer, Anna Phillips, Hsiang H. Lin, "Freshman-Senior Collaboration in a Capstone Design Course," presented at the *2002 ASEE Summer Annual Meeting* during June 2002 in Montreal, Quebec, and published in the *2002 Annual Conference Proceedings,* on CD.

2. Janna, W. S., John I. Hochstein, Michael Racer, Anna Phillips, Hsiang H. Lin, "Senior-Freshman Collaboration in a Capstone Design Course," presented at the *2003 ASEE Summer Annual Meeting* during June 2003 in Nashville, TN, and published in the *2003 Annual Conference Proceedings,* on CD.

3. Janna, W. S., John I. Hochstein, "An Assessment Process for a Capstone Course in Design of Fluid Thermal Systems," presented at the *2004 ASEE Summer Annual Meeting* during June 2004 in Salt Lake City, UT, and published in the *2004 Annual Conference Proceedings,* on CD.

4. Janna, W. S., *Design of Fluid Thermal Systems*, Brooks/Cole Publishers, Monterey, CA, 1998.

See also: http://www.people.memphis.edu/~herffcoll/mech4314.html

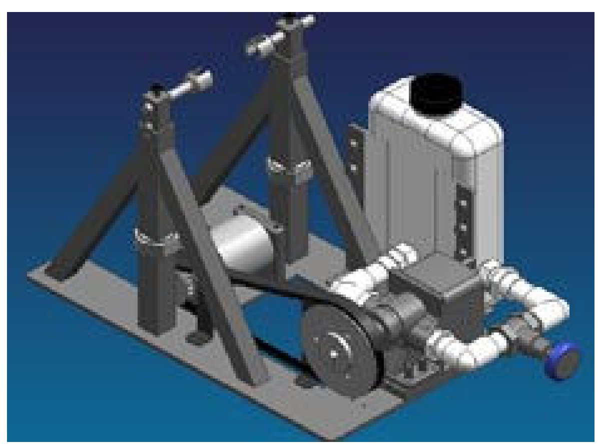

## BIOGRAPHICAL INFORMATION


**JOHN I. HOCHSTEIN**—John I. Hochstein joined the faculty of The University of Memphis in 1991 and currently holds the position of Chair of the Department of Mechanical Engineering. In addition to engineering education, his research interests include simulation of micro gravity processes and computational modeling of fluid flows with free surfaces. He is a co-author of a textbook, *Fundamentals of Fluid Mechanics*, with P. Gerhart and R. Gross and is an Associate Fellow of AIAA. Dr. Hochstein received a B.E. degree from the Stevens Institute of Technology (1973), an M.S.M.E. degree from The Pennsylvania State University (1979), and a Ph.D. from The University of Akron (1984).

**WILLIAM S. JANNA**—William S. Janna joined the faculty of The University of Memphis in 1987 as Chair of the Department of Mechanical Engineering. He served as Associate Dean for Graduate Studies and Research in the Herff College of Engineering. His research interests include boundary layer methods of solution for various engineering problems, and modeling the melting of ice objects of various shapes. He is the author of three textbooks, a member of ASEE and of ASME. He teaches continuing education courses in the area of piping systems and in heat exchanger design and selection, for ASME. Dr. Janna received a B.S. degree, an M.S.M.E. and a Ph.D. from the University of Toledo.


## APPENDIX: PROJECT DESCRIPTIONS

### Bicycle Dynamometer



A dynamometer is a device for measuring the output power of a system. Dynamometers have been used extensively for measuring power from an internal combustion engine, from a turbine, and from an automobile. Dynamometers can be of the electric type, in which the output power is used to produce electric power, or of the fluid type, where the output power is used to pump a liquid (usually water) or move air. On a smaller scale (than IC engines), it is desirable to measure the output of a person pedaling a bicycle. Results of such tests are of interest in physical education studies of human power output and endurance, and to manufacturers of bicycles. Consequently, there is a need to have a dynamometer onto which a complete bicycle can be attached and pedaled, and from which output power can be calculated.

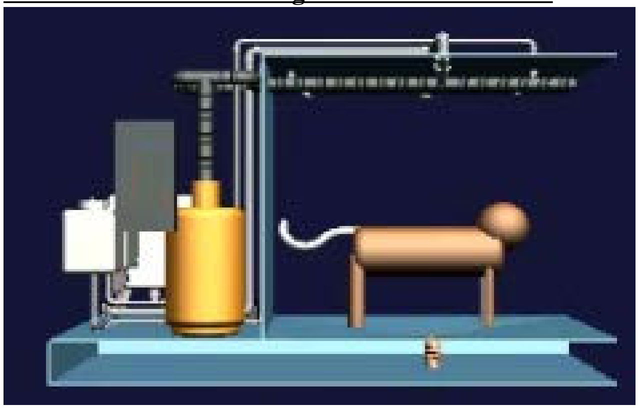


*Copyright © 2005, American Society for Engineering Education*

**Fireplace Heat Recovery**

Sheet metal fireplaces can be added to a room after the structure is built; that is, the fireplace need not be built when the home is. In order to enhance the usefulness of a sheet metal fireplace, it has been proposed to devise a means for recovering more of the heat that would ordinarily be discharged up the stack with the exhaust gases. It is believed that the most effective way to transfer more of the heat from combustion is by convection so that the air in the room is heated.

**The Cat's Meow: Design of a Cat Washer**



Consider a Cat Washer that would be targeted for use by large commercial pet stores, such as "PetCo." The Cat Washer would do more than merely wash a cat. A more inclusive list of objectives would be to design a device that will:

- Wash a cat with water and liquid shampoo,
- Apply up to two post-wash water soluble additives such as conditioner/deodorizer/flea killer,
- Remove loose hair from the cat's coat, and
- Dry the cat.

The Cat Washer should be adaptable to any size of cat, and should minimize trauma to the animal. The device should optimally clean all parts of the cat.

The Cat Washer should be reliable and rugged, as well as inexpensive. It should operate quietly, and be easy to clean and maintain. Ideally, the device should operate automatically to minimize any actions required of an operator.

If electricity is needed, the device should operate at 120 V AC. The Washer must be safe for both the cat and the operator, and should be designed for indoor use.

**Vacuum System for Cleaning Buses**

The local transit authority is responsible for operating and maintaining vehicles used in public transportation, specifically buses. One of the maintenance tasks includes cleaning of the buses every evening when they are returned to the garage. Currently, buses are cleaned by an individual who walks through, picks up large refuse items, and vacuums the floor. This procedure is time consuming and costly in person-hours.

It is proposed to use a huge air moving system to clean the buses. Two huge air pipes are attached to a bus. One pipe delivers high-velocity, high-pressure air, while the other pipe takes in air exhausted from the passenger compartment. Use of such a system eliminates the need for someone to walk through the bus to clean it and would take far less time to complete the work.

**Analysis of Source of Noise in a Nesbittaire Cooling Unit**

It is proposed to analyze a cooling unit manufactured by Nesbittaire and determine sources of noise that the unit produces. The objective of the study is to locate these sources and provide methods of reducing the noise to an acceptable level.

An air handling unit must adhere to certain codes, especially those that apply to the generation of noise. One such unit is to be used in this study. Instrumentation that must be purchased and installed includes a noise meter and a velometer.

Students will investigate methods for reducing noise, and obtain whatever is needed to reduce the noise level associated with the unit. When noise reduction methods are employed, air velocity and sound data will again be taken and compared to that obtained earlier.

The overall objective for the students is to make recommendations regarding noise control for the Nesbittaire unit we are working with.

- Students will provide a detailed velocity profile for the air flow through the unit.
- Students will provide a detailed sound survey for the unit.
- Students will make 3 recommendations for noise reduction, and rank them in order.
- Students will show expected improvement in noise reduction using their recommended methods as well as costs.


*Copyright © 2005, American Society for Engineering Education*