# Civil and Environmental Engineering (CEE) 220: Anytime Anywhere Final Evaluation Report

*Bayta L. Maring and Joanna Burgess*
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# EXECUTIVE SUMMARY

This report describes evaluation findings from a redesign of Civil and Environmental Engineering (CEE) 220 Mechanics of Materials.   The goals for this project were to re-allocate course resources, including lab space and instructor/TA time without any decline in student performance or satisfaction.  To this end, the Winter 2005 version of CEE 220 included the following innovations:

- Use of an integrated online course system, called [Moodle](), that centralized and organized class materials, assignments, and activities

- Online pre-lecture quizzes, implemented through the Moodle system, that were designed to prepare students for lecture above and beyond the reading itself

- Homework assignments that were completed and immediately graded online, also via the Moodle system

- Extra out-of-class help, including a weekly session at the Center for Learning and Undergraduate Enrichment (CLUE), specific tutoring times for CEE 220 at the Engineering Advising and Students Center (EASC), and an online discussion board (also a part of the Moodle system)

- An option to attend weekly labs outside of the regularly scheduled sessions

To assess the effectiveness of these changes in regards to the project goals, the Office of Educational Assessment was hired to conduct an evaluation of the new CEE 220 course.  The following evaluation activities were conducted as part of this evaluation:

- Student surveys administered at the middle and end of the term

- Interviews with 12 CEE 220 students

- Interviews with the instructor and TAs for the course

- Comparison of student performance data (grades and exam scores) and standard UW course evaluation data between CEE 220 in Winter 2005 and Winter 2004, when it was taught by the same instructor

## Summary of Findings

### Student Performance

- In terms of overall grades, there were no significant differences between CEE 220 in Winter 2005 and 2004, although an analysis of exam scores revealed that students in 2005 scored significantly worse than 2004 students on the second mid-term and final.  However, because the exams were somewhat different across years, it is unclear whether they were appropriate assessments of student learning.

- According to their own reflections, the instructor and TAs suggested that students' understanding of the material was deeper in this class than they had seen in the same or similar classes.

### Student Satisfaction

- Overall, student response to the new version of CEE 220 was overwhelmingly positive, and was, on the whole, more positive than the same course taught by the same instructor in Winter 2004.

- The instructor's commitment to the course and concern for student learning was highlighted by a large number of students as something that made the course unique and a positive experience.

- Compared to students in CEE 220 in 2004, students in Winter 2005 generally reported devoting more hours to this course and that a larger proportion of these hours was valuable.

### Moodle System in General

- For the most part, students responded positively to the integrated online course content, although there was a small number of individuals who had generally negative reactions to Moodle and the course in general.

- The TAs and instructor were very pleased with the time they saved by using the Moodle system to handle administrative aspects of the course such as assignment grading and grade recording.

### Online Reading Quizzes

- According to self-report, the majority of students (68.8%) completed all of the pre-lecture reading quizzes and all of them completed at least three-quarters of the quizzes.

- Data indicated that at the beginning of the term, students completed the quizzes after they had done the reading, but by the end of the term, they would look at the quiz before or while they were reading.

- Students saw three primary benefits of the reading quizzes:  (1) highlighting important points in the reading; (2) motivating them to complete the reading; and (3) showing them what they do not understand from the reading.

- Although students, in general, did not strongly suggest that the pre-lecture quizzes enhanced their learning, the TAs and instructor believed they did.  The instructor suggested that the quizzes might have helped students learn, though repetition and exposure, without them realizing it.

- Student satisfaction with the reading quizzes was extremely varied, with some students considering them an important part of their learning experience and others considering them a nuisance.

### Online Homework Grading

- There was consensus among students, TAs and the instructor that the primary benefit of the online homework grading was that students received immediate feedback about their responses, making the assignments a learning tool as opposed to an evaluation.

- Students appreciated the opportunity to attempt the homework multiple times, which also reinforced the idea of homework as a learning tool.

- Online grading was a welcome change to the TAs because it freed up time to spend on the more rewarding activities of teaching and working with students.

### Extra Out-of-Class Help

- In general, students made use of the out-of-class help to assist them in completing their homework assignments.

- In addition to helping students with their homework, the CLUE sessions benefited both students and instructor by allowing them to interact more informally than in lecture.

- Tutoring at the EASC was appreciated by most of the students who attended, though all of these students thought the room should be larger and that adding another TA or two would be helpful.

- The discussion board was active for this class and students appreciated it as a 24-hour source for help. The instructor and TAs were minimally involved in the discussion board and were impressed at the extent to which students helped each other.

*Alternate Lab Times*

- Only one group of students opted to have their lab session at an alternate time (9:30am instead of 8:30am).

- Although many students appreciated the opportunity for flexibility, almost half reported that the time they had originally scheduled "was perfect."

- Students who would have preferred another time but did not reschedule either could not find a mutually agreeable time with their group or had committed to other activities that made it difficult to change the lab time.

*Suggestions for Improvement*

Across all data sources, participants proposed a wide variety of suggestions for improvement. Below is a brief summary of those mentioned most frequently; a more thorough list is provided in the main report.

- Overall, the strongest suggestion was to obtain a faster server for the Moodle system, which has already been done.

- Another strong suggestion was to increase the amount of practical examples and applications in both lecture and lab.

- To improve the reading quizzes, the strongest student suggestions were: (1) make the due dates consistent; (2) provide additional hints for incorrect answers; and (3) save answers for each re-attempt (note that the instructor thought that compelling students to remember answers for each re-attempt enhanced learning).

- In regards to the online homework assignments, students made the following suggestions: (1) provide additional hints, as in the Tycho system used by the Physics department; (2) make it easier to re-submit questions; and (3) do not require submission of an additional paper copy of the homework.

- Ideas for encouraging students to attend alternate lab times included: (1) offering additional lab times; (2) organizing groups according to availability; and (3) establishing a full, unstructured day for lab sessions.

## Evaluator Comments and Recommendations

Based on an interpretation of the data, the evaluator drew several conclusions and made a few specific recommendations. Below is a brief description of these more expansive thoughts.

- The Moodle system afforded a number of opportunities for re-allocating resources. In particular, online homework grading, discussion board, and online grade book saved a considerable amount of TA and instructor time.

- These time saving aspects of Moodle (homework grading, discussion board, grade book) might be the strongest "selling points" for future instructors.

- If Moodle is used more widely, consideration should be made for students who do not have easy access to a computer or the internet.

- One option for the alternate lab space re-allocation would be either a dedicated "lab day" or a completely independent lab assignment, so that student groups could complete the sessions on their own with available online assistance.

- To encourage students to learn from each other, lab groups could be encouraged to also be study groups or teams, though this might require a linear grading structure and a reward structure to motivate students to work in teams.

- The Program in Course Redesign, funded by the Pew Charitable trust might provide valuable ideas and insight into how to re-allocate resources in this course.

- Holding a CLUE session, perhaps in lieu of an instructor's office hour, is a valuable and "low cost" (in terms of instructor time) way to provide additional assistance to students and potentially increase capacity of the course while still giving students a valuable learning experience.

- If the reading quizzes are implemented in future courses, certain changes, such as consistent due dates, should be made to these assignments to maintain student satisfaction with the course.

- It is unclear, at this point, how these innovations affected student learning. More controlled follow-up studies, might provide more accurate information about any longer-lasting effects on how well students absorbed and retained the material from CEE 220.

- In general, the primary challenge for this course redesign will be adaptability. The instructor for this version of CEE 220 was uniquely committed to the course and concerned about student learning, which are qualities that cannot be disseminated.

- Acknowledging that changes will happen slowly and beginning with small cost (in terms of time) changes would be advisable.

- If TAs are relied upon to carry out some of these changes, these responsibilities should be acknowledged as part of their time commitment to the course.

- Providing support for new Moodle users, perhaps by assigning a person in the department or college as a "Moodle expert," might facilitate the adoption of this potentially resource-saving system.

## BACKGROUND

Civil and Environmental Engineering (CEE) 220 Mechanics of Materials is an introductory engineering course required for undergraduate degrees in five of the ten departments comprising the University of Washington's College of Engineering. In Winter 2005, a redesign of this course was implemented as part of the "CEE Anytime Anywhere" project. The purpose of the redesign was to re-allocate course resources, including lab space, instructor time, classroom time, and graduate teaching assistants' time, without a loss in students' performance or satisfaction. Towards this end, the following changes were made to the course:

- **Use of online Moodle system.** Moodle is open source software designed to provide an easy-to-use interface for both students and instructors for organizing and delivering course content in an online environment. For CEE 220, the Moodle system included announcements from the instructor, general information for the class (e.g., syllabus, requirements), listing of all assignments, lecture notes and handouts, quiz keys, a student discussion forum, an online grade estimator, and other resources. Providing this information online was intended, in part, to assist the instructor in communicating with students about course materials. There were two changes implemented on the Moodle system that were of particular interest in this project, pre-lecture quizzing and online homework grading, which are described below.

- **Pre-lecture reading quizzes.** These brief quizzes were implemented through the Moodle system and contained several questions (some multiple choice, some short answer) about the reading assignment for the upcoming lecture. Students received a small amount of course credit for completing these assignments in a timely manner. The goal of these assignments was to increase the amount of out-of-class learning students did in preparation for lecture, thus increasing the value and/or impact of in-class time.

- **Online homework grading**. All homework assignments for CEE 220 in Winter 2005 were submitted online. Students also handed in paper copies of their assignments for the purpose of validation and as a back-up in case of online system failure. The paper assignments were not graded. The purpose of this innovation was to conserve TA time so that more time could be dedicated to direct interactions with students.

- **Increased availability of out-of-class help.** One unique aspect of this course was a special session held on Monday evenings at the Center for Learning and Undergraduate Enrichment (CLUE). These informal review sessions were led by the instructor and primarily covered students' questions from the upcoming week's homework assignments. In addition to the CLUE session, the instructor led an out-of-class review session before each exam and the Engineering Advising and Student Center (EASC) held tutorial sessions on Tuesdays and Thursdays specifically for CEE 220. The purpose of this increased out-of-class help was to encourage students to work together in groups on course material and questions outside class, thereby increasing the value of in-class time.

- **Option of alternate lab times.** In an effort to redistribute lab space resources, the experimental version of CEE 220 included an option for participants to attend a lab session outside of the regularly scheduled lab times. The original project proposal included a provision for undergraduates to be paid

assistants during this lab time, with TA's also available for help.  This option was presented three weeks into the quarter, after participants had already formed lab groups based upon their birthdays.  Only one group opted to have their lab session one hour later than scheduled (9:30am instead of 8:30am), which overlapped with an existing lab when TA's were present.  Hence, no undergraduate helpers were needed.

The University of Washington's Office of Educational Assessment (OEA) was asked to conduct an evaluation of the revised version of CEE 220 with a focus on (a) documenting impact on student performance and student satisfaction; (b) exploring both students' and instructors' experiences with each of the specific innovations; and (c) gathering suggestions for further improvement.  The following methods were used to collect relevant information:

- **Student Surveys:**  A brief online survey that focused on the course innovations was administered in the middle of the term and a similar paper survey was administered during one of the final class sessions.

- **Student Interviews:**  In Spring 2005, twelve of the 88 students enrolled in the course participated in interviews with the evaluator.

- **Instructor Interviews and Diary:**  The two teaching assistants and the instructor were interviewed in Spring 2005.  The instructor also kept a diary of his experience in the course, which provided additional data.

- **Student Performance Data:**  Exam scores and final grades from the experimental CEE 220 taught in Winter 2005 and the traditional version of the course taught in Winter 2004 by the same instructor were analyzed and compared.

- **Course Evaluation Data:**  Standard UW course evaluation data from CEE 220 in Winter 2005 and Winter 2004 were analyzed and compared, including both numerical ratings and students' comment sheets.

## METHODS

Below is a summary of the participants and procedures for each of the methods used in this evaluation project.

## Student Surveys

### Mid-Term Survey

An email was sent to all 88 students in CEE 220 during the sixth week of the term inviting them to participate in the online survey.  The instructor also made announcements in class about the survey, emailed students encouraging them to participate, and added a link to the survey in one of the online reading quizzes.

A total of 42 students (46.7%) completed the online survey administered in the middle of the term. No demographic information was collected from participants. Results form the mid-term survey were summarized in a brief report that was submitted to the instructor and project lead in February 2005. All of the questions from this survey are included in Appendix A.

*Final Survey*

A pencil-and-paper survey was administered to all students who attended the penultimate class session. The survey contained many of the same questions as the online survey administered in the middle of the term. The instrument was distributed and collected simultaneously with the administration of the standard UW course evaluations. The survey was completed by 48 students (54.5%); no demographic information was collected. All of the questions from this survey are included in Appendix A.

## Student Interviews

Early in the quarter after they had completed CEE 220 (Spring 2005), all 88 students who had taken the course were sent an email message inviting them to participate in a 90-minute focus group. Refreshments were offered as an incentive. The instructor sent one email encouraging students to participate. Due to lack of response, a subsequent email was sent to the same list of students, inviting them to take part, instead, in individual interviews at a time convenient for them. The incentive for participation was a 128GB flash drive for the first ten interviewees.

A total of twelve students (three female and nine male) participated in this aspect of the evaluation (two of them consenting to participate without incentive). Ten individuals were interviewed in person at various locations on the UW campus (primarily in the Husky Union Building); three of these participants were interviewed together as a group. An additional student was interviewed by phone. During all of these interviews, the evaluator took type-written or hand-written notes. An audio-recording was made of all of the in-person interviews for the purpose of accuracy of quotes and clarification. One additional participant responded to the interview questions via email. All of the questions from the interview protocol are included in Appendix C.

## Instructor Interviews and Diary

Two teaching assistants and the instructor were interviewed in person, with the two TAs interviewed as a group. Sessions were audio-recorded for accuracy and clarification. In addition, the instructor kept a class diary, that included weekly entries tracking topics covered and noting some observations about classroom sessions, out-of-class help sessions, and classroom innovations.

## Student Performance Data

Exam and final grade data from CEE 220 in Winter 2005 and Winter 2004 were obtained from the instructor, who had taught both courses. Students who missed two or more exams were not included in the analysis resulting samples of 83 students for 2004 and 85 students for the experimental class in 2005.

**Course Evaluation Data**

Data from two standard UW course evaluation forms were used in evaluation of this project. The first was a scannable form with 31 numerically rated items about overall class satisfaction, class structure and organization, quantity and quality of content learned, and required workload/effort for the course. In addition, the back of the form included 11 questions (again, all numerical ratings) adapted from the Accreditation Board of Engineering and Technology (ABET)'s program outcomes for baccalaureate level programs. The second form included one forced-choice question and four open-ended questions.

Evaluation data from these forms for the Winter 2005 CEE and the Winter 2004 CEE 220 courses were analyzed and compared. In 2004, 48 (57.1%) students returned the scannable form, and 42 (50%) submitted open-ended comment sheets. In 2005, 46 students (52.3%) returned scannable forms and 48 (54.5%) returned open-ended comment sheets.

## RESULTS

This section includes a synthesis of all the data used in this project, organized according to evaluation topic: (a) student performance; (b) student satisfaction; (c) specific course innovations; (d) suggestions for improvement; and (e) additional ideas for the future. Please see the appendices for a more detailed, comprehensive and descriptive analysis of the student surveys (Appendix A), student interviews (Appendix B), and course evaluation data (Appendix C).

**Student Performance**

One of the goals of this project was to experiment with innovations that might re-allocate resources while not affecting student performance. . As described above, several students were not included in grade analyses because they had missed two or more exams. Two of 85 students enrolled in the 2004 and five the original 90 enrollees in 2005 fit this criterion. This difference in drop rate was not statistically significant.[1]

Figure 1 shows differences in grades across the three exams in 2004 and 2005.[2] Note that the exams student took in 2004 and 2005 were similar, but not identical. In fact, the final exam in 2005 was worth 100 points while in 2004 it was worth 80.

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[1] According to a chi-square test of association, $p > .05$.

[2] Note that these scores do NOT include "0" scores for students who did not complete an exam. Similarly, the grades shown in Figure 2 do not include grades from students who missed two or more exams.

**Figure 1:  Percentage scores on the three exams in CEE 220, according to year**
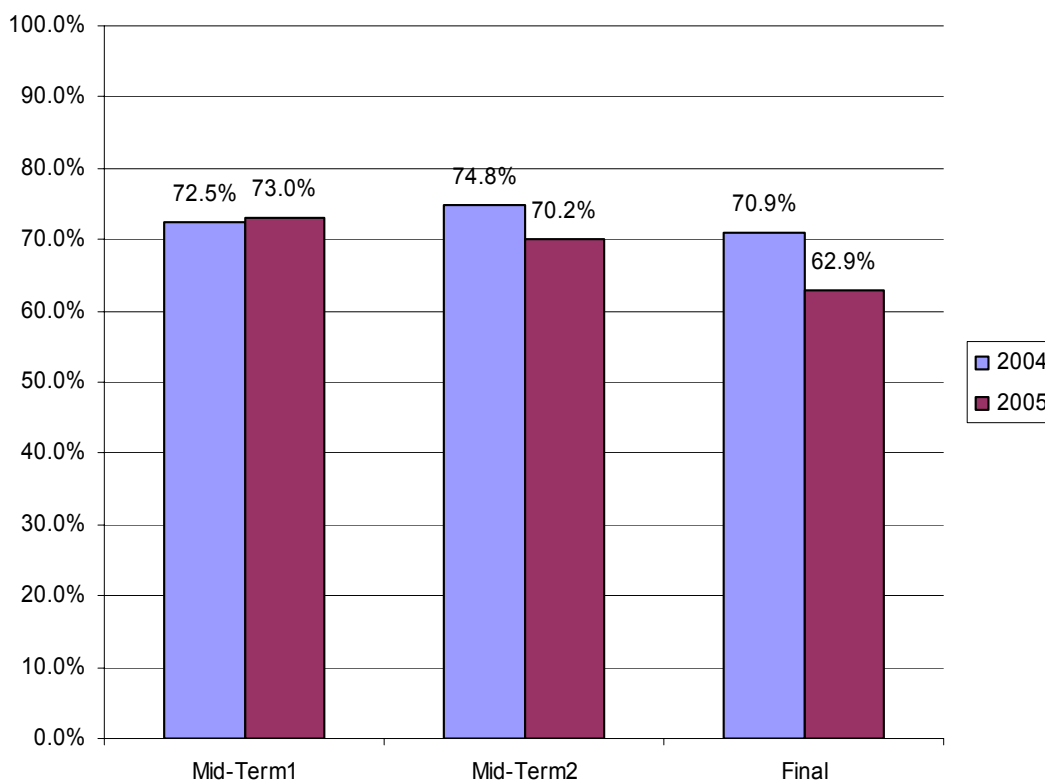


As can be seen from this graph, exam scores in 2004 remained fairly steady, while there was a steady decline in 2005.  Statistical analysis confirmed this pattern, suggesting that the gap between years increased significantly across exams.[3]  Further, 2005 scores on the second mid-term and final were significantly lower than in 2004.[4]  As stated previously, the exams given in 2004 and 2005 were not identical, and it is possible that the decline in performance was due to the fact that the exams became increasingly more difficult in 2005 as compared to the exams in 2004.  There was also no question-by-question analysis of exam performance (i.e., comparing performance on parallel or identical exam questions across years), so it is difficult to say whether students' learning was negatively affected by the 2005 innovations.

Although there was a decline in exam performance in 2005 as compared to 2004, anecdotal evidence from the TAs and instructors suggested that the students in the Winter 2005 version of CEE 220 were learning more difficult material than in similar classes, were more prepared for classes, and appeared to learn the material beyond the level of understanding necessary to pass an exam.  The TAs also firmly

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[3] A repeated measures Analysis of Variance indicated a significant interaction between exam and year, $F_{(2, 330)}$ = 91.3, $p$ < .001, suggesting that the disparity between the two cohorts' scores (2004 and 2005) varied significantly according to exam.

[4] A follow-up analysis of between-subjects simple main effects, using a Least Significant Difference comparisons revealed significant differences between 2004 and 2005 on both the second mid-term, $t(165)$ = 4.909, $p$ < .05 and the final, $t(165)$ = 7.99, $p$ < .05.

believed that students were challenged in the Winter 2005 CEE 220 course more than might be expected for an engineering fundamentals course, as the following quotations suggest:

*TA1: The material they were expected to cover was above and beyond what you'd find in most courses at this level at most Universities . . . they managed to do it, they did a great job with it. They were all very bright.*

*TA2: Students were getting on board. We'd give them questions that would lead them along and lead them into new material and Peter just kept pushing them. We challenged them to keep going, to keep doing the reading assignments, and I think as a result, they got a lot out of this class.*

*TA1: We'd even mentioned what they're doing to friends of ours in the department and they'd kind of drop their jaws and say, 'They're doing that?' All of us, we never covered this stuff until our senior year, the first year of our graduate studies. There were times when we had to scratch our heads to figure things out.*

In terms of overall grades, there was also no significant difference between 2004 and 2005; however, the distributions of grades between the years were slightly different. Figure 2 shows histograms of grades from each year. Note that the 2005 grades were adjusted slightly to award a few students with extra credit; the grades represented in the figure, however, are NOT adjusted in this way.

**Figure 2: Distribution of final grades from CEE 220 in Winter 2004 and Winter 2005**
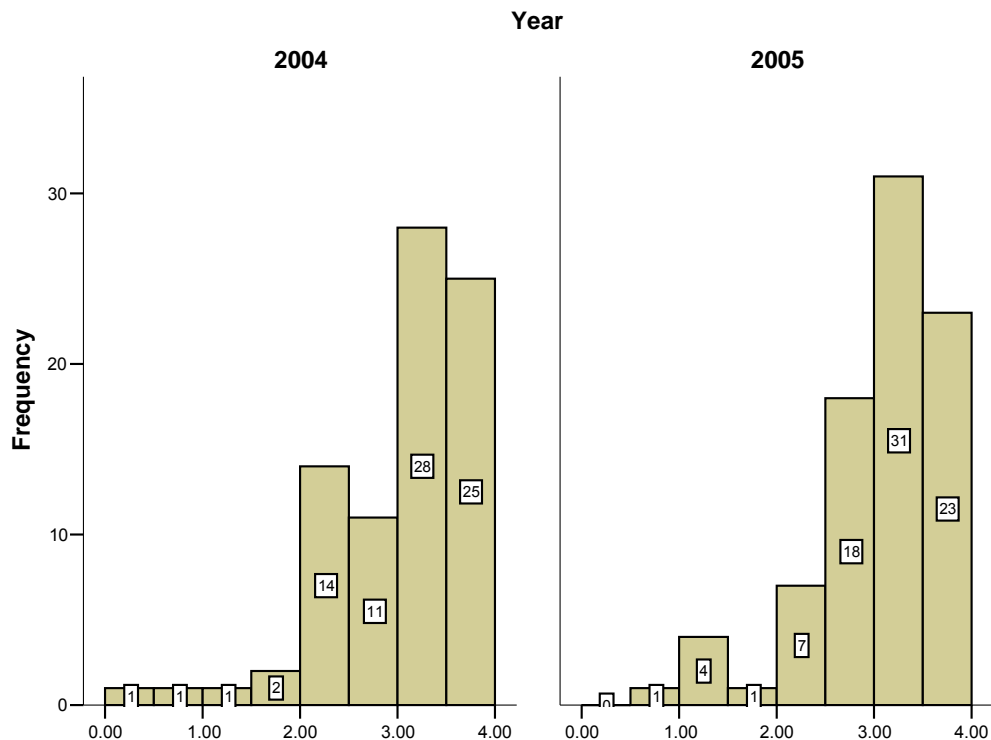


In looking at these two distributions, one overall difference is that the distribution in 2005 was somewhat more normal than in 2004. In particular, among the students who received between a 2.00 and 2.99 (25

in both years), there were more 2005 students who were in the higher end of this range (2.5 – 2.99) as compared to 2004 (18 vs. 11, respectively).  However, the distribution of grades between 3.00 and 4.00 was fairly similar across years.  One possible explanation for this difference is that the classroom innovations in 2005 might helped students who were "middle-of-the-road" reach a slightly higher level of achievement than they might have otherwise, as opposed to providing support to students who were in the highest achieving group.  This conclusion is, however, purely speculative and represents only one possible interpretation of this finding.

## Student Satisfaction

Overall, students were extremely satisfied with CEE 220 in Winter 2005.  All of the course evaluation ratings were high; and in comparison to CEE 220 in 2004, **all** numerical ratings, with the exception of the "ABET" questions, were consistently higher in 2005.  In the student interviews, the majority of the participants praised the course.  For example, one student said,

> *That was one of the best classes I've ever taken.  I have a lot of good things to say about that class.  Well run, really well-organized, always well planned.  The professor has a lot to do with how the class was run.  We had a marvelous professor.  He really wanted students to learn.  He was one of the best professors I've ever had.*

There were two interviewees (of twelve) who did not have such a high opinion about the course and gave consistently critical comments throughout their sessions.  However, student course evaluations suggested that these two interviewees did not represent a consistent minority voice in the class.  One of these individuals, in fact, noted that he agreed to participate in the interview because he did not like the class, particularly the online Moodle system, and wanted to voice his opinions.

### Comments on Lecture

The course evaluation data suggest that students' sense of the value of lecture improved between 2004 and 2005.  In the previous year, 11 individuals listed lecture as something that distracted from their learning, whereas only one did so in 2005.[5]

Perhaps the strongest suggestion for improvement, reported in both the student interviews and the course evaluation data was to include more examples and cover less theory (e.g., derivation of formulas) during lectures.  However, this suggestion may not be relevant to an assessment of the experimental 2005 course, because according to course evaluation data, this was also a suggestion for improvement in 2004.

One individual provided specific ideas about the types of examples he would have liked to see in lecture:

> *"Go through the derivation to a point, then say, 'Well, this is the conceptual of how it was -- how this equation was created, but in using this equation, we can check things.  So . . .look at this room, there's the concrete ceiling, or whatever.  How heavy is that?  What do*

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[5] This difference in proportions was significant according to a chi-square test of association.

*we need in order to make sure that these things work, because that's really what matters, that the things work. Then, let's do a couple of examples, maybe a few problems from the text, but let's also just check things, because we can."*

Another individual suggested taking a tour of the Materials Science lab to see how concepts are applied in "real life."

Other comments about the lecture concerned the instructor's practice of using a projected Tablet PC so that he could write on the slides as well as save and post these hand-written notes. Only a few individuals mentioned this aspect of the course, but most of them felt it helped them learn the material. However, one or two individuals in both the interviews and course evaluations felt that having all the notes saved in that way actually made the course less interactive by discouraging students from taking their own notes.

### *Satisfaction with Instructor*

One clear theme that emerged in the student interviews was their appreciation of the instructor. In particular, most of these students pointed out that the instructor was exemplary because of his strong commitment to their learning and his obvious investment of considerable time and energy into the course. In fact, six of the interviewees commented that this was one thing that made the course unique. This theme was supported by data from the course evaluations. When asked what supported their learning, students in 2004 and 2005 frequently mentioned the professor in response to the open-ended question, "What aspects of this class contributed most to your learning?"

One particular component of the class that students appreciated was that the grades were not curved. In other words, there was no structure in which a limited number of A's could be awarded. Several student interviewees commented on the linear grading policy as one of the best aspects of the class, because it relieved pressure and competition. The instructor reported that the linear grade calculation sent a message to students that he was not interested in "weeding out" students, but that he genuinely wanted them to learn.

Interestingly, the teaching assistants also expressed their gratitude for the instructor's consideration for their experience. They noted that the professor did as much as he could to keep their workload manageable and was understanding when other aspects of their careers or lives affected the work they could do for the class.

### *Workload*

Considering the additional online course materials (e.g., the online reading quizzes), it is not surprising that the high workload for this course was mentioned in students' interviews and in their course evaluations. Almost half of the students who were interviewed (5 of 12) felt the course stood out because of the amount of work involved; however, not all of these individuals saw this increase in workload in a negative light. In fact, at least one person viewed it positively: "The class was more work than I've ever put into a class and I didn't mind doing the extra work because I got a lot out of it." Judging from the course evaluation data, it appears that students felt this way in general. When asked how many hours per week they spent on this class, the mean estimate from students in 2005 was significantly higher than

in 2004.[6]  However, the number of hours the 2005 students found valuable was also significantly higher in 2005 than in 2004.  These results are summarized in Figure 3.

**Figure 3:  Students' estimate of the number of hours per week they invested in CEE 220 and the number they found valuable, according to year (2004 and 2005)**
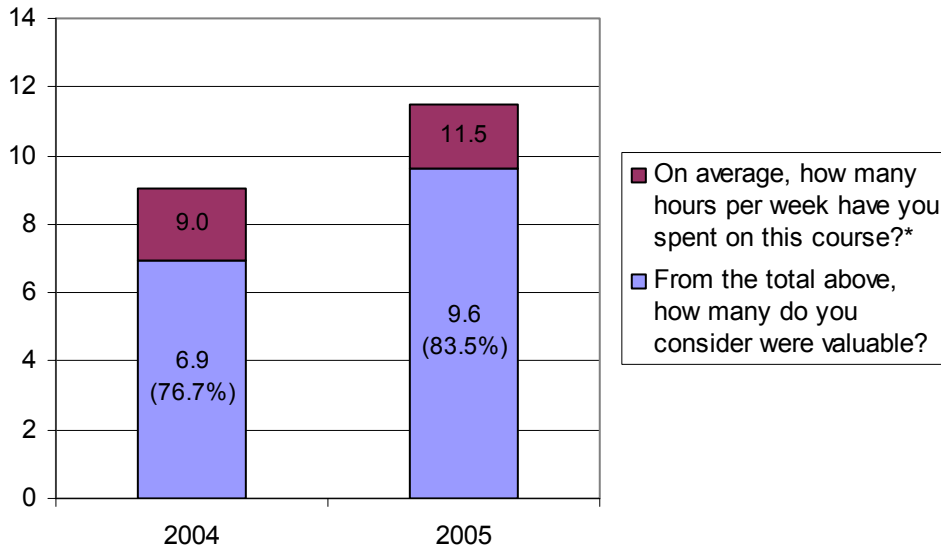


Data from the open-ended evaluation comments also indicated that the workload might have been heavier in 2005 than 2004:  Five individuals listed workload as something that detracted from their learning in 2005; whereas no students did so in 2004.  In addition, when asked whether the course was intellectually stimulating, more students in 2005 described the course as challenging in general than did students in 2004, but more students in 2005 also indicated that they were stimulated because they had learned so much new information.  Although these differences are not statistically significant, the pattern fits with the finding summarized in Figure 3.  Interestingly, the instructor, during his interview, commented on these results from the course evaluation and felt they fit with his experience of the course.

*TAs  and Lab*

Similar to comments about the instructor, several student interviewees felt that the teaching assistants were committed to their learning and invested considerable effort into the course.  According to course evaluation data, the lab sections strongly contributed to students' learning in both 2004 and 2005.  In 2005, these sessions consisted primarily of the completion of a quiz worksheet in groups.  According to interview data, several participants appreciated and enjoyed working in groups, but one individual had difficulty with the mixed ability level in his group.

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[6] Statistically significant at the .05 level according to an independent samples t-test.  Note that the criterion for significance in the course evaluation tests was lowered to .01 to account for the family-wise error rate.

**Specific Course Innovations**

Student and instructor reactions to the specific course innovations are presented below.  In general, there was positive response to the innovations:  more than one half of respondents listed at least one of the specific innovations in their open-ended course evaluations when asked what contributed most to their learning.  Students found the out-of-class help and the online homework grading particularly valuable.  Students' opinions about the usefulness of the online reading quizzes were somewhat more varied, though the TAs and instructor felt they were a valuable addition to the course.   Students also generally gave positive comments about the online Moodle system as a whole, though there was a small minority who did not appreciate the increased online presence in the course.  Finally, although only one group of students took advantage of the alternate lab times, the students, TAs, and instructor appeared to agree that the idea had potential and provided some suggestions for how to encourage students to take advantage of this option and how to best structure the alternate times.

*Online Moodle System*

In assessing students' reactions to the online Moodle system as a whole, there was one, extremely clear grievance:  the server was too slow.  Although this problem has already been resolved, it is possible that students' attitudes towards Moodle were influenced by their frustration with its slow reactions.  Most participants in the interviews were generally positive or neutral about Moodle, and in the open-ended evaluation comments, several participants listed the course web site or online system as something that contributed to their learning; many more listed either the online reading quizzes or the homework.

In the surveys, interviews, and course evaluations, however, there were several suggestions for improvement to the Moodle system.  These are described in more detail under each of the specific innovations listed below and in Suggestions for Improvement section. Two student interviewees had generally negative comments about the online Moodle system.  While one of these participants felt that the system added too much to his workload, the other generally valued in-class interaction more and felt that the course was being "turned into a correspondence course."

From the TA and instructor perspectives, students seemed to adapt well to having so much course content and their assignments online.  As one of the TAs commented, "it's an extension of what they are already doing."  The instructor noted that the system is particularly useful because it is open source-code and referred to adaptations that might be possible given the appropriate development resources.  He also pointed out that a couple of other departments are using the software.  The TAs also felt that other course instructors and departments should be encouraged to use the software because it allows them to redistribute their time (see Online Homework Grading below) and seems to enhance students' understanding of the concepts (see Online Reading Quizzes below).  Given these benefits, the TAs agreed that the system could be "sold" to other professors.

The instructor did indicate one lesson learned during the experimental version of CEE220:   he felt that students' experiences and reactions might have been improved if he had introduced them to the system earlier in the term or even before the term began.  In particular, he thought putting together a Frequently Asked Questions page and distributing it or putting it online as soon as possible would help students understand what to expect and improve their reactions to the system.

*Online Reading Quizzes*

According to the mid-term and final surveys, students in CEE 220 completed almost all of the online reading quizzes. In his interview, the instructor commented that the completion of these quizzes accounted for only a very small portion of students' grades, yet even these few points served as an incentive for students to complete the assignments. Students, on the other hand, gave mixed feedback about receiving credit for the reading quizzes. According to survey and interview data, some students were annoyed at having to complete these assignments, while a few others felt the quizzes were so helpful, they would have completed them even if they were not for credit. Others appreciated the fact that quizzes were mandatory, as they served as an external motivator for students to look at the reading before lecture.

In terms of how students used these reading quizzes, survey and interview data suggested that students' use of these quizzes changed towards the end of the term. In the survey, there was a statistically non-significant pattern in the data suggesting that at first, students were more likely to look at the quiz after they had done the reading as opposed to before or during; but that later in the quarter they were more likely to look at the quiz first or to look at the quiz while doing the reading. Although this difference was not statistically significant, it fits with several comments from the interviews, in which students pointed out that they were very diligent about completing both the reading and the quizzes early in the term, but that eventually, this level of effort was not possible. As one individual comments:

> *"In the beginning, I'd do the reading and then take the quiz, but after a while, I'd be, like, taking the quiz and then going back to the reading and pulling out those key points that he talked about."*

These quizzes were designed as a way to extend students' learning outside of the classroom, to make them more prepared for lecture, and thereby increase the value of in-class time. While a few students from the interviews did feel that the reading quizzes facilitated their comprehension of concepts presented, many more students said that the reading quizzes served as either (a) a conceptual "highlighter," allowing them to focus on key points in the reading; (b) an external motivator to keep up with the readings; or (c) a mechanism for pin-pointing what they did not understand from the reading.

According to the instructor, however, students may or may not be aware of the learning side effects of the reading quizzes. He argued they were effective in preparing students above and beyond what they might do on their own, even if only through sheer repetition. As he puts it:

> *"The idea behind this is not every student will always read. But if they have to take the quiz again and again and the answers are shuffled, they have to memorize the answers, at least for 10 minutes . . . so even if they don't want to read, they invest a little bit of time in preparation: they knew what was going to happen in class, they've heard some of the key words before, they might not have memorized it because it's a very weird word for them . . . but they just get one more repetition of that new word."*

As suggested by this quote, participants received feedback about their initial responses to the reading quizzes and then took the quiz again, but with the questions and answers in a different order. Interestingly, a few students revealed in their interviews that there was a "loophole" in the reading quizzes

in which they saw the correct answers the first time they submitted their quiz.  It is unclear whether students interpreted the feedback they received as "seeing the correct answers," or whether they truly saw the correct answers; however, the instructor pointed out that because of the shuffled order of the questions, students could not simply remember the *letter* answers but had to at least remember the short answer.  This would provide the repetition and minimal preparation that he saw as an inherent value in the reading quizzes.

The TAs also suggested that the reading quizzes facilitated students' understanding of certain concepts, evidenced in the quality of the questions they asked and in the type of interactions they had in lab sessions:

> *"When they asked questions in a lab section, they were pin-pointed and they were well informed questions.  They weren't looking for answers; they were looking for, 'Why?'"*

The TAs also felt the reading quizzes were important in forcing students to do the reading.

Overall, students' attitudes about the reading quizzes were somewhat mixed, with a sizable minority feeling they enhanced their learning and a similarly sized minority feeling that the reading quizzes were not beneficial.  In the interviews, several participants said that the reading quizzes were extremely valuable in helping them learn the material, while a few felt they were annoying.  Similarly, in the open-ended course evaluation comments, 10 individuals listed the reading quizzes as an aspect of the course that contributed most to their learning, while three listed the quizzes as a part of the course that detracted from their learning.  In the brief mid-term survey, there were quite a number of positive reactions to the reading quizzes (33.3% said they could not be improved), although there were a number of suggestions for improvement (26.2% provided at least one such suggestion).  This mixed response from students to the reading quizzes might be summarized by one individual's comment in an open-ended survey question:

> *"At times the quizzes can be overwhelming, but at the same time I feel like I need them in order to understand the concepts."*

The variation in students' responses to the reading quizzes can also be seen in their suggestions for improvements:  in the interviews, four students felt that there should be fewer quizzes, while two proposed making the quizzes longer or adding additional quizzes.  There were quite a number of specific suggestions (see Suggestions for Improvement, below), but the most frequently mentioned were:

- Save answers so that students do not have to re-enter their responses each time they take the quiz (note that the instructor felt this was an important way to force students to remember key words, however briefly)

- Make the due dates for the reading quizzes more consistent (note that this was also something that the instructor felt could have been improved)

- Provide some additional hints when short answers were slightly off (e.g., power of 10 or sign)

*Online Homework Grading*

Overall, data from students, TAs, and the instructor suggest that there were very strong benefits in having the homework graded online. In particular, for students, receiving immediate feedback appeared to be the primary benefit of the online homework. On both the mid-term and final surveys, participants were asked to rate the extent to which they disagreed with the following statement: "Receiving immediate feedback about my solutions is worth the effort it takes to submit them electronically." Only one student on both surveys disagreed with that statement, and all but five students agreed or strongly agreed. The interview data also indicate that immediate feedback was the most frequently mentioned benefit of the online homework assignments. The teaching assistants also pointed out that online grading was particularly valuable because of the immediate feedback and that normally, students would not benefit from feedback on homework.

> *"No one looks at the homework [normal, paper version] that's returned to them. You get it back a week after you finished thinking about it . . . you don't have time to look at it right away. By the time it gets put in that notebook, maybe you get it out the night before the exam, maybe you don't, but you sure as heck don't look at it before then . . . Online, you have to look at it right then, when you're thinking about it, and deal with it."*

A few students in the interviews and surveys also mentioned appreciating, specifically, the opportunity to submit an unlimited number of times, thereby improving their grade. According to the instructor, he provided this option to convey the idea that the homework was intended primarily as a learning tool:

> *"I'm not using homework to decide a grade for them. I consider homework in this class . . . as one key part of learning and preparation for the exams. So, whatever they get points on in the HW, again it's part of the class, but homework, the reading quiz plus lab [equals] 30% [of their grade] . . . so I took it very easy when [a student] would say, 'Oh, I missed this reading quiz.' [I would say], "Just complete it."*

The instructor went on to say that the way that students completed the homework (e.g., working together in groups, submitting multiple times after feedback) is not necessarily relevant beyond the extent to which the assignments helped them learn the concepts and perform well on the exams. In looking at the course evaluation data and interview data, it appears that many students did view the assignments in this way. In the open-ended course evaluation comments from 2005, students mentioned homework most frequently (17 of 47 participants listed it) as an aspect of the class that contributed most to their learning.

Another important benefit of the online homework was in terms of TA time. When asked in their interview how the term went, the TAs were quick to note that they did not have to grade and, therefore, they were able to spend more time working with students:

> *"One thing I really liked was we didn't have to grade anything, so you didn't spend any of your time doing that, and you had all your time to interact with students . . . and that's much more enjoyable."*

The TAs went on to say that most teaching assistants would appreciate a re-allocation of their time from grading to having face-to-face time with students (e.g., in lab sections, office hours)

One concern that emerged from the students in the interviews (mentioned by 4 of 12 participants), and at several points in the surveys and evaluations, was that students were asked to submit a paper copy of the homework in addition to entering their answers online. Students commented that this was somewhat burdensome: one interviewee noted that she usually wrote out her homework once, then completed the online assignment, then re-wrote her work "to look nice." Two interviewees commented that it was clear the professor never looked at the paper versions; and from the instructor interview, this assertion was probably true.

When asked about having students turn in these paper versions, the instructor said they were necessary for three reasons: (1) as a back-up just in case the online system was unreliable; (2) as a mechanism to submit graphical answers; and (3) to prevent students from cheating by just entering the online answers their friends had answered. On the whole, however, the instructor indicated that he did not do much with these written homework assignments except file them in a box.

Students provided several specific suggestions for how to improve the homework assignments, but by far the most frequently-offered suggestion was to increase the amount and specificity of hints provided. In the surveys, interviews, and course evaluations, participants mentioned that they appreciated the type of help offered by the Physics "Tycho" system. Administered by the University of Illinois, Tycho is an online homework program, very similar to the homework quizzes on the Moodle system. Students reported that Tycho's feedback was more extensive:

> *"The homework was a lot more helpful in Tycho, you could see exactly what you did wrong, instead of one answer right or wrong, two points for each. It guided you in what to solve.*

> *"Sometimes Tycho also has an interactive example, as part of your homework. It takes things step by step. Maybe if some homeworks were based step by step."*

Another aspect of the Tycho homework program that students appreciated was the ability to work on homework problems one at a time (i.e., they did not need to submit their answers all at once, but received feedback on a question-by-question basis).

### Extra Out-of-Class Help

Students indicated in their interviews and surveys that there was plenty of out-of-class support for this class. There was some indication in the survey data that students started attending these sessions more frequently toward the end of the term; however, these comparisons were not statistically significant.[7] In support of this finding, one individual interviewee mentioned that he would have started attending CLUE sessions earlier in the term if he had known they were led by the instructor. The data from each of the different types of out-of-class help are addressed in the sections below.

In terms of the benefits of the sessions, students appeared to view the CLUE sessions, tutoring through the Engineering Advising and Student Center, and the online discussion board as resources for helping

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[7] A chi-square test of independence comparing the proportion, between the mid-term and final surveys, of students who had attended one or no out-of-class sessions and the proportion who had attended two or more was not significant, $\chi^2 (1) = 1.87$, ns.

them complete their homework (not studying for exams).  In fact, on the mid-term survey, participants' endorsement of the statement "Tutoring helps me solve my homework problems" was significantly higher than their ratings of the statement "Tutoring helped me prepare for the first mid-term."[8]  In addition, data from the mid-term survey also indicated that almost all students (18 of 19 who attended an out-of-class session, or 94.7%) agreed or strongly agreed that the out-of-class sessions contributed to their learning.

CLUE Sessions. Every Monday during the quarter, the instructor led a 90 minute session at the Center for Learning and Undergraduate Enrichment (CLUE), a program designed to provide a location for late-evening study groups and tutoring/review sessions for UW courses.  Although having individual sessions tailored to particular courses is a fairly common aspect of this program, most of these sessions are for classes that are larger than CEE 220 and it is rare to have the actual course instructor leading these sessions.  Students were aware that this option was out of the ordinary, with four of the 12 interview participants listing the CLUE sessions as something that made the course unique.

Data from the student and instructor interviews suggest that the CLUE sessions were not particularly well attended.  The instructor indicated that there were, on average, about 10 people in the sessions (or 10 – 12% of the class) and most of those were "regulars." On the final survey, 17 (or approximately 19%) of the class indicated that they had attended at least one CLUE session.  One student interviewee, who said she was a "regular," was surprised that more students did not take advantage of the opportunity to have additional help directly from the instructor.  Another interviewee who said he had never attended a CLUE session said that he would have started doing so early on in the term if he were aware that the instructor was leading the sessions.

In general, students who attended these sessions responded to them extremely positively.  In their open-ended course evaluation comments, seven individuals listed the CLUE sessions specifically as an aspect of the course that contributed the most to their learning in the class.  According to several interviewees, students also appreciated the opportunity to make significant head-way on their homework assignments early in the week.  Another significant benefit of these sessions was the opportunity for students to get to know their professor in a more relaxed environment.  One student reported feeling as if the instructor turned into a "big brother" during those sessions; similarly, the instructor, in his interview, said that in class, he was the authority, but in the CLUE sessions, he was a friend.  It provided him the opportunity to get to know some of his students.

Creating this relaxed environment also benefited the instructor because students were willing to tell him about how the class was going:  what was working, what was particularly challenging, and what could be improved.  The instructor indicated that there was relatively little effort involved in running the session (he did zero preparation for them) and that the benefits for students and himself outweighed the 90 minute weekly time commitment.

Tutoring through the Engineering Advising and Student Center.  The EASC offers general tutoring sessions for engineering students.  During the term of this course, Tuesdays and Thursdays from 3:00pm to 6:00pm were set aside specifically for help with engineering fundamentals course, including CEE 220.  From student interview and survey data, it appears that these sessions were attended by slightly more students than the CLUE sessions.  On the final survey, 18 (20.5%) individuals said they had attended the

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[8] According to a matched-pairs t-test, the means between these two items differed significantly, $t(19) = 5.50$, $p < .001$

Tuesday session at least once, and 15 (17.0%) indicated they had been to the Thursday session. In the interviews, two participants said they were "regulars" at the EASC and two more attended sporadically.

In terms of student satisfaction with these EASC sessions, comments from the interviews indicated some mixed reactions. While the two "regulars" regarded these sessions very positively and were grateful for the opportunity, all the interviewees who had been to these EASC sessions said they would have appreciated a larger room and additional TAs. One individual, in particular, went to only one of these sessions and felt very uncomfortable having to fight for the TAs' attention. Three individuals listed the study center in their course evaluation open-ended comments as an aspect of the course that contributed to their learning.

Discussion Board. Another source for help outside class was the online discussion forum that was part of the Moodle system. Several student interviewees commented that this resource was available in their other classes; but the instructor, TA's, and a few students reported that this forum was extremely active in comparison to other similar boards. The instructor felt that the discussion board was so active in CEE 220 because it was well-integrated with all of the other online class components (i.e., reading quizzes and online homework assignments) within the Moodle system.

For the most part, students reported that the discussion board was helpful. Eight of the 12 student interview participants said they used the discussion board regularly, and seven of these made very positive comments about its usefulness. For the most part, students used the forum to ask other students questions about how to do the homework or reading quizzes. One unique aspect of this resource was that it was always available, even late at night. As one student put it, "there is always someone there."

The TAs also thought this resource was extremely helpful for students and were impressed at how often and how well students used it:

> *"They provided each other with some wonderful help and some wonderful discussions and showed maturity that I thought was well beyond their years. They didn't even just hand each other the answers, but they provided good advice and good suggestions on ways to go about completing problems and sometimes it was just some good encouragement."*

The instructor was also pleased at the level of participation in the discussion board. In particular, the forum provided a mechanism for students to help each other instead of receiving help from him via email. Early in the term, when students would email him a question about the homework, he would encourage them to post it on the discussion board instead. The professor checked this board once or twice a day and only posted if students were providing bad information or if no one was answering someone's question. The instructor commented that these daily checks required much less time and effort than answering student emails individually. By the end of the term, students did not email him directly, but immediately posted on the discussion board.

Another benefit of the discussion board was that it provided the instructor with information about which points students were struggling with and what might be beneficial to review in lecture.

<u>Other Out-of-Class Help</u>.  There were several other sources of out-of-class help available to students in CEE 220, as follows:

- Before each exam, the instructor provided extra review sessions (not in class).  Three student interviewees commented that these sessions were extremely helpful and were also very unique.

- Each TA and the instructor held regular office hours for CEE 220 (each TA held two office hours per week, and the instructor held three).  The TAs commented that attendance at their office hours was lower than for other classes and they attributed this decrease in attendance to the help available online and at the CLUE sessions.  However, the TAs thought that the instructor probably had busier office hours than they did.  Two student interviewees mentioned TA office hours as an additional source of out-of-class help.

- Two students indicated in their interviews that their primary source of help was a group of friends who were enrolled in CEE 220 together.  One individual felt this resource was more convenient than the CLUE or EASC sessions and that it was probably more enjoyable.

- Finally, one interviewee commented on the tutoring she received through the Office of Minority Affairs' Instructional Center (IC).  She pointed out that the environment at the IC was much better than at the EASC and that the help she received was particularly flexible and useful, although it was not necessarily designated as tutoring for CEE 220 (i.e., there was no special session for the class).

### *Alternate Lab Time*

One option presented to students in CEE 220 was to attend a lab session at an alternate time, outside of the sessions scheduled for the course.  The purpose of this option was to explore the possibility of having students use lab space in a more flexible manner and, perhaps, with the assistance of undergraduate assistants as opposed to teaching assistants.  This option was announced during the fourth week of the course.

Although it was clear from survey and interview data that students were aware that this option was available to them, very few students opted to change the time of their lab.  Judging from the information provided in the mid-term survey and the student interviews, only one group decided to attend the lab session at 9:30am instead of 8:30am.  Because the time overlapped with existing lab times and TAs were already present, there was no need for help from undergraduates.

In general, however, students appeared to appreciate the fact that this option was offered.  In the student interviews, no one reported that they had attended an alternate lab time, though eight of the 12 participants spontaneously mentioned that it was a good idea.  The TAs and instructor also said that the intention behind the option was good and that increasing flexibility was potentially beneficial to students.

The question remains, then, why more students did not take advantage of the flexibility offered to them.  Data from the surveys and interviews suggest that many individuals chose not to attend an alternate lab time because the time they had chosen for the lab worked "perfectly" with their schedule.  In an open-

ended question on the mid-term survey, over half of students (53.8%) of students reported that this was the case.

Waiting to tell students about the option until the fourth week of class might also explain why only a few students opted for an alternate time.  In the interviews, many students reported having to commit to a work or activity schedule early in the term (or even before the term started), making it impossible to change their lab times.  In addition, the lab groups were established during the first week, so that during Week 4, if a student wanted to attend an alternate lab time, he or she had to find a time that worked for the entire group.  This posed a difficulty for several students; three student interviewees reported wanting to attend an alternate time, but that they were unable to find a mutually agreeable time within their group.

Another concern expressed by a few students in the surveys and interviews was that they wanted a graduate student teaching assistant available during the labs to help them.  The TAs from CEE 220 reported that students would probably not have a problem with undergraduate helpers as aids in the lab sessions, though in the final survey, the majority of students (66.7%) agreed or strongly agreed with the statement "I did not want to attend an alternate lab time because I wanted to have TA support during the lab."

Students, TAs, and the instructor generated several possible solutions for encouraging students to take advantage of flexible lab scheduling.  Among the most frequently mentioned were:

- **Offer additional lab times.**  One suggestion was to list five or six possible lab times for the course.  Although this might involve an increased time burden to the TA's, the two teaching assistants for CEE 220 suggested that the increase would be offset by the reduced time spent grading and dealing with administrative aspects of the course.

- **Organize groups according to times when they are available.**  A frequent suggestion was to devote the first scheduled lab session to organizing groups around the time when they are available.   Another suggestion was to keep the time for the lab unannounced and have students organize their lab groups AND time before the course begins, using the Moodle system.

- **Create an "open forum" for lab sessions.**  One possible solution would be to dedicate an entire day be dedicated to lab session and students could come when it was most convenient for them.  According to student interview data, the hours between 8am and 4pm would be optimal for students.

Another important point raised by the instructor was that keeping the times flexible for lab sessions was fairly easy for a class such as CEE 220 in which the only limited resource is space.  In other engineering classes, special pieces of equipment are not only limited resources in and of themselves, but require some preliminary training from a TA or instructor.  The professor suggested that one possible solution would be to provide video instruction for equipment and an undergraduate helper to answer any additional questions.  These considerations are important if alternative or flexible lab times are intended to be adopted by courses with specific limited resources.

## Suggestions for Improvement

Throughout the surveys, interviews and evaluations, students, TAs, and the instructor provided a wide variety of suggestions for how the course could be improved. While many of the most frequently mentioned suggestions are presented in the sections above, Table 1 represents a complete list of these ideas and shows how frequently they were mentioned (the number of individuals who gave the suggestion) in each data source.

**Table 1: A summary of all suggestions for improvement**

| MOODLE SYSTEM (General) | | | |
|---|---|---|---|
| **Suggestion** | **Surveys** | **Student Interviews** | **Course Evals** | **TA/Instr Interviews** |
| Faster server | 14 | 4 | 22 | ** |
| Eliminate Moodle | | 1 | | |
| Provide Moodle FAQ's at the beginning of the term or before the term begins | | | | 1 |

| ONLINE READING QUIZZES | | | |
|---|---|---|---|
| **Suggestion** | **Surveys** | **Student Interviews** | **Course Evals** | **TA/Instr Interviews** |
| Standardize due dates (e.g., always same day each week) | 2 | 3 | 2 | |
| Set it up so that your answers were saved after you submitted once | 2 | 2 | 1 | |
| Reduce number of quizzes | 3 | 1 | | |
| Increase the number of questions | 1 | 1 | | |
| Make questions simpler (conceptual instead of calculations) | 1 | 1 | | |
| Make them optional, not mandatory | | 1 | 1 | |
| Eliminate the reading quizzes | 1 | | 1 | |
| More questions that apply knowledge instead of directly from the reading | 1 | | 1 | |
| Don't always provide the answers | 2 | | | |
| Ask some quiz questions in class, reward class attendance | | 1 | | |
| Reduce number of questions, make more specific | 1 | | | |
| Eliminate true/false questions | 1 | | | |
| Post reading quizzes for next week before the week-end | 1 | | | |
| Make it easier to print out the quizzes and answers | 1 | | | |
| Give quiz again AFTER the lecture | 1 | | | |
| Put the page number next to the question | 1 | | | |
| Provide extra credit instead of making them mandatory | 1 | | | |
| Provide hints | | | 1 | |
| Improve interface for creating the reading quizzes | | | | 1 |

**Table 1 (cont.): A summary of all suggestions for improvement**

| ONLINE HOMEWORK GRADING | | | | |
|---|---|---|---|---|
| **Suggestion** | **Surveys** | **Student Interviews** | **Course Evals** | **TA/Instr Interviews** |
| Additional help/hints on the homework, such as those on the Physics Tycho system | 14 | 5 | 2 | |
| Make it more convenient to redo problems, not having to go through several screens to get back to your answers, answer questions individually | 5 | 2 | | |
| More leeway for small errors | 4 | 1 | | |
| Do not require paper copy submission | 2 | 3 | | |
| Increase number of step-by-step questions, make it more structured | | 3 | | |
| List quiz questions with homework assignments (i.e., list all the questions that will be asked online with the homework assignments) | 2 | | | |
| Return paper copies once reviewed | 1 | 1 | | |
| Fewer questions which could be answered by looking in the back of the book | | 1 | | |
| Don't reveal how many attempts it took to complete the HW correctly (makes students feel bad) | | 1 | | |
| Provide option to print out individual questions | 1 | | | |
| Provide feedback for correct answers as well as incorrect ones | 1 | | | |
| Save homeworks online as a studying resource | 1 | | | |
| OUT-OF-CLASS HELP | | | | |
| **Suggestion** | **Surveys** | **Student Interviews** | **Course Evals** | **TA/Instr Interviews** |
| Larger room for EASC sessions | | 3 | | |
| Move CLUE session to later in the week | | 2 | | |
| Increase number of tutors at EASC sessions | | 2 | | |
| Increase number of pre-engineering tutors available within CLUE program as a whole | | 1 | | |
| More time options for review session | | | 1 | |
| ALTERNATE LAB TIME | | | | |
| **Suggestion** | **Surveys** | **Student Interviews** | **Course Evals** | **TA/Instr Interviews** |
| Form groups early in the term according to availability | 1 | 5 | | |
| Provide many different options for lab times | 1 | 3 | | |
| Provide a window between 8am to 4pm to choose from | | 1 | | |
| Schedule/arrange labs before the course begins using the Moodle system | | 1 | | |

**Table 1 (cont.): A summary of all suggestions for improvement**

| COURSE IN GENERAL | | | | |
|---|---|---|---|---|
| Suggestion | Surveys | Student Interviews | Course Eval.'s | TA/Inst. terviews |
| More examples, sample problems, in lecture | 2 | 5 | 8 | |
| Make a course pack for notes (or hole punch notes) | | 2 | 2 | |
| Better room | | 3 | | |
| Reduce workload | 1 | 1 | 1 | |
| More hands-on, practical lab sessions, such as the lamp post lab | | 2 | | |
| Encourage group work | 1 | 1 | | |
| Provide a brief Q & A session during class about the homework assignments | 1 | | | |
| Change due date of homework assignments to Thursday | 1 | | | |
| Let students know from the beginning that the course will not be curved | 1 | | | |
| Make labs shorter | | 1 | | |
| No long homework assignments right before exams | | | 1 | |
| Make class time later | | | 1 | |
| Encourage more in-class participation in lecture | | | 1 | |
| Videotape the lectures | | | | 2 |

An important point about these suggestions is that many of them represent minority views among the course. For example, while two students felt the reading quizzes should be optional, many more found that they were motivated to do the reading because the quizzes were mandatory. Similarly, some suggestions contradict each other (e.g., increase the number of questions on the online reading quiz/reduce the number of questions). The purpose of the table above is to present a comprehensive picture of how participants thought the course could be improved; not all of the suggestions should be implemented.

## Additional Ideas for the Future

In addition to the suggestions for improving the class presented above, students and TAs were asked a theoretical question about how to expand the capacity of CEE 220 (i.e., teach the course with twice the number of current students). The instructor and TAs also provided quite a few comments about introducing some of the new elements of the course (particularly the Moodle system) to other instructors in the future. A summary of these findings is presented below.

### *Expanding Capacity*

In the student and TA interviews, participants were asked how they might redesign CEE 220 to accommodate twice the number of students with the same instructor load (i.e., one instructor, two TAs). Interestingly, one interviewed student felt there would not necessarily need to be changes to the course to

accommodate more students.  This echoes a comment from the instructor who noted the scalable quality of the Moodle system.  Similarly, the TAs felt that as a database of homework and reading quiz questions is established after the course is taught several times, the workload of TAs would continue to decrease (assuming grading is done online), and they would be available to handle more students and perhaps hold more lab sessions.

Several additional students felt that there would not need to be any changes made to the lecture to accommodate twice as many students, but about half of the participants noted that changes would need to be made to the labs.  Specifically, students suggested increasing the number of lab times and the number of TAs helping during labs.  One individual felt that if one full day were dedicated to completing a lab assignment, during which TAs could take shifts either manning the lab or holding office hours, students would still be able to complete the assignment and learn what they needed to learn.

Several students focused on increasing out of class help, such as holding more office hours, adding a CLUE session, hiring undergraduate helpers to answer questions, having a tutor at the EASC dedicated to CEE 220, and simply encouraging students to use the existing out-of-class help.  Students also suggested increasing the amount of online grading, videotaping lectures for students who could not come, and including interactive multiple choice questions during lecture (using "clickers" to collect immediate data on students' understanding of particular concepts).

### *Encouraging Adaptation*

In TA and instructor interviews, this question led the participants to think about the adoptability (and adaptability) of the innovations made to CEE 220.  In particular, the issue arose of exactly how to "sell" the Moodle system to other professors in the department and college.  Both of the TAs and the instructor conceded that there were some faculty who would not be willing to use the Moodle system.  Specifically, the instructor commented that a few faculty members seemed resistant to any new developments in their course material and would thereby resist any curriculum changes.

The instructor went on to say that the Moodle system could be handled by TAs.  Considering that many of the beneficial aspects of the Moodle system (online grading, grade posting) concern TA duties as opposed to instructor duties, transferring the responsibilities to teaching assistants might be appropriate. The two TAs from this course appeared to agree that the benefits of the Moodle system to teaching assistants were striking.  They also suggested that the primary "selling point" for TA's might be "you don't have to grade."

## EVALUATOR COMMENTS AND RECOMMENDATIONS

The following section contains comments and recommendations from the evaluator, organized according to theme. Note that the synthesis and ideas presented in this section were generated from the evaluator's interpretation of the data and are, therefore, open to further discussion.

In sum, the new version of CEE 220 was extremely successful.  In particular, the online homework assignments, CLUE sessions, and discussion board were instrumental in saving instructor and TA time and in enhancing the student experience.  Additional thought might be devoted to different models and procedures for the "alternate lab time" offerings, the online reading quizzes, and, in general, how the

different innovations made to CEE 220 could be adopted by other instructors in the department and college.

## Resource Re-Allocation

One of the goals of this project was to explore the benefits and drawbacks of different mechanisms for re-allocating resources in an engineering fundamentals course.

### *Integrated Online System*

One aspect of the course that was particularly successful in regards to this goal was online homework grading. Having students submit responses to homework questions online not only significantly reduced (and almost eliminated) grading time for TAs, it also provided immediate feedback to students on their responses, thereby supporting their learning. In addition, by allowing students to submit their responses multiple times, the assignments were seen less as an evaluation and more as a tool for student learning.

The TAs also mentioned that the Moodle system in general provided quite a bit of welcome assistance with the administrative aspects of the course, such as grade recording. The instructor also pointed out that the online discussion board was extremely effective in saving his time answering individual student emails about homework assignments and their grades. He suggested that these two components (discussion forum and online grade book) were only so successful because they were integrated into one system that also linked to their homework and reading quizzes.

On the whole, the Moodle system provides many opportunities to save both TA and instructor time that can be allocated to assisting students in other ways (e.g., additional lab time offerings, extra help sessions). It could potentially be a fundamental resource for future plans to increase the size of engineering fundamental courses. There is start-up time for instructors to learn how to use the system and adapt to using it, but much of the work could be done by teaching assistants. As a database of online homework assignments and reading quizzes is established, the time investment will slowly decrease.

Students provided a variety of different suggestions for how to improve the online homework assignments. However, student satisfaction with this aspect of the Moodle system would probably be increased if (1) more hints were provided (including indications for when there are small errors); (2) it were easier to redo problems, or they were submitted one at a time; and (3) paper copies were not also required. Using the "Tycho" system used in the Physics department might not only provide valuable information about improving the system, but also make engineering students more comfortable with the online grading (almost all of them would have taken Physics and used the Tycho system before). In regards to the paper copies, the instructor reported that they serve several important functions; if they are collected, then it might benefit students to have them returned, even if they are not graded.

One point to consider as more course content is moved to the online Moodle system is accommodating students who do not have their own computers. One interviewee struggled considerably in CEE 220 because his online access at home was negligible and it was not convenient for him to use public computers on campus. If a critical mass of courses began to use the Moodle system, perhaps it would be feasible to dedicate a set of computers to Moodle users, or for engineering fundamentals courses, making

them available at night.  The home page for these computers could be the Moodle web site.  At the very least, if the system were adopted more widely in engineering departments, the home page in departmental computer labs could be set to the Moodle login page.

### Lab Time and Space

One attempt at re-allocating resources was to give students the option of attending lab sessions at times outside the established schedule.  Only one group of students chose to take advantage of this option and it seems that for many students, the lab time they selected worked very well.  Others struggled to find a mutually agreeable time among their group.

One suggestion from students, TAs, and the instructor was to form groups according to students' availability.  This is certainly a viable option and would allow students to be more flexible with their time.  Using the Moodle system to establish these groups either before the class begins or during the first week of the course might be convenient.  In addition, students would be compelled to try out the Moodle system and figure out how it works before the class began.

It might also be beneficial for students to view these groups not just as lab groups but also as study/homework help groups.  Two student interviewees mentioned that their primary source of out-of-class help was a group of people they knew and studied with.  Encouraging students to form such groups and work together on the homework might be a way to decrease the amount of time the instructor and/or TAs spend helping with homework or reviewing for exams.  Being part of these groups might imbue a sense of accountability in students, making them feel obligated to set aside time to work on their homework with their groups.  However, if students are working together, it would probably be necessary to have a linear vs. curved grading structure, so that they did not feel as if they were in competition with each other.  To encourage team "spirit," extra points or other rewards might be granted to the group who received the highest mean exam grades.

Another option for the lab session, explored in student interviews, was to have one day set aside for students to complete a lab assignment.  TAs could take shifts between 8am and 4pm either introducing students to the assignment or holding open office hours to answer student questions.  Undergraduate helpers might also be available to help.  This model could provide groups with some flexibility when scheduling their lab times but would also limit the possibilities for time.  Hence, when students are trying to find their groups, they could indicate their availability on the "lab day," and students signing up for the class could be aware that they would need to attend a lab session at some point in that day.

In order to ensure that the TAs and space were not flooded, students would probably need to schedule their lab times.  A scheduling system integrated into Moodle would be ideal to handle these logistical issues.  This scheduling would be particularly important if there were limited equipment or software involved in the lab sessions.

Another possibility is to replace the lab session with an almost fully independent setting.  Groups could gather in a dedicated space or at another location on campus and go through the lab together.  TAs or undergraduate helpers could be available via instant messaging or phone for questions.  Students would be asked to complete the lab session before a certain point in the week and could decide, with their

groups, when to complete it.  Implementing these assignments online within the Moodle system might be beneficial in integrating the lab assignments with the rest of the course materials.

Such an independent course completion is similar to innovations made by various schools involved in the Pew Charitable Trusts Program in Course Redesign.  In this program, 30 institutions from across the country were each granted $200,000 to redesign large lecture courses with the goal of reducing costs without reducing performance or satisfaction.  While no engineering courses were involved in the program, and most of the classes had larger enrollment than CEE 220, it might be worthwhile exploring the various changes these projects made.  Program descriptions for all 30 projects can be found at the program's web site:  http://www.center.rpi.edu/PewGrant/ProjDesc.html.  Of particular interest to the redesign of lab sections might be the "Replacement Model" projects, in which class meetings are replaced by out-of-class, online, active learning activities.  More generally, this web site provides extremely valuable information about course redesign projects that focus on reducing costs and/or increasing course capacity.

## Student Experience

Another important aspect of this project was to make course changes without significant declines in student performance or student satisfaction.  The data overwhelmingly indicate that students responded very well to this course, with some having extremely positive experiences:  In addition, students' reactions to the innovations were mostly positive, with some objections to the online reading quizzes and a few individuals who were, in general, opposed to the amount of online content in the course.

Perhaps the aspect of the course that contributed the most to students' experience was that the instructor communicated to students that he cared about their learning.  In both course evaluations and interviews, students mentioned that this had a positive effect on their learning.  Faculty communicate such concern in many ways, and this instructor demonstrated caring by what students saw as a significant commitment of extra time, effort, and care to the course.  In addition, the TAs for the course felt that the instructor cared about their schedules and their work, and those perceptions likely influenced their performance, which, in turn, affected students' perceptions and performance.  While course innovations were important contributors to students' success and satisfaction, it is wise to remember that often the most significant part of any academic experience for students is how they feel about the faculty and TAs who are teaching them.

One aspect of the course that strongly contributed to the student experience was the extra help sessions offered through the course.  Specifically, the CLUE session was beneficial to students not only by providing them an opportunity to ask questions about the homework, but also as a source of motivation for completing the assignments and as an opportunity to make more information connections with their professor.  The instructor benefited from these sessions by learning which topics were particularly tricky for students, getting to know students on a more personal level and in hearing students' impressions of the class.  Given the relatively low amount of time commitment (the instructor reported doing zero prep. work for these sessions), it might be worthwhile encouraging other instructors to hold similar sessions, perhaps in the place of one of their office hours.

In terms of student learning, students in 2005 did perform significantly worse on the second mid-term and final as students in 2004. However, the TAs and instructor both reported anecdotal evidence that students learned more in this class than in other, similar classes, or previous versions of the same class. It is entirely possible that the exams from the two years were not equal in difficulty, which might account for differences in exam scores. It might be worthwhile, if other innovative courses are to be evaluated, to use exams or specific questions that are identical from previous, traditional versions of the course, thereby providing a more controlled measure of student learning.

Interestingly, both the instructor and TAs felt that the online reading quizzes supported student learning. On the other hand, students' responses to these assignments were mixed, with quite a few students thinking of them as annoying and not helpful and others seeing them as a strong contributor to their learning. One interesting point the instructor made was that students might not be aware of the ways which the reading quizzes helped them learn. He proposed that a minimal level of awareness of various vocabulary words before lecture gives students an advantage in comprehending the lecture material.

If reading quizzes are incorporated as a regular aspect of CEE 220, one change that would improve the student experience would be establishing a regular due date for them. Students were often confused about when they were supposed to do the quizzes. In addition, it might be worthwhile considering reducing the number of quizzes (e.g., one per week), so that students do not feel overwhelmed. The workload for this class was very high, though students appeared to consider most of this time valuable.

In regards to changes in student learning, there are no systematic data suggesting that the reading quizzes or other innovations improved student learning. However, some of these changes might not show immediate effects on student learning but might help students retain the material as they move on to more advanced courses. It might be interesting, therefore, to investigate student performance in a subsequent engineering course that applies CEE 220 concepts, according to whether students were enrolled in this version of CEE 220 or another version (controlling for time elapsed between the courses). Such a follow-up study might also reveal that students who were in the innovative version of CEE 220 realize how the reading quizzes and other innovations contributed to their learning, something they might not have been aware of until they were asked to apply and build on the material they had learned.

## Adaptability

A common challenge with course redesign projects is adoptability. Often, one instructor commits to improving a course, invests time and interest in a course that is successful, but the changes are never adopted by other professors because they are not as committed to student learning. This situation might describe CEE 220. It is abundantly clear that the instructor of CEE 220 in Winter of 2005 was strongly committed to the course redesign and, in general, cared deeply about whether students learned the material he was trying to convey.

This particular instructor was instrumental in making this new version of CEE 220 a success. However, there is some cause for concern that the benefits of the new course might be due to an "instructor effect." Almost all student interviewees commented that they thought the instructor was excellent and many of them commented that he made the course unique. In considering the future of the innovations made to this course, it is important to consider that not all instructors will be as committed to student learning as

this instructor was and, therefore, may not be willing to invest the considerable amount of time and effort this instructor did.

Granted, the amount of effort necessary to carry-on these innovations pales in comparison to the work necessary to initiate them. However, it is important to convey to future instructors of CEE 220 that their workload will be increase only minimally. For example, the weekly CLUE review sessions were extremely valuable to the students who attended them and enhanced their learning experiences and if instructors replaced one of their office hours with the CLUE session, there would be no increase in workload. Similarly, instructors might be happy to hear that having an online gradebook and a lively discussion board would reduce the amount of time they spent answering individual student emails.

One inevitable "ramp up" investment for instructors adopting these innovations is the time it takes to learn how to use the Moodle system. One way to circumvent this potential barrier, as suggested by the instructor, is to rely more on TAs to handle the Moodle system. Given that most of the components included in this system are the TAs domain, this might be reasonable, but this would involve a considerable amount of time investment from the TAs, particularly as these graduate students are learning the system and a database of homework and reading assignment quiz questions is still being developed. During the first few adoptions of the Moodle system, it would be important to consider this additional amount of time investment when allocating TAs to courses: the time savings of Moodle will be slowly cumulative.

In addition, one extremely important suggestion from the instructor was to have additional support for the use of the Moodle system. He proposed that it would have been nice to have someone on campus who could help him overcome challenges and small flaws in the system. One option would be to assign one TA in the college or department who could develop expertise with the system, could alter the freeware software to accommodate faculty needs, and would generally be available for support. Another option would be to foster a community among the faculty and TAs across colleges who are using this system, so that they could troubleshoot with each other and discuss how to make the most of this resource. For example, faculty in the College of Arts and Sciences in Spanish, German, Japanese, and Economics Departments have made use of Moodle in the past year. As faculty working with Moodle collect materials (such as FAQ's) and insight into how the system works, they could share it with other instructors; in fact, the department, college, or University could establish a Moodle site for instructors using Moodle.

# APPENDIX A: DETAILED FINDINGS FROM MID-TERM AND FINAL SURVEYS

This appendix contains detailed, descriptive statistics for each of the survey items in turn.  Note that the mid-term surveys and final surveys contained many of the same items; hence, results from these two instruments are presented together.  For an overview of these findings according to theme, see the Results section in the main report.  Note that some of the content below is excerpted from the report on the mid-term survey, delivered in February 2005.

## Section 1:  Pre-Lecture Reading Assignment Quizzes

### What percentage of the pre-lecture reading assignment quizzes have you completed?

For this question, asked in both the mid-term and final survey, participants chose between five different percentage ranges to indicate what proportion of the reading assignment quizzes they had completed. Responses from both surveys are presented in Figure A1.

**Figure A1:  Proportion of reading assignment quizzes participants completed, according to time point**
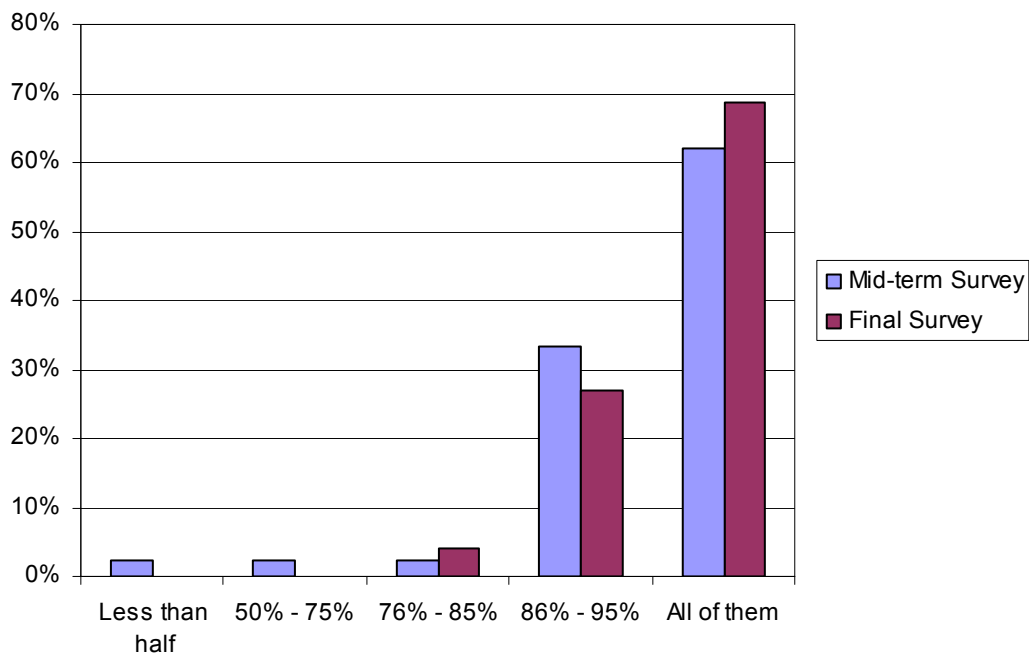


### When do you usually look at these reading assignment quizzes for the first time?

In order to gather more information about how exactly students used these reading quizzes, participants indicated when they first looked at the reading quizzes, choosing from three different options.  This question was asked in both the mid-term and final surveys; data from this item are presented in A2.

**Figure A2: Students' responses to item about when they first looked at the reading assignment quizzes, according to time point (mid-term or final)**
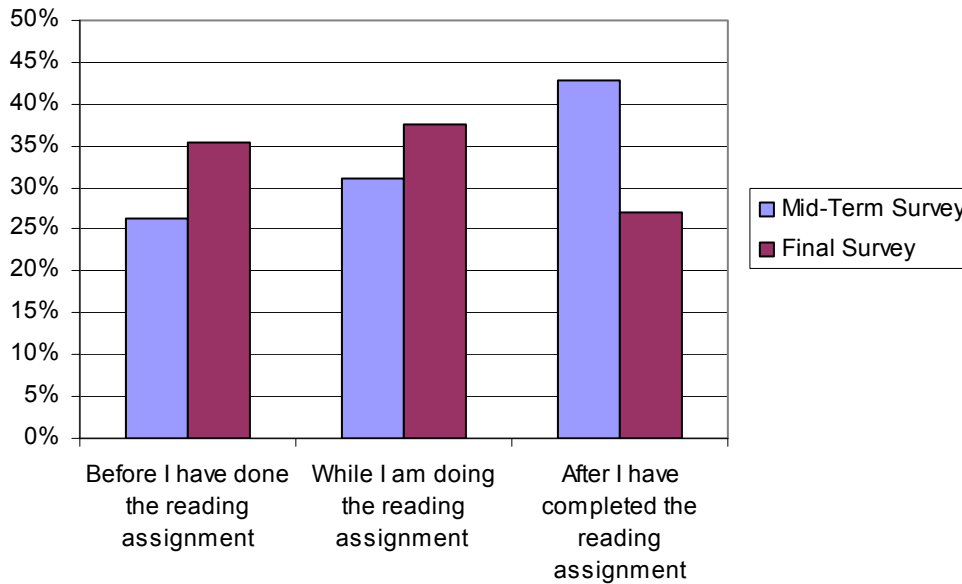


## What are the benefits of completing the reading assignments themselves? What additional benefits (if any) do you gain from completing the associated reading assignment quizzes?

In the brief mid-term survey, participants responded to these two questions in an open-ended format. Most participants focused on the second question (i.e., benefits of completing the reading assignment quizzes). Responses to the first question indicated that readings helped students understand lecture (33.3% of respondents made this comment). Two individuals also commented that the readings were necessary for completing the homework. Comments addressing the second question are presented in Figure A3:

**Figure A3: Responses to an open-ended item in the mid-term survey about the benefits of the reading assignment quizzes**
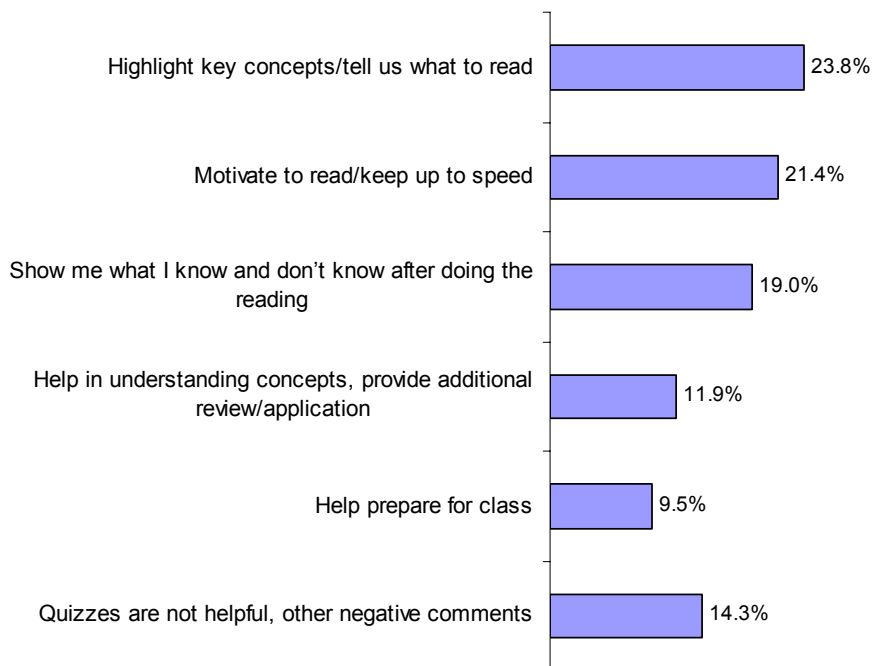


In the final survey, participants were given a list of possible benefits of the quizzes and asked to rank them from most beneficial (1) to least (6). In addition, participants wrote an "x" next to any aspects of the reading quizzes they did not find beneficial at all. Table A1 shows the rank order of the these benefits according to (a) the number of first-place rankings and (b) the mean rating, with six points assigned to a first place ranking, five to a second, etc. Any X's were given a 0.
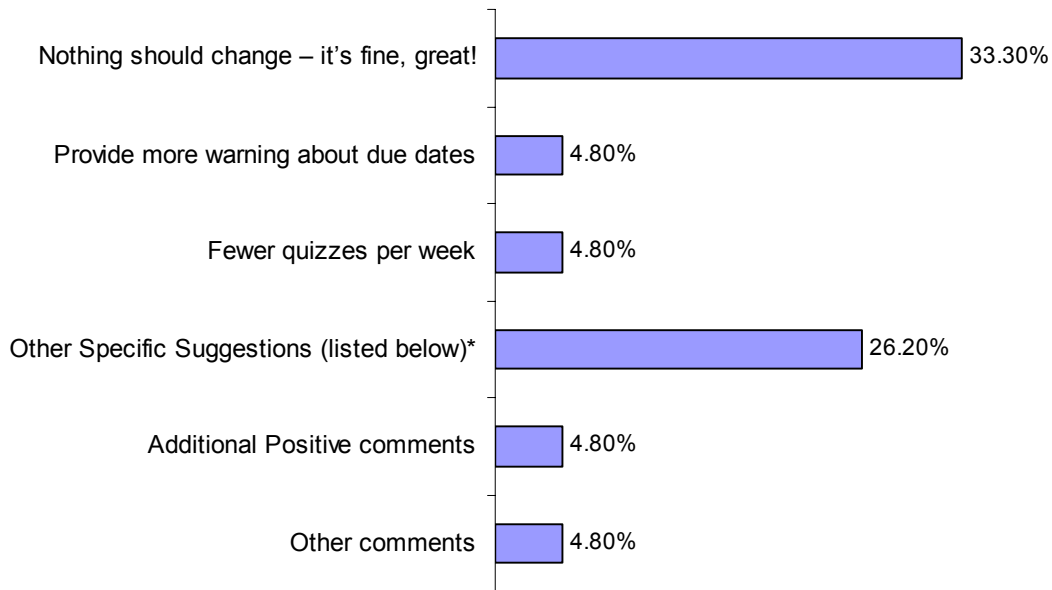
**Table A1: Results from ranking of benefits of the reading assignment quizzes. Items are presented in order according to number of 1st place ratings and mean ranking**

| According to # 1st Place Rankings | | According to Mean Ranking | |
|---|---|---|---|
| Highlighting key concepts from the reading | 14 | Highlighting key concepts from the reading | 4.12 |
| Motivating me to complete the reading | 14 | Showing me what I do not understand from the reading | 3.91 |
| Showing me what I do not understand from the reading | 13 | Preparing me for lecture | 3.74 |
| Preparing me for lecture | 5 | Motivating me to complete the reading | 3.40 |
| Deepening my understanding of certain concepts | 3 | Deepening my understanding of certain concepts | 3.10 |
| Providing an additional way to review the reading | 2 | Providing an additional way to review the reading | 2.70 |

### *How could this aspect of the course be improved?*

This question was only asked in the mid-term survey, not the final survey. The 31 codable responses are presented in Figure A4 (as reported in the mid-term survey report).

**Figure A4:  Responses to open-ended item about how the reading assignment quizzes could be improved**

| Category | Percentage |
|---|---|
| Nothing should change – it's fine, great! | 33.30% |
| Provide more warning about due dates | 4.80% |
| Fewer quizzes per week | 4.80% |
| Other Specific Suggestions (listed below)* | 26.20% |
| Additional Positive comments | 4.80% |
| Other comments | 4.80% |

* Other than the two suggestions listed in the table above ("Provide more warning about due dates" and "Fewer quizzes per week" -- each mentioned by two participants), students provided eleven specific ideas about how the quizzes could be improved:

- Make the quizzes even more specific, so we know what the MOST important things are

- Create questions that can be answered by only one reading of the text – none that require more teaching or particularly complex concepts

- When re-taking the quiz, keep those answers that were correct, so they don't have to re-enter them.

- Eliminate true/false questions – they can be answered just by guessing and do not encourage concept learning or retention.

- Post reading assignment and quizzes for the following week before the week-end; it's easier to schedule time that way.

- Make it easier to print out the quiz questions and correct answers as a future study guide.

- Give the quiz once after both the reading and lectures have been completed to ensure that the concepts were learned

- Eliminate the reading quizzes

- "Not give answers all the time.  Gives you an out to get around the reading.  but it's good at time because you might not be able to do the reading at certain times, but can still get the points."

- Put the page number next to each question

- Instead of making quizzes mandatory, provide some extra credit to students who complete all the quizzes or a certain number of them.

### *Endorsement items.*

Finally, on both the mid-term and final surveys participants indicated how much they agreed or disagreed with a set of five statements about the reading assignment quizzes.  Responses are summarized in Table A2

**Table A2:  Endorsement of statements about the reading assignment quizzes, according to time point (mid-term or final survey)**

| Statement | Time Point | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Mean | SD |
|---|---|---|---|---|---|---|---|---|
| Without the quizzes, I would struggle in figuring out the readings. | Mid-Term | 6 (14.3%) | 14 (33.3%) | 9 (21.4%) | 11 (26.2%) | 2 (4.8%) | 2.74 | 1.15 |
| | Final | 6 (12.5%) | 14 (29.2%) | 14 (29.2%) | 13 (27.1%) | 1 (2.1%) | 2.77 | 1.06 |
| I usually read only those parts of the text that help me figure out the answers to the online quiz questions. | Mid-Term | 8 (19.0%) | 10 (23.8%) | 11 (26.2%) | 11 (26.2%) | 2 (4.8%) | 2.74 | 1.19 |
| | Final | 12 (25.0%) | 9 (18.8%) | 6 (16.7%) | 13 (33.3%) | 5 (6.3%) | 2.77 | 1.32 |
| Compared to other classes, I understand lectures in this course better because of the quizzes. | Mid-Term | 1 (2.4%) | 6 (14.0%) | 13 (31.0%) | 17 (40.5%) | 5 (11.9%) | 3.45 | 0.97 |
| | Final | 3 (6.3%) | 6 (12.5%) | 18 (37.5%) | 17 (35.4%) | 4 (8.3%) | 3.27 | 1.01 |
| I would complete the quizzes even if they did not count towards my grade. | Mid-Term | 4 (9.5%) | 15 (35.7%) | 13 (31.0%) | 8 (19.0%) | 2 (4.8%) | 2.74 | 1.04 |
| | Final | 4 (8.3%) | 13 (27.1%) | 13 (27.1%) | 16 (33.3%) | 2 (4.2%) | 2.98 | 1.06 |
| Overall, I think the reading assignment quizzes definitely help me in learning the course material. | Mid-Term | 1 (2.4%) | 2 (4.8%) | 7 (16.7%) | 22 (52.4%) | 10 (23.8%) | 3.90 | 0.91 |
| | Final | 2 (4.2%) | 5 (10.4%) | 11 (22.9%) | 17 (35.4%) | 13 (27.1%) | 3.71 | 1.11 |

### Additional comments about the online reading quizzes

In the final survey (but not the mid-term survey), participants were asked to provide any further comments they had about the online reading quizzes.  Fifteen individuals gave codable responses as follows (numbers in parentheses indicate number of times comment was made):

*General Comments*
- Generally positive comments about the reading quizzes (5)
- Sometimes did not do the reading, only did quizzes
- Quizzes forced me to read
- Quizzes helped me understand concepts
- Did not like questions when you had to input your own answers
- Too many multiple choice questions, too easy for points
- It would be OK if they were not for a grade
- Appreciated they were short, not burdensome

*Suggestions for Improvement*
- Make server faster (3)
- Include hints (e.g., if answer is off by a power of 10)

- Don't show the answers right away, give three tries
- More questions might have encouraged increased/more thorough reading
- More applied questions instead of directly from the reading
- Save correct answers for multiple attempts
- There were too many – reduce the number (2)

## Section 2:  Homework Assignment Quizzes

*Endorsement items.*

On both the mid-term and final surveys, participants indicated how much they agreed or disagreed with a set of four items about the homework assignment quizzes.  Responses are summarized in Table A3
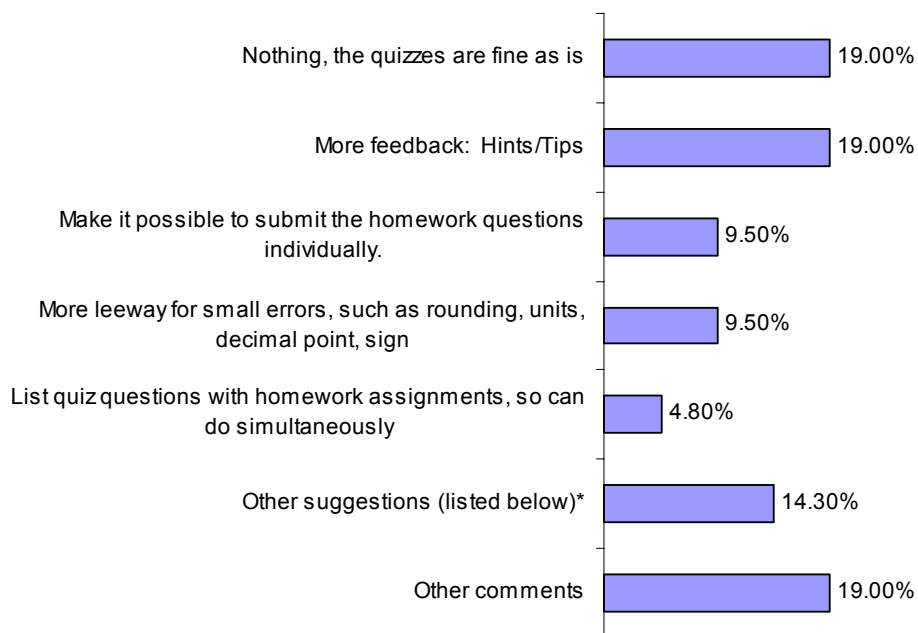
**Table A3:  Endorsement of statements about the homework assignment quizzes, according to time point (mid-term and final survey)**

| Statement | Time Point | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Mean | SD |
|---|---|---|---|---|---|---|---|---|
| The feedback provided by the homework quizzes helps me to identify mistakes in my homework solutions. | Mid-Term | 3 (7.1%) | 5 (11.9%) | 8 (19.0%) | 15 (35.7%) | 11 (26.2%) | 3.62 | 1.21 |
| | Final | 3 (6.7%) | 5 (11.1%) | 19 (20.0%) | 13 (28.9%) | 15 (33.3%) | 3.72 | 1.23 |
| The questions in the homework quizzes contain useful hints on how to solve the problems. | Mid-Term | 1 (2.4%) | 7 (16.7%) | 12 (28.6%) | 13 (31.0%) | 9 (21.4%) | 3.52 | 1.09 |
| | Final | 2 (4.4%) | 5 (11.1%) | 6 (13.3%) | 19 (42.2%) | 13 (28.9%) | 3.79 | 1.14 |
| Receiving immediate feedback about my solutions is worth the effort it takes to submit them electronically. | Mid-Term | 1 (2.4%) | 0 (0.0%) | 1 (2.4%) | 13 (31.0%) | 27 (64.3%) | 4.55 | 0.77 |
| | Final | 0 (0.0%) | 0 (0.0%) | 3 (6.7%) | 16 (35.6%) | 25 (55.6%) | 4.34 | 1.13 |
| Overall, I think the homework assignment quizzes definitely help me in learning the course material. | Mid-Term | 1 (2.4%) | 0 (0.0%) | 4 (9.5%) | 13 (31.0%) | 24 (57.1%) | 4.40 | 0.86 |
| | Final | 0 (0.0%) | 0 (0.0%) | 4 (8.9%) | 18 (40.0%) | 22 (48.9%) | 4.28 | 1.17 |

*How do you think this aspect of the course could be improved?*

This question was asked only in the mid-term survey; responses from 37 participants are presented in Figure A5.

**Figure A5: Responses to an open-ended question (mid-term survey only) about how to improve the online homework quizzes**



| Response | Percentage |
|----------|-----------|
| Nothing, the quizzes are fine as is | 19.00% |
| More feedback: Hints/Tips | 19.00% |
| Make it possible to submit the homework questions individually. | 9.50% |
| More leeway for small errors, such as rounding, units, decimal point, sign | 9.50% |
| List quiz questions with homework assignments, so can do simultaneously | 4.80% |
| Other suggestions (listed below)* | 14.30% |
| Other comments | 19.00% |

\* The six other suggestions for improvement were as follows:

- Make it possible to save correct answers so don't have to re-enter
- Provide an option to print out individual questions
- Faster server
- Provide feedback for CORRECT answers as well as incorrect ones
- "If I could log back into the homework quiz even after it is due so that I can study it before tests."
- A brief Q & A session during lecture about the quizzes

The "other" comments were as follows:

- "It would be nice to get our written homework back to study before the midterms."
- It doesn't work correctly on all browsers
- Some of the problems are too complex, long, and time consuming
- "Problems involving drawing graphs or plotting data on paper are really awful."
- Timing of work: Questions on homework quizzes during the week before the mid-term were not relevant to exam. No new material before an exam (that isn't on the exam)

In the final survey, participants were asked a more general question to provide additional comments about the homework quizzes. A total of 15 individuals answered this open-ended item; responses were as follows:

*General Comments*

- Generally positive comments (2)
- Better than written homework because all items are graded, revealed errors (2)
- Appreciated when questions directed to the answer to problems; they were like clues

- Definitely helps learn problems better
- Immediate feedback motivated continued attempts
- Appreciated opportunity to have unlimited attempts

*Suggestions for Improvement*

- More feedback, hints, particularly when errors are minor, model after physics Tycho system (6)
- Make server faster (4)
- Eliminate requirement to hand in a paper copy as well (2)

## Section 3:  Out-of-Class Support

***How many times have you attended the CEE 220 sessions at the Engineering Advising & Student Center OR at C.L.U.E.?***

The first question in this section, asked on both the mid-term and final survey, assessed students' participation in the three primary sources of out-of-class help for CEE 220.  Participants selected from a choice of five different frequency options; responses are summarized in Figure A6.

**Figure A6:  Responses to question about frequency of use of out-of-class support, according to time point (mid-term or final survey)**
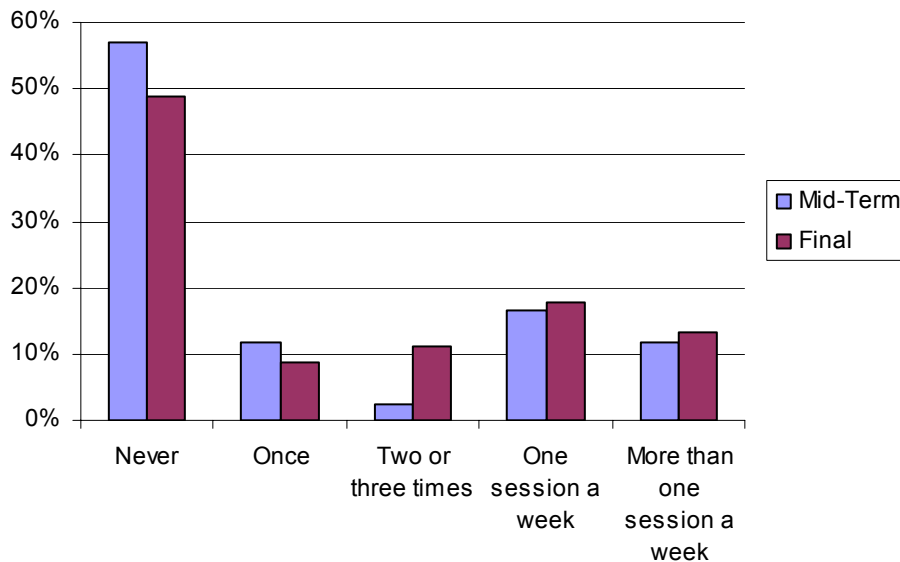


The following two questions were answered only by students who indicated that they had attended at least one of the CLUE sessions:

***Which tutoring sessions did you attend? (Check all that apply)*** [9]

For this item, participants in both the mid-term and final survey indicated all of the sessions they had attended more than once.  Results are summarized in Figure A7.  Note that there appears to have been an increase in CLUE attendance from the mid-term to final surveys.

**Figure A7:  Sessions attended by students who made use of at least one type of out-of-class sessions, according to time point (mid-term and final survey)**
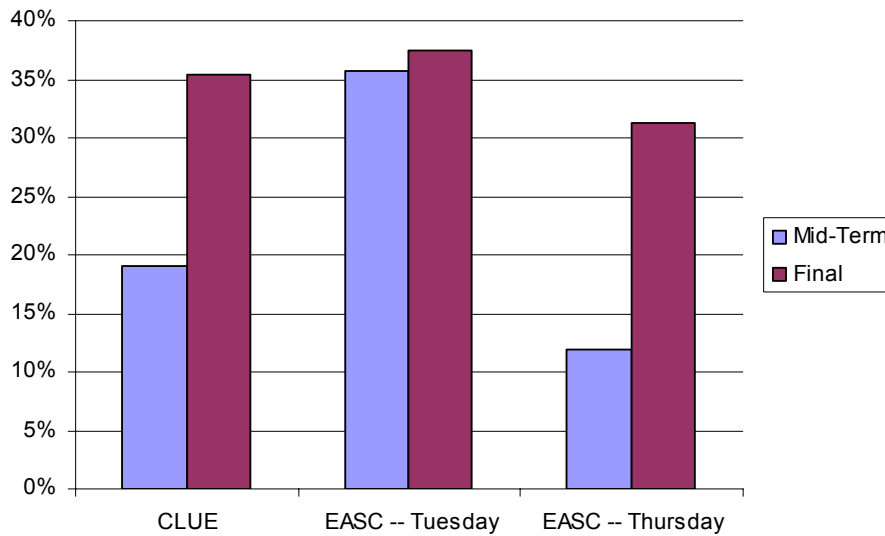


An additional analysis was performed to reveal who had attended none, one, two or all three of these out-of-class options.  Results are presented in Figure A8.

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[9] Percentages do not sum to 100% because participants were allowed to select multiple responses; each percentage represents a proportion of the total number of surveys completed (42).

**Figure A8: Number of students who attended from none to all three of the out-of-class help options, according to time point (mid-term and final survey)**
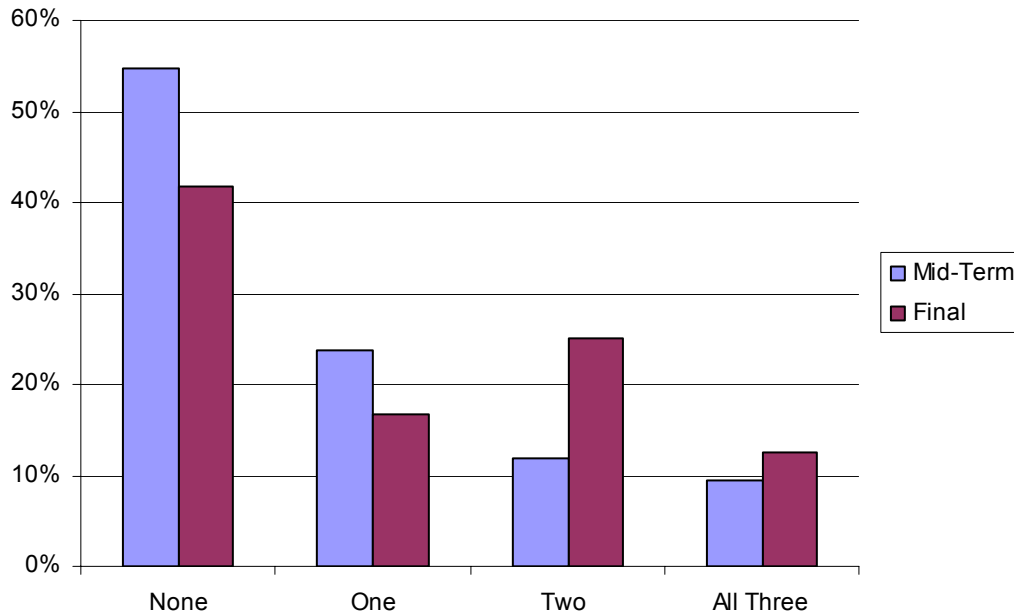


*Endorsement Items (Mid-Term Survey Only)*

In the mid-term survey only, participants were asked to indicate how much they agreed or disagreed with statements about the out-of-class help. Responses are presented in Table A4

**Table A4: Responses to endorsement items about out-of-class help (mid-term survey only)**

| | 1 Strongly Disagree | 2 Disagree | 3 Neutral | 4 Agree | 5 Strongly Agree | Mean | SD |
|---|---|---|---|---|---|---|---|
| Tutoring helps me solve my homework problems. | 0 (0.0%) | 0 (0.0%) | 1 (5.3%) | 8 (42.1%) | 10 (52.6%) | 4.47 | 0.61 |
| Tutoring helped me preparing for the 1st midterm. | 0 (0.0%) | 2 (10.5%) | 9 (47.4%) | 7 (36.8%) | 1 (5.3%) | 3.37 | 0.76 |
| There is an adequate amount of tutoring available for this class. | 1 (5.3%) | 1 (5.3%) | 2 (10.5%) | 6 (31.6%) | 9 (47.4%) | 4.11 | 1.15 |
| Overall, I think the tutoring offered for this class definitely helps me in learning the course material. | 0 (0.0%) | 0 (0.0%) | 1 (5.3%) | 9 (47.4%) | 9 (47.4%) | 4.42 | 0.61 |

## Section 4:  Alternate Lab Times

***Have you participated in a lab outside of the regularly scheduled lab times (as agreed upon by your lab group)?***

Very few individuals indicated they had attended an alternate lab time.  A total of **three** said they had at the mid-term survey, and **two** said they had in the final survey.  Judging from their open-ended responses on the mid-term survey, these individuals were most likely in the same group.  They decided to have their lab at 9:30am instead of 8:30am to get some extra sleep, which they valued.  One individual in the group also thought they were more efficient because they were better rested.  According to their numerical endorsements of several statements, all three of these individuals (probably the same two in the final survey) agreed that they knew who could answer their questions during their session and that they were just as efficient as groups that participated in the regularly scheduled class time.

***If you did not attend an alternate time session, why not?***

Participants who had NOT participated in the alternate lab times were asked a separate set of questions. In the mid-term survey, participants were first asked an open-ended question about why they decided not to take advantage of this option.  Responses are presented in Figure A9.

**Figure A9:  Responses to open-ended answer about why participants did not take advantage of an alternate lab time (mid-term survey only)**
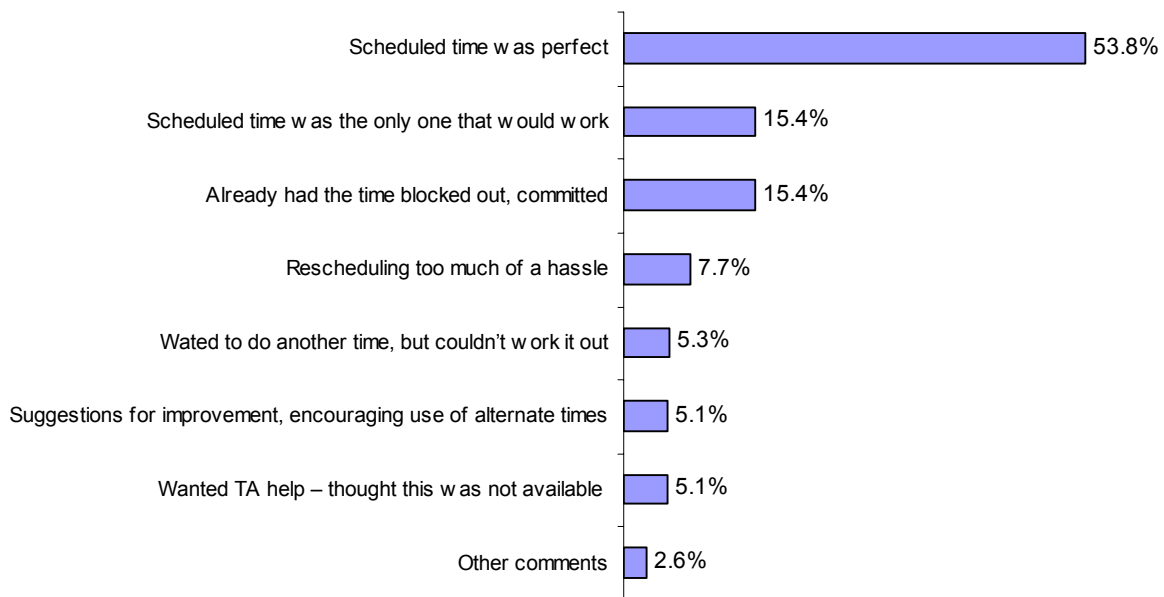


The mid-term survey also included a forced-choice follow-up question for participants who did not attend an alternate lab time.

***If you did not attend an alternate time lab session because your group could not decide on a mutually convenient time, would you consider changing groups if it meant your lab session would be held at a more convenient time for you?***

This question was asked to find out whether students would have taken advantage of this option if the primary barrier (scheduling) had not been present. Responses are presented in Table A5.

**Table A5: Responses to question about whether participants would have chosen an alternate lab time if there were not scheduling difficulties**

| Options (n = 39) | Frequency | Percentage |
|---|---|---|
| Yes | 8 | 20.5% |
| No | 14 | 35.9% |
| Maybe | 14 | 35.9% |

In the final survey, participants were asked to respond to a set of items based upon the responses from the mid-term survey about why students did not opt for the alternate lab time.

*Endorsement Items (Final Survey Only)*

In the final survey, participants were asked to indicate how much they agreed or disagreed with various statements about the alternate lab times. These items consisted primarily of various reasons for not choosing the alternate lab times generated in an open-ended item in the mid-term survey (See Figure A9). Responses to these items are presented in Table A6.

**Table A6: Responses to endorsement items about the alternate lab times (final survey only)**

| | 1<br>Strongly<br>Disagree | 2<br>Disagree | 3<br>Neutral | 4<br>Agree | 5<br>Strongly<br>Agree | Mean | SD |
|---|---|---|---|---|---|---|---|
| I would have been more likely to attend an alternate lab time if we had decided on a time at the outset of the term. | 7<br>(15.9%) | 11<br>(25.0%) | 12<br>(27.3%) | 10<br>(22.7%) | 4<br>(9.1%) | 2.84 | 1.21 |
| I did not want to attend an alternate lab time because I wanted to have TA support during lab. | 0<br>(0.0%) | 3<br>(7.1%) | 11<br>(26.2%) | 17<br>(40.5%) | 11<br>(26.2%) | 3.86 | 0.90 |
| The existing lab times for this course were perfect; I could not have picked a better time. | 0<br>(0.0%) | 2<br>(4.5%) | 10<br>(22.7%) | 13<br>(29.5%) | 19<br>(43.2%) | 4.11 | 0.92 |
| An alternate lab time was attractive to me, but our group was unable to find a time that worked for everyone. | 9<br>(20.5%) | 12<br>(27.3%) | 11<br>(25.0%) | 7<br>(15.9%) | 5<br>(11.4%) | 2.70 | 1.29 |

***Do you have any additional comments about the innovations made to this course (reading and homework quizzes, out-of-class support, and alternate lab times) or the course in general?***

In the mid-term survey, participants were asked one final question, asking them to provide any final comments about the course as a whole.  Responses from 25 participants are presented in Figure A10.

**Figure A10:  Responses to an open-ended item asking participants for any additional comments about the course (mid-term survey only)**
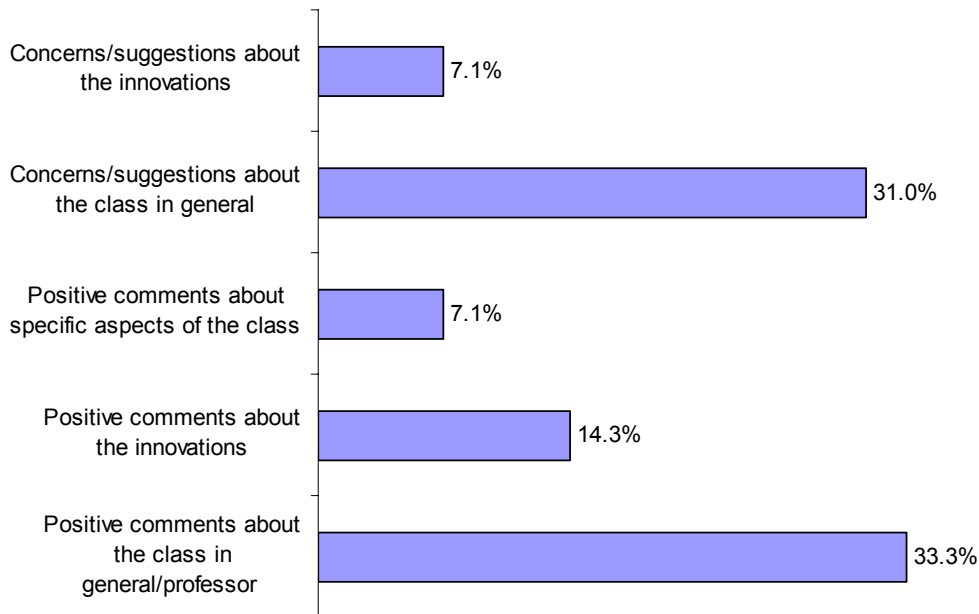


*Concerns about the class in general were as follows:*

- Faster server for web site (4)
- Web site is a little busy:  (3)
- Have homework due on Thursday nights so can work on them in spare lab time.
- Model of group work from another course:  bonus if all members of group score well on exam, meeting outside lab, and using lab time to do HW problems.
- From the beginning, tell us that the class isn't curved –serves as a motivator
- Lectures are sometimes confusing (but that is that case with other classes) and mid-terms seem a bit long
- Workload
- "I feel like the professor could move a little faster over the theory in lectures to try to work in more example problems"

*Concerns about the course innovations were as follows:*

- Quizzes encourage guessing as opposed to learning
- All of these extra things can be somewhat hectic if not on a regular schedule.
- "At times the quizzes can be overwhelming, but at the same time I feel like I need them in order to understand the concepts."

In the final survey, participants were asked if they had any final comments about the alternate lab times or about the class in general.  Responses from nine participants were as follows:

*Comments about the alternate lab times:*

- Had my schedule set at the beginning of the quarter, hard to change it
- Good idea but hard to coordinate
- "I would have certainly picked on alternate time but I got a great group w/o the supervised by an amazing TA."

*Comments about the class in general:*

- Web site slow/upgrade server (4)
    "Chat room on the website isn't a real chat room -- text appears 10-15 seconds after entering. It's very slow and frustrating."
- Positive comments (3)
    "Thank you for caring for students so much."
    "Labs were generally helpful
    "Excellent professor and Ta's. Always available for additional help! Kudos!"

# APPENDIX B: DETAILED FINDINGS FROM THE STUDENT INTERVIEWS

The following summary represents a question-by-question narrative of how the twelve student participants responded in their interviews. For a more synthesized summary according to theme (and in relation to the other data), please see the Results section of the main report.

## Question 1. So how did you come to take CEE 220?

All twelve respondents took CEE 220 because it was a required course for their engineering major.

## Question 2. Tell me a little about your experience in CEE 220 last quarter. What was it like being in that class?

Responses to Question 2 overlapped considerably with those for Question 3. Hence, the two questions were analyzed together; responses are summarized below (under Question 3).

## Question 3. In comparison to other similar classes, did CEE 220 stand out in any way – how was it unique?

### *Overall response to CEE 220*

The overall response toward the class was positive, with two students regarding it very highly ("really good" and "one of the best classes I've ever taken") and a majority regarding it well ("good overall," "pretty good," or "decent"). While most students said they did not have any preconceived expectations of the class, the two individuals who did felt the class met or exceeded their expectations.

Five individuals described the course as being difficult or a lot of work (one of whom was responding to Question 3, regarding what made the course stand out). Of those five participants, one person directly related the workload to the subject matter: "Initially, the information was harder – I had to follow example problems in the book and stuff. ...I went to office hours because I had more questions on the material." The other four students related the difficulty of the course to the amount of work, which they perceived as being higher than average. Two of the five students seemed to view the difficulty level of the class in a negative light, primarily due to personal dislike of the online technology interface Moodle. The other three were either neutral or positive about the difficulty level of the class (i.e. "The class was more work than I've ever put into a class and I didn't mind doing the extra work because I got a lot out of it").

Seven of twelve students voiced positive comments about the instructor (i.e., "He added humor – it felt comfortable," "He was really good and knew what he was teaching"). Particular emphasis was placed on the instructor's high degree of concern and enthusiasm for students' learning, and the amount of time invested by the instructor ("He just really wanted us to learn...whenever we needed help, he was there," "Probably the most significant thing was the teacher's time commitment…[he] put more work into the class than my other three teachers last quarter combined"). While these comments tended to emerge at the start of the interview, in response to Question 1 or 2, six of these students also added – in response to Question 3 – that the professor's commitment to their learning made CEE 220 stand out as unique. A few students also expressed positive comments about the class TAs.

The other topics that students mentioned in Questions 2 & 3 included:
- Online innovations: homework & quizzes (mentioned by all 12)
- Lectures (10 of 12)
- Online discussion forum (5 of 12)
- CLUE/Monday night review sessions (4 of 12)
- Lab work (2 of 12)
- The fact that the class was not curved (1 of 12)

With the exception to the feedback regarding lectures, the remainder of these topics will be summarized later in the document, and grouped with the questions that pertain to them.


***Feedback regarding lectures***

A majority of participants spoke up immediately about the content or presentation of lectures. Just over half of the students interviewed (7) shared a perception that the class lectures were heavily based on theory. One student liked this emphasis ("[It was] actually theory–based, he actually wanted us to understand which was cool because I never really understood"), one student appeared to be neutral ("Uh, I guess kind of the same, more theory than usual, but . . . still just lecture"), and five students disliked the focus on theory. Those students who critiqued the emphasis on theory appeared to have difficulty understanding how to apply the material. Examples from three students follow:

> *"One thing I did dislike – lectures didn't help at all, they only covered theory. No practical problems. I got screwed up in the beginning because I thought there would be theory in the beginning and that was what was important, so I didn't think about what it was applying to."*

> *"I think I could have gotten more out of the lectures if they were more computational and less theory. I think that way about most my classes, but this one especially seemed like we rarely had actual examples in class."*

> *"I thought the lectures were really difficult to understand, maybe it was the material. I thought we went through it conceptually and not entirely . . . most engineering disciplines, they go through a derivation perhaps and then talk about how it's used, the focus is how the equations are used, not the math behind it. We didn't get the use, very much of the math behind it. It was difficult to follow, and you couldn't ask anyone else in the class because they didn't know it."*

However, in an interview session in which more than one student participated, one student responded to the above type of comment by pointing out that the CLUE sessions provided a useful counterpart for helping students to better understand lectures ("The professor was more helpful in the CLUE session. He asked who had problems and helped them").

Meanwhile, four students commented on the presentation of class lectures (one of whom had also commented on lecture content). Three students mentioned the professor's use of the PC Tablet in conjunction with the Power Point: two liked this feature of the lecture, while one was neutral about it. Another student gave positive feedback about the practice of handing out copies of slides to students.

**Appendix B:  Detailed Findings from Student Interviews**

**Question 4.  What did you think of the online reading quizzes?**

**Question 5.  What about having homework assignments graded online?  How did that go?**

As noted above, all twelve interview participants mentioned the online quiz/homework innovations in some regard in response to Questions 2 and 3. That feedback has been summarized here together with the responses to the aided questions (4 and 5).

*Overall response to Moodle*

In general, most of the 12 students interviewed tended to be either positive or neutral toward the online innovations. Just two of the twelve participants strongly disliked the use of online options in the class. Of these two students, one felt that the online innovations required too much work and preferred traditional paper assignments, while the other found the interface confusing, had problems figuring out an efficient way to save/access the URL, and said the technology didn't fit with his/her learning style.  Students who made general positive comments about the online innovations said things like: "I liked the way the website was set up," "[What stood out about the class was…] The server, the model, the new way of doing things…everything being online was really helpful," and "Having all those extra options helped me succeed much with this course."

However, suggestions about how the Moodle experience could be improved stemmed from all three types of students – those who liked the online innovations, those who were neutral, and those who disliked it. Some comments had to do with assignment structure and content, while others were specifically related to the Moodle user interface. In particular, students tended to weigh Moodle against Tyco (the interface used by the physics department), and point out ways that Moodle does not perform as well as Tyco, and could be improved to function better. These suggestions are outlined in closer detail in the following sections regarding the reading quizzes and the online homework.

*Response to reading quizzes*

Feedback about the online quizzes was mixed. At least five participants felt that the online quizzes were beneficial in helping them keep up with the reading, or even compelling them to do the reading at all when they may not have otherwise have done so. A couple of students also found the quizzes useful in highlighting what they were supposed to take away from the readings. Two students (not the same two who disliked Moodle in general) disliked the quizzes: one felt that they were unnecessary and that simply doing the reading should suffice, while the other believed that the contribution of the online quizzes to the overall workload actually caused him to read less.

Aside from the two afore-mentioned students, most participants who critiqued the quizzes (nine students overall) did not advocate throwing them out wholesale, but instead made suggestions as to how the process could work better for them. Four students – including two who had described the quizzes as helpful – indicated that having fewer quizzes would be helpful. In three separate interviews, students called the frequent quizzes "annoying" and explained that while the quizzes helped to stay on track at first, it soon became very difficult to stay on top of them.

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Not just a factor of the frequency of the quizzes however, this situation appears to have been compounded by the fact (pointed out by three students) that the due dates for quizzes were constantly shifting. Students felt that this inconsistency made it particularly hard to stay on top of the quizzes, and suggested having the quizzes on a consistent, set day. One student also suggested that the quizzes not all be mandatory.

A handful of students also commented on the programming bug that caused the correct answers to be displayed: though aware that the answer display was unintentional, students argued that it actually provided a very helpful means of understanding what the professor felt to be the salient points in the material. On the other hand, four students criticized the interface for its inability to "save" their correct answers, such that if a student wanted to go back and revise any problems, they consequently had to do all the problems over again. One of these students also pointed out that the Tyco interface is better in that regard, as it is programmed to save correct answers.

Finally, a couple of differing opinions were voiced with regard to content of the online quizzes. One student felt that adding five or so additional questions to the each quiz would be helpful, to ensure that more of the lecture points were covered. Another student thought that the quizzes were too involved as-is, and that they should be based on testing students' conceptual knowledge, rather than requiring students to complete complex problems step-by-step.

### *Response to online homework grading*

Half of the interview participants made positive comments about the online homework grading, while the remainder tended to focus on ways to improve them. In contrast to the online quizzes, however, none of the interview participants were adamantly opposed to the online homeworks. Among the students who made positive comments, the most common was the appreciation of the immediate feedback on homework – this was mentioned by at least five students. Two students were highly enthusiastic about the option of being permitted multiple tries to get 100%, while one student disliked the function: "You get it wrong, you get it wrong. I didn't like submitting 100 times to get it to the right decimal." (This student was also one of those who disliked the online innovations and interface altogether.) One student who liked the online homework felt that it encouraged her to put in more effort and input, while someone else felt that the online homeworks were useful in reviewing for tests.

The most common suggestion for improving the Moodle homework experience was to enable the interface to provide additional help and feedback for students when they answer a problem wrong. Eight interview participants made this suggestion, with most of them citing Tyco as an example, as the following quotations from three students illustrate:

> *"Physics Tyco has help within the homework – that was something nice about the Tyco that he didn't have. Some kind of help would have been nice."*

> *"The homework was a lot more helpful in Tyco. You could see exactly what you did wrong, instead of one answer right or wrong, two points for each. It guided you in what to solve.*

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> *"Sometimes Tyco also has an interactive example, as part of your homework.  It takes things step by step.  Maybe if some homeworks were based step by step."*

At least four students disliked having to turn in a paper copy of the homework in addition to doing online homeworks; some of these four disliked having to take time to make their homework "look nice," while a few seemed to take issue with the fact that homeworks were not graded or were not returned with any feedback. A couple of additional suggestions were mentioned regarding ways to improve the Moodle homework application. Two students voiced frustration at having to review all the problems before being able to see their answers and resubmit. Last, one person disliked the fact that Moodle displayed the number of times the student had resubmitted because she felt it "makes you feel bad about yourself."

## Question 6.  Did you attend any of the out-of-class tutoring session, either at CLUE or in the Engineering Advising and Student Center?  Can you tell me a little about your experience with these sessions?

In many of the interviews, students discussed other external help they received in addition to the CLUE sessions and the EASC tutorial sessions.  In general, the twelve interviewees felt that there was plenty of out-of-class help for this course.  Four individuals were asked specifically whether there was any out-of-class help they wished had been available that wasn't; all four answered "no."  One went on to say "People can't complain about not having enough help, unless it was just timing, because there were so many different opportunities."  Below is a summary of comments about each type of external help.

### CLUE sessions

Of the twelve individuals interviewed, seven indicated that they had attended at least one CLUE session. Two of these participants referred to themselves as "regulars," three said they had attended a "few" or "three or four times," and two said they had attended once or twice.  Of the individuals who said they had never attended these sessions, two indicated that it was difficult to get motivated to come back to campus in the evening, particularly considering that there was so much help available online.  A third pointed out that he would have gone if he had known they were led by the professor, but he was not aware of this fact until near the end of the term.

Four individuals mentioned the CLUE sessions when asked what was unique about the course (Question 3). One added, "I wish all teachers did [that] and you had the choice to go."  In terms of the actual CLUE experience, at least two participants thought it was an excellent time to make significant progress on the homework well before it was due.  Two others particularly appreciated having a chance to get to know their professor in an informal, relaxed atmosphere.  One individual's comments revealed how the sessions built strong relationships between teacher and student:

> *"He turned into someone, like a good helper, like an older brother that knows everything. He's like, 'Oh yeah, you just do this.'  So it was, like, completely helpful if you put the effort into it."*

At least three other participants had generally positive comments about the CLUE session saying they were "great" overall.

A few individuals felt the CLUE sessions could have been improved. Two people indicated that they wished the CLUE sessions had been later in the week, closer to when the homework was due. However, a third participant pointed out that she appreciated having the CLUE sessions has an external motivator to begin her homework earlier and not procrastinate.

One participant thought that the larger CLUE program should have more pre-engineering tutors available. The only other criticism was that if a student had a question about one of the last questions on the homework, she had to wait until the professor reached that question during the session.

### Engineering Advising and Student Center (EASC)

Two participants indicated they were regular patrons of the EASC tutorial sessions on Tuesday and Thursday afternoons. Two others commented they had been there two or three times.

One participant was very enthusiastic about this resource, saying that he had used it for other classes and really appreciated the help offered. One other participant said he went there and was happy to find someone working there whom he knew from freshmen orientation.

Three of the four individuals who commented on the EASC also pointed out that it was extremely crowded and that there should be a bigger room for the tutorial sessions. One individual pointed out, in particular, that the atmosphere seemed less friendly because students often fought for the TAs' attention and that the room was extremely noisy. She said she often had to wait "for like an hour" to get an answer to a question at the EASC. One participant proposed adding some additional tutors so that students could receive the help they needed in a timely manner

### Online Discussion Board

One aspect of the class that was discussed in the interview sessions was the online discussion board. This aspect of the Moodle system was mentioned spontaneously by two participants, and the interviewer explicitly asked an additional six individuals about the forum. All eight of these participants indicated they used the discussion board and seven of them indicated they found it very useful. Four of these individuals only read what other people had written, three had contributed once or twice and one interviewee was a regular contributor. According to these students, the discussion board was used primarily by students, though the TAs and professor would also occasionally contribute. Some of the students (5 of 8) mentioned that they had used a similar system in other classes.

The general consensus was that this online tool was used primarily to help students figure out the solutions to their homework problems, often the night before the assignments were due. From several individuals' comments, it appears that one advantage of the discussion board was that it represented a time-free forum for outside help. As one individual put it, there was "always someone there."

### Other Out-of-Class Help

Three students commented that they had attended the pre-exam review sessions held by the professor out of class. All three of these participants felt the sessions were extremely helpful, particularly in giving them an idea of what would be on the tests. One participant indicated that it was fairly unique for a class to have such a session.

**Appendix B: Detailed Findings from Student Interviews**

Two individuals indicated that their only regular source of out-of-class help was a group of friends who were all taking CEE 220. This group work was seen as considerably more convenient than the other sources of outside help and, for at least one participant, made studying for the class more enjoyable.

Few participants (2) mentioned going to either T.A. or instructor office hours as a source of outside help. One of these individuals commented on how available the TA's were for office hours by appointment if the scheduled times did not work.

One student made some extensive comments about the help she received from the Office of Minority Affairs' Instructional Center (IC). In particular, this student commented on the striking contrast in atmosphere between the IC and the EASC. She found the IC to be friendly and never crowded, whereas the EASC was just the opposite. She also commented that the style of the tutors at the IC was refreshing, that they would try and "think outside the box" if they were unsure about how to answer her question. While this interviewee admitted that it would be difficult to get the same tutor-to-student ratio in the EASC as in the IC, she thought that the engineering center might strive to model its tutorial sessions after those in the IC.

### Lab sessions

Finally, although the scheduled lab/quiz/tutorial sessions were not, technically out of class, six participants discussed the quality of the lab sections either in response to this question or at some point throughout the session. Three of these individuals had extremely high praise for the sessions and for the T.A.'s. One individual felt the sessions were not particularly helpful and could have been shorter, but did appreciate the CLUE sessions and other out-of-class help. Two participants (interviewed together) had mixed feelings about working in groups. In particular, one of their groups was split between individuals who were able to do the problems quickly and easily and others who were not quite as adept at the problems. This presented some challenges during the lab time.

### Question 7. Last term in CEE 220, there was an option to have a lab time at a different time than what was posted. Does that sound familiar to you? What did you think of that option?

All twelve of the interview participants were aware of this option, but none of them actually took advantage of it. One individual had a friend who attended an 8:30am session at 9:30am and stayed in the lab a little later. From the participant's perspective, this time shift was actually detrimental to the entire class's experience. The interviewee saw it as a distraction and also felt that his friend had a less-than-optimal experience at the later time.

Although none of the participants actually took advantage of the opportunity to have an alternate lab time, most of them (8 of 12) appreciated the fact that the opportunity was available. Two interviewees pointed out that the option had the potential to include individuals who otherwise would not be able to be in the class because of scheduling conflicts. One student also thought that if TA's were available during the alternate lab times, then one might receive additional, individualized help than during the normal lab times. However, another individual expressed some concern that the alternate lab times must have been inconvenient for TA's.

Two individuals did not think the alternate lab time was a good idea. One of these interviewees just personally preferred more consistency and structure; the second had received pressure from his group to change lab times to a slot that did not work well with his schedule. A third individual pointed out that keeping the original lab time should be an option.

Four individuals did not take advantage of the alternate lab time opportunity because they were satisfied with the original lab time. As one participant pointed out, "I picked the lab time for a reason. I didn't want to have it at a different time. Our whole group agreed." This individual went on to say that if she had been forced to register for the 8:30am time she might have felt differently.

For the most part, participants saw the benefits of the alternate lab times for students who got "stuck" with the 8:30am time. Three individuals said that their 8:30am groups wanted to find another time but simply could not find another slot that worked. When asked about what the benefits of the alternate lab time might be, two people commented that students might be able to switch out of the 8:30am lab time and thus be thinking more clearly during lab. However, one participant voiced the opinion that if you registered for the 8:30am time, "then so be it, it starts at 8:30am, you just gotta be there, and if you can't handle that . . . then I would say, 'then tough.'"

Throughout the sessions, five participants commented that preferred times for lab are during the day and not on "off hours," such as evenings or week-ends. As one individual put it, there is a six hour window between 9am and 3pm when all lab sessions should be scheduled.

The three participants who were interviewed together thought the alternate lab time idea was great, but that there was a fatal flaw in trying to get groups to agree on a time after groups had already been established. Two other participants made similar comments, one of whom thought it was "silly" to expect students to be able to find a time that could work together.

Participants provided several solutions to encourage students to take advantage of this option, all of which concerned offering the alternative earlier. Six individuals suggested having groups formed according to when students were available. One expanded this idea to suggest that students have access to class list on Moodle before the class started and arrange their groups and times by email up to one month before the class started. This individual also thought, however, that students should also be encouraged to work with students they did not know, an opinion echoed by one other interviewee. Another suggestion was to offer a lot of different lab times from the outset and simply allow students to register for the time that worked best for them.

Two individuals thought that the instructor had done everything that he could to encourage students to attend an alternate lab time and that there was no other way to do so. Two participants pointed out that there was no reason to encourage students to use an alternate lab time if the original times worked for them.

## Question 8. Any ways that the course could be improved?

In response to this question, five individuals responded that they could not think of any ways the course could be improved. All of these individuals went on to give positive feedback about the course in general. Two specifically identified the amount of work that the TA's and instructor put into the course.

**Appendix B: Detailed Findings from Student Interviews**

*"Mackenzie was an awesome professor . . . [pause]. He gave us tea! He gave us tea and coffee on our mid-term and our final, it was so nice. [Int: Really?] Yeah . . . you would just never think . . . especially when they have, like 300 kids . . . it's hard to think of them [the profs] as being warm and [that they] actually care about us. It's like, 'Yeah, we know you had a tough night, we know you were studying all of the past couple of days, here's some coffee.' It's like, 'Thanks. [laughing] You're nice.' It's like you're back in elementary again where the teacher cares about you."*

*"The amount of effort the TA's and instructor put into this course was superior [to] any other course I've had, so . . . I didn't have any problems I'd like to see solved."*

A third individual also praised the general format of the TA sections, particularly one session during which students calculated how large bolts on a lamppost would need to be to ensure safety.

Such hands-on examples were the topic of the strongest suggestion for improvement. Five students commented that the lectures could have contained more examples or sample problems and less theory. One individual used his Dynamics class (ME230) as a model for a lecture structure, with 25 minutes of theory with the rest of the time devoted to examples and sample problems. Another individual suggested that working through just one problem would be extremely helpful.

One interviewee had very specific ideas about the type of examples he would have liked to see in class:

*"Go through the derivation to a point, then say, 'Well, this is the conceptual of how it was -- how this equation was created, but in using this equation, we can check things. So . . .look at this room, there's the concrete ceiling, or whatever. How heavy is that? What do we need in order to make sure that these things work, because that's really what matters, that the things work. Then, let's do a couple of examples, maybe a few problems from the text, but let's also just check things, because we can."*

The remaining suggestions (each proposed by one interviewee, except where noted) were as follows:

- Faster server (2)
- Additional help/hints on the homework or a few comments at the top
- Standard day for homework and reading quizzes to be turned in
- Provide a course pack of the slides (at least hole punch)
- Different room
- Make labs more hands-on and visual, e.g., going to the Materials science lab
- CLUE session at a different time
- Take away Moodle (This comment might have been a joke, but this participant was not satisfied with the emphasis of online content.)

**Appendix B: Detailed Findings from Student Interviews**

**Question 9.  Imagine a CEE 220 class with twice the number of students as last quarter, but with still one instructor and two TA's.  What might you do to ensure that students in that class still learned the material and were satisfied with the course?**

*Difficulty with Question*

A few students struggled with this question and felt it would be difficult to maintain the quality of the course with twice the number of students.  One individual pointed out that the only thing that really mattered was how the professor presented the material, regardless of the number of students.

One individual thought that it would not really be necessary to make any changes to CEE 220 as taught in Winter 2005 with double the number of students:

> *"Honestly, I'm not quite sure that there is anything really that would change with the way the course was taught last quarter; because, like I said, Professor Mackenzie was very very involved, and the class itself was about 80 people, and in my Dynamics class right now, which is ME 230, they have about 140 people, so that's almost twice the size.  And it's pretty much the same thing, like, you know, we have a bigger room, but the teacher still has, like, the same office hours, and like, the same support through, you know, the different things that UW has.  And you're gonna get the same, probably 10 to 20 percent of kids that are really gonna work hard, like contacting, you know, getting extra help or need extra help.  And then, you know, the majority of the class is just going to be kids that do it on their own . . . You know, with any class, there would be the same distribution of grades.  I think kids on the whole would be satisfied the same because they're not going to get any lower grade.  The course is still taught that you go to lecture, learn concepts, do homework, and pass your class."*

*Changes to lab*

Four of the interviewees specifically pointed out that doubling the number of students would not be a problem at all in lecture, but that it would pose a problem for the lab sections.  A fifth individual did point out that students might feel more intimidated to speak up and ask questions in the larger lab section, but did not have a specific suggestion for how to overcome this hurdle.

Six individuals suggested increasing the number of lab sections so as to maintain the small size.  In particular, one participant, when asked what size the sections should be, responded that 20 was ideal, 25 was realistic, and 30 was maximum. One of these participants also pointed out that it might not be possible to have this large number of sections without more T.A.'s, and another suggested including the professor as a lab instructor.  A seventh participant thought that the structure of the lab sessions might be changed so as to include a much larger number of students.

As far as the structure and timing of the labs, one individual thought spreading them out across more than one day might be beneficial to students.  However, another participant proposed a model used in another engineering course (ME 230: Kinematics and Dynamics) in which labs occurred in a non-regular schedule throughout an entire day each week:

*"Thursdays is our day of section. With our two TA's, and we have a pretty big dynamics class – yeah, actually, that's a good example . . . both TA's would be there the first hour, for the general, um, like, whatever we have to do for the tutorial. And then the second hour, one TA leaves, 'cause he'll have his offers hours and the other T.A. will be with our section. And then this will go on throughout the whole day, where every hour, there'll be a TA for the whole day Thursday. So it's nice to have, like availability, like one whole day, because everyone can generally make, it's just, like the time. So, maybe it's like this big window of time when you could come to a TA, and just get your help. And generally like, maybe two days before, or a day before the homework's due."*

### Out-of-Class Help

Several ideas about how to accommodate a large number of students included increasing the amount of out-of-class help. Five individuals had ideas along these lines; specific suggestions were as follows (each proposed by one student except where noted):

- Hold additional office hours (2)
- Have a tutor (either at the EASC or CLUE) specifically dedicated to CEE 220
- Hold an additional CLUE session or sessions
- Have paid undergraduate helpers available for questions
- Additional study options provided by the College of Engineering, including a larger study center
- Encourage students to use the outside help that exists

Two students' comments included the idea of having students form study groups that would be overseen by the TA's and, perhaps, the professor:

*"If you could get, like, study groups together – outside study group – to have students come together and discuss concepts we went over in class, or homework problems, or labs. More of that type of work would be helpful and then having, like, a T.A. or professor check up on each study group every so often. Like breaking it up into smaller groups, I think that might be helpful to downplay the giant, the large class size."*

### Additional Ideas

Four students had additional ideas for accommodating twice the number of students in CEE 220; these comments were as follows (each proposed by one student except where noted):

- Bigger lecture hall (2)
- Increase the amount of online grading
- Include more out-of-class quizzing for small amount of credit
- Videotape lectures for students who cannot come
- Include "clicker questions" in class: brief multiple choice quiz questions for which students can transmit their responses immediately so as to keep tabs on the class' progress and involve students more in the class.

Finally, one student made several comments in response to this question about his personal philosophy of how courses should be run. This individual did not appreciate the course and was not a supporter of the online Moodle system. First, this interviewee felt that it should not matter whether students were

satisfied with the course, as long as they learned the material.  He proposed teaching using a variety of methods, with a mix of theory and practice presented in class.  From his perspective, hand-written homeworks were fine and it did not matter if all the problems were graded.  Similarly, he felt that almost-immediate turn-around of the exams was also not necessary (and hence should not be a concern in the number of students were doubled).  Finally, he proposed reducing the amount of web content and rewarding those students who actually attended class by giving them additional information during class that was not available elsewhere.

## Any Additional Comments?

At the end of the interview, participants were asked if they had any additional comments about the course that they had not already stated.  Three participants had no further comments.  Six individuals had generally positive comments about the class.  One of these six respondents pointed out specifically that he appreciated the professor.  A seventh respondent pointed out that he thought the professor was "a nice guy" and "very understanding," but that he did not like the course (Note:  this was the same participant who expressed strong opinions about the course and the Moodle system throughout the session, including Questions 2, 3, and 9).

Two interviewees concluded the session by pointing out that they enjoyed the online web interface, and one went on to comment on the benefits of the Moodle calendar in particular.  The three participants who were interviewed together all commented again that the in-class content was too theory-heavy and could have benefited from additional examples.  Three participants commented on the professor's use of the PowerPoint slides.  One thought they were extremely useful, though two had reservations that the slides allowed students to take fewer notes than they might have otherwise and that the slides increased the pace of the lecture so that it was not possible to keep up with the content.

Two students commented on the extra help available in the class.  One re-emphasized that he was impressed with the amount that was available and the other though students in the future should be strongly encouraged to take advantage of the help that was provided.

# APPENDIX C:  DETAILED FINDINGS FROM THE COURSE EVALUATIONS

This appendix contains descriptive statistics for each of the items in the course evaluations from CEE 220 in Winter 2004 and Winter 2005.  The same instructor taught both courses, so the comparison is appropriate.  For additional synthesis and interpretation, please see the Results section of the main report:

## Scannable Form

### Section 1

Participants responded on a six-point scale from Very Poor (0) to Excellent (5) to four items about the course as a whole:

**Figure C1:  Participants mean ratings on Questions 1 – 4 in 2004 and 2005**
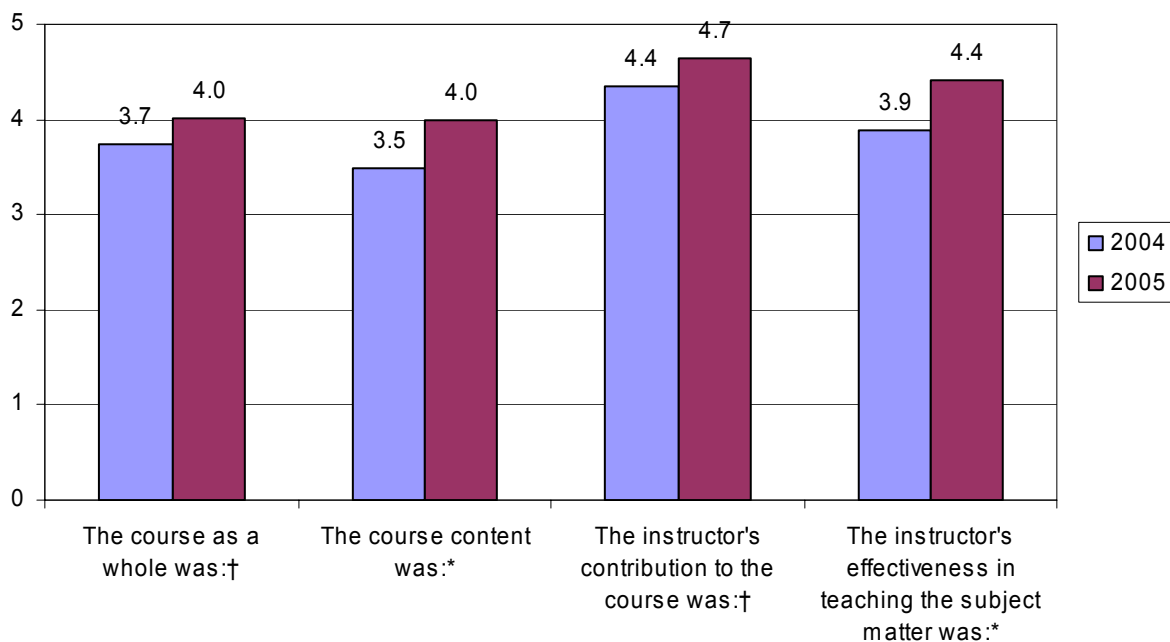


† Indicates a difference that reaches the alpha criterion of .05 or lower.

* Indicates statistical significance, $p$ < .01 level.  Because of the number of comparisons being made, the alpha criterion for significance was lowered to .01 to correct for family-wise error rate.

Participants responded on a seven-point scale from Never (1) to Always (7) about how frequently a set of statements were true about the course

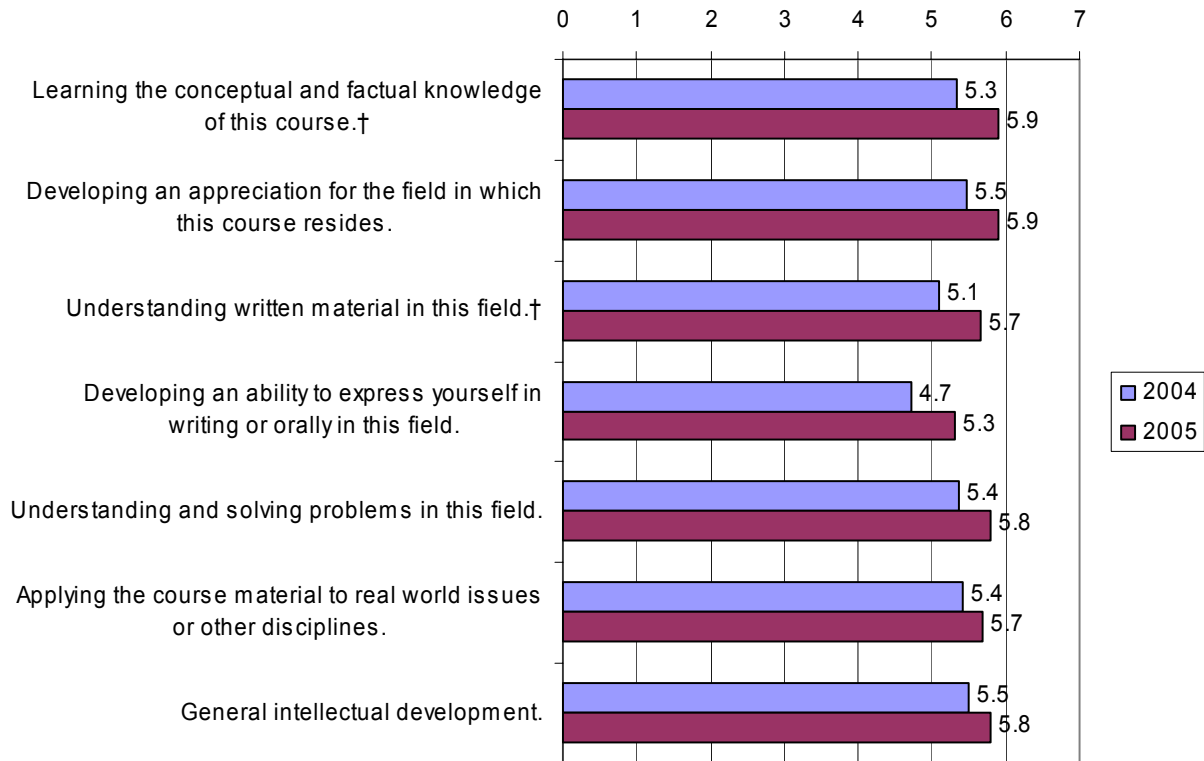**Figure C2:  Participants mean ratings on Questions 5 - 15 in 2004 and 2005**

**Appendix C:  Detailed Findings from Course Evaluations**
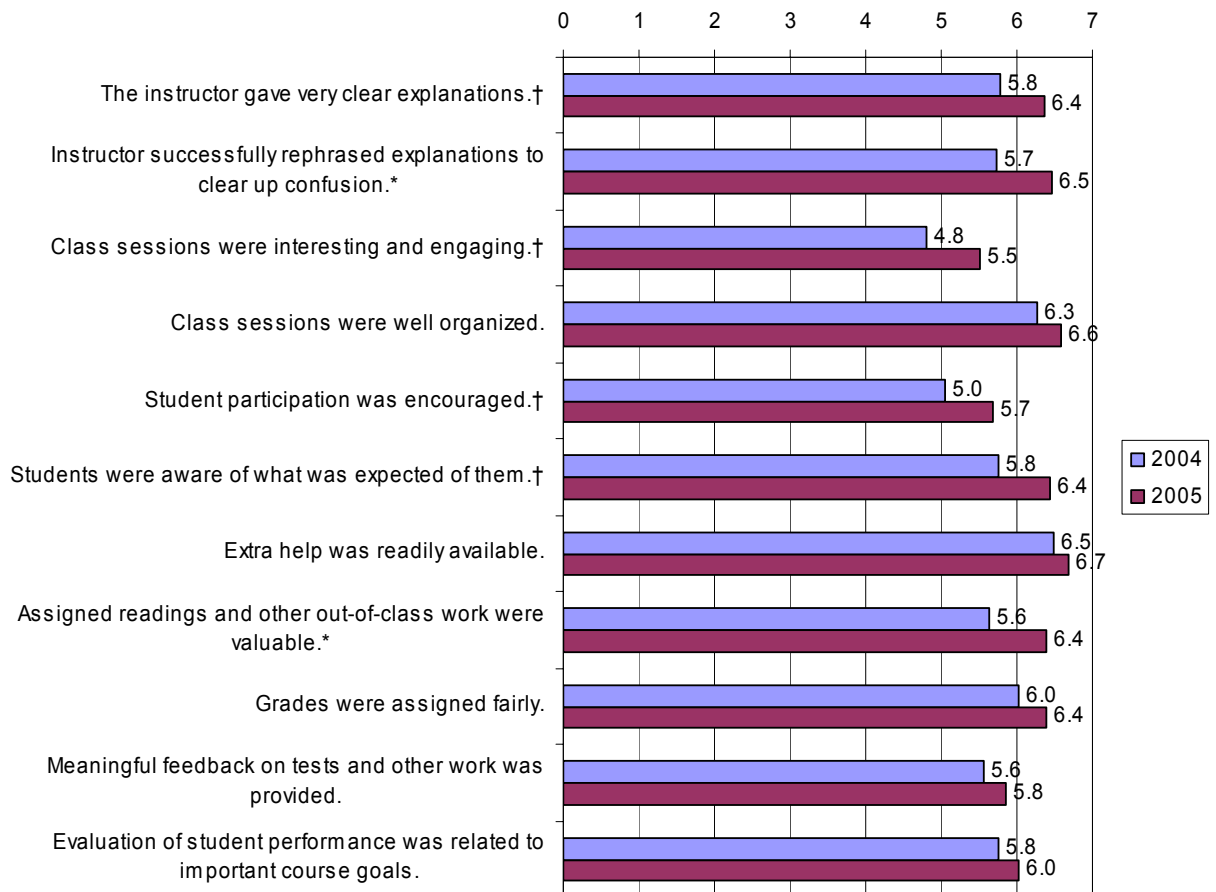
*Section 3*

Participants were asked about the course in relation to other courses they have taken.  They responded to seven items about their progress in several areas using a seven-point scale from None (1) to Great (7)

**Figure C3:  Participants mean ratings on Questions 16 - 22 in 2004 and 2005**

**Appendix C:  Detailed Findings from Course Evaluations**

*Section 4*

In this set of five items, participants rated several aspects of this course in relation to other courses they've taken on a seven-point scale from Much Lower (1) to Much Higher (7).

**Figure C4:  Participants mean ratings on Questions 23 - 27 in 2004 and 2005**
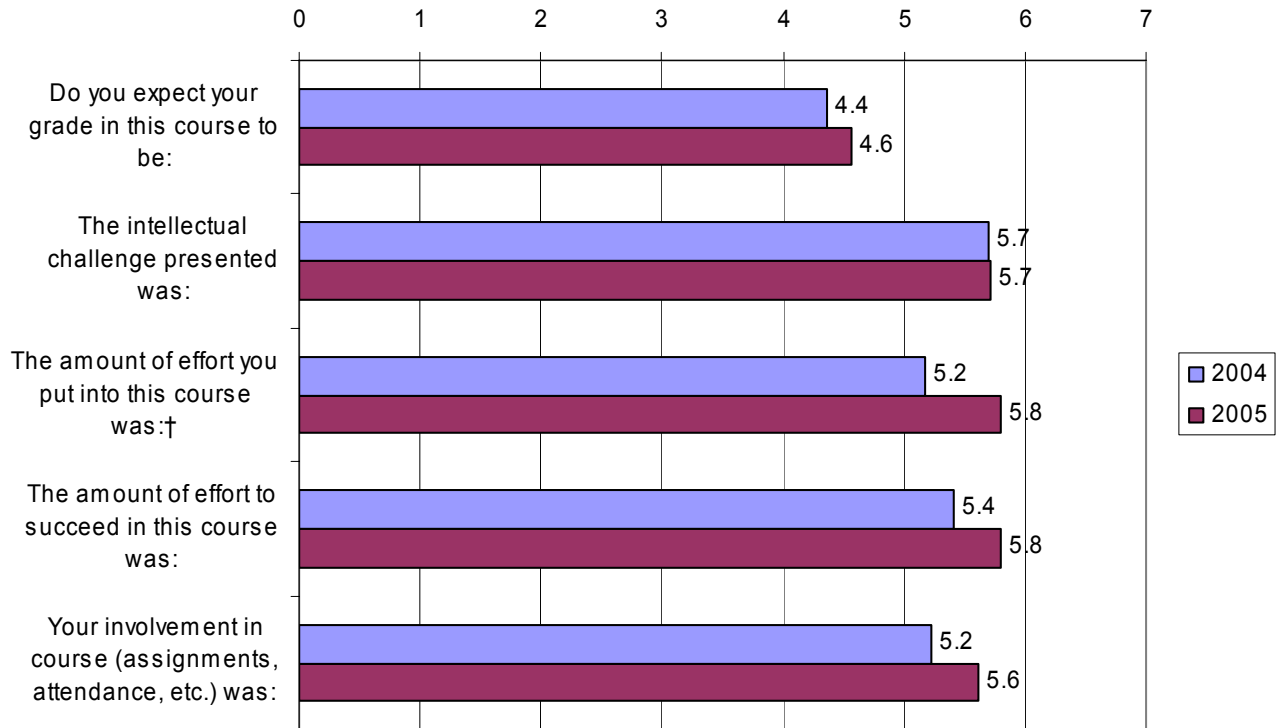


*Hours in Class*

In the following two questions, participants indicated how many hours peer week they had spent on the course and the number of hours they found valuable.  The figure below shows the mean number of hours participants found valuable

**Appendix C:  Detailed Findings from Course Evaluations**

**Figure C5: Participants responses to questions about hours per week spent working on class and number of hours that were valuable.**
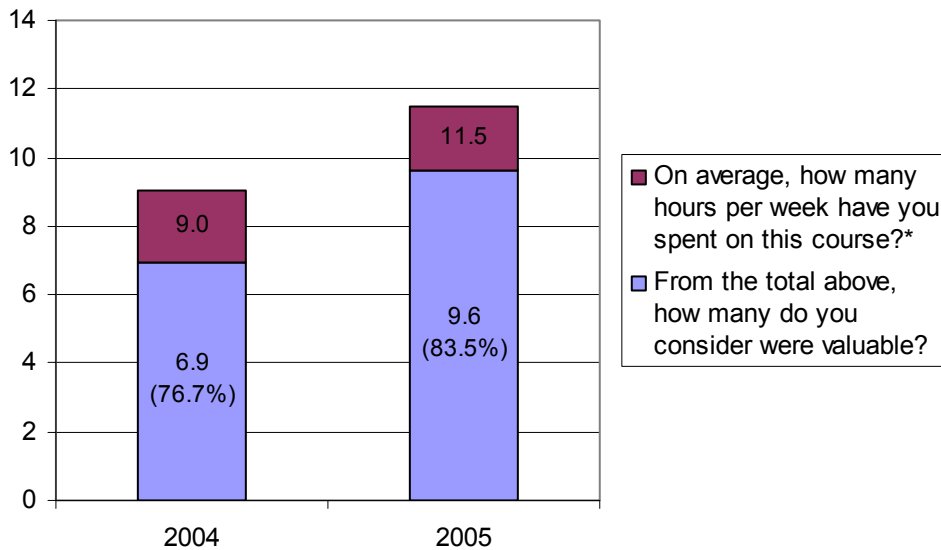


*Estimated Grade*

On the evaluation form, participants were asked to estimate their grade in the course. Figure C6 shows a comparison between their average estimated grade and the actual average grade in the courses in 2004 and 2005. Looking at these averages, participants appeared to be fairly accurate in their grade estimation, though the estimates were slightly higher than the actual grades. This difference was most likely due to the sample and not the inaccuracy of estimation.
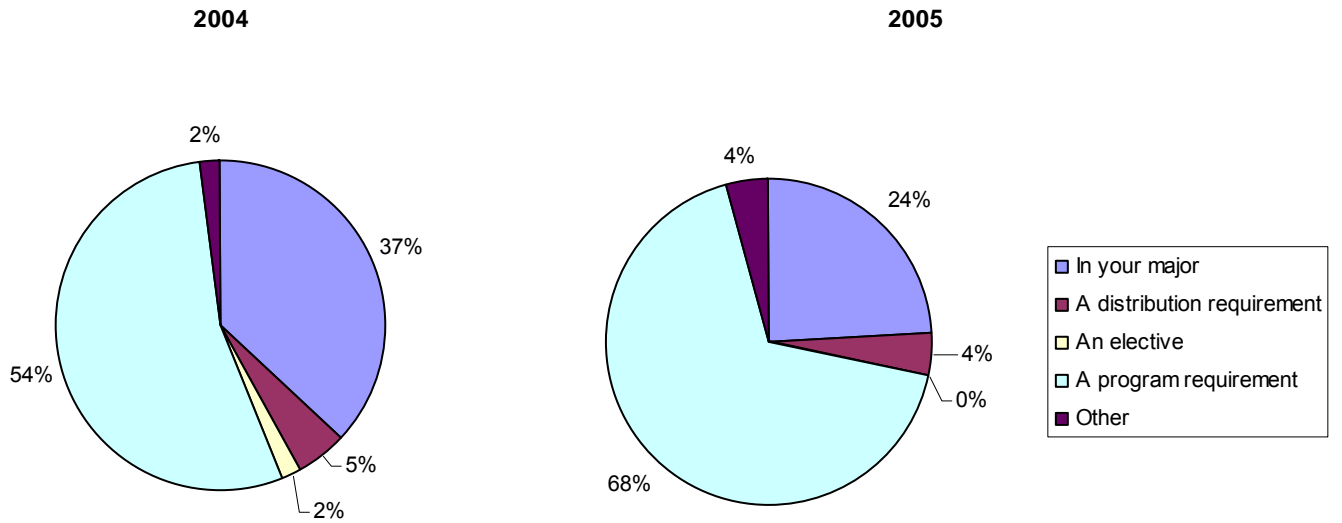
**Figure C6: Participants mean estimated and actual final grades in 2004 and 2005**

**Appendix C: Detailed Findings from Course Evaluations**
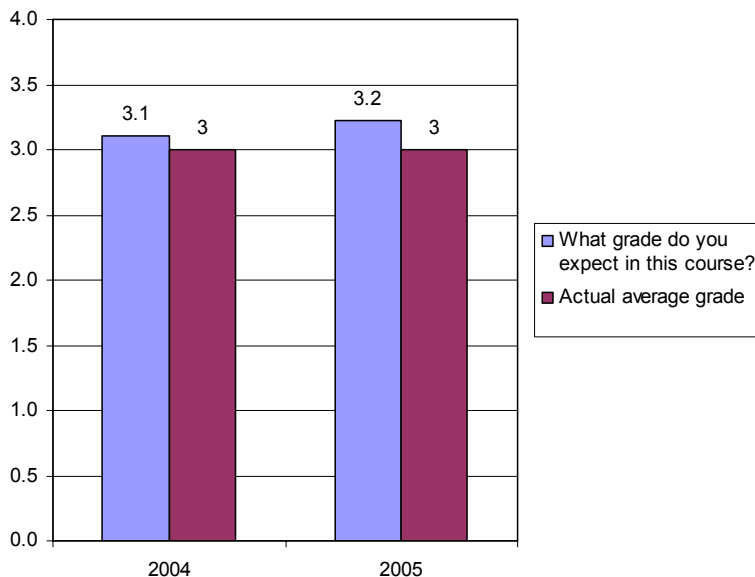
### *Course Fit*

In this question, participants were asked how CEE 220 fit into their academic planning.  They indicated how they would best describe the course: Figure C7 summarizes their responses

**Figure C7:  Frequency of different types of responses to Question 31 according to year**

**2004**

**2005**



Legend:
- In your major
- A distribution requirement
- An elective
- A program requirement
- Other

**Appendix C:  Detailed Findings from Course Evaluations**

## *ABET items*

This set of 11 items, presented on the back of the scannable form, were intended to assess this course according to baccalaureate program outcomes set out by ABET (Accreditation Board of Engineering and Technology).  Students rated the Responses from 2004 and 2005 and presented in Figure C8.

**Figure C8:  Mean ratings on ABET items in 2004 and 2005**
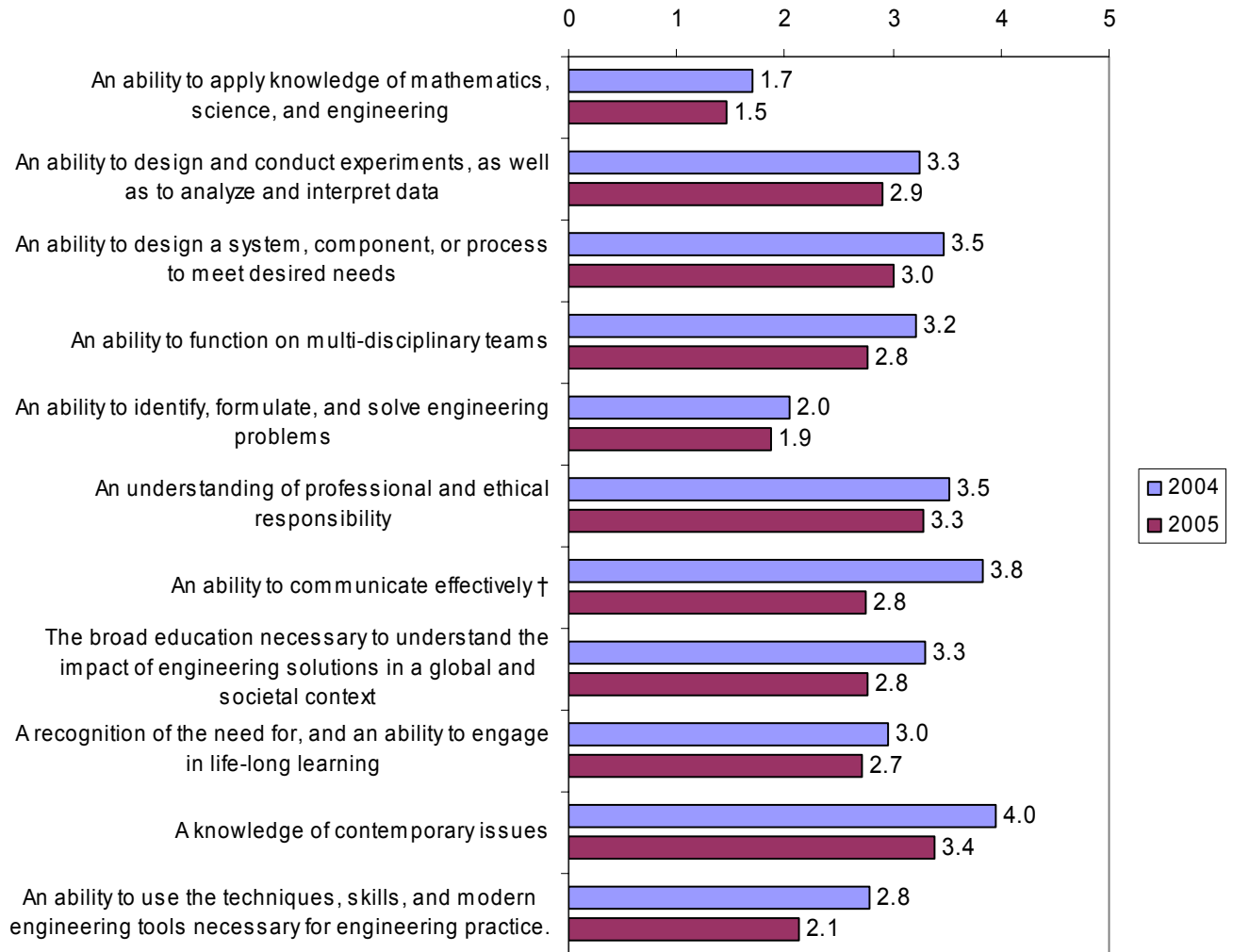


Note that although all mean ratings were higher in 2004 than 2005, none of these differences was statistically significant.

**Appendix C:  Detailed Findings from Course Evaluations**

## Open-Ended Comment Sheets

The first item on the open-ended comments sheet is actually a forced-choice question (yes or no), asking students if the course was intellectually stimulating: "Did it stretch your thinking?" In 2004, 37 of the 42 participants (88%) who submitted forms answered this question, and all but two of these participants responded "Yes." In 2005, 44 of the 47 students who made comments on their sheets (93.6%) answered their questions, and all of them answered, "Yes."

This forced-choice question was followed by the open-ended question "Why or Why not?" Participants responses to these items were categorized according to major theme. Results are presented in Figure C9.

**Figure C9: Responses to open-ended question #1: Why or why not was this class intellectually stimulating, according to year**
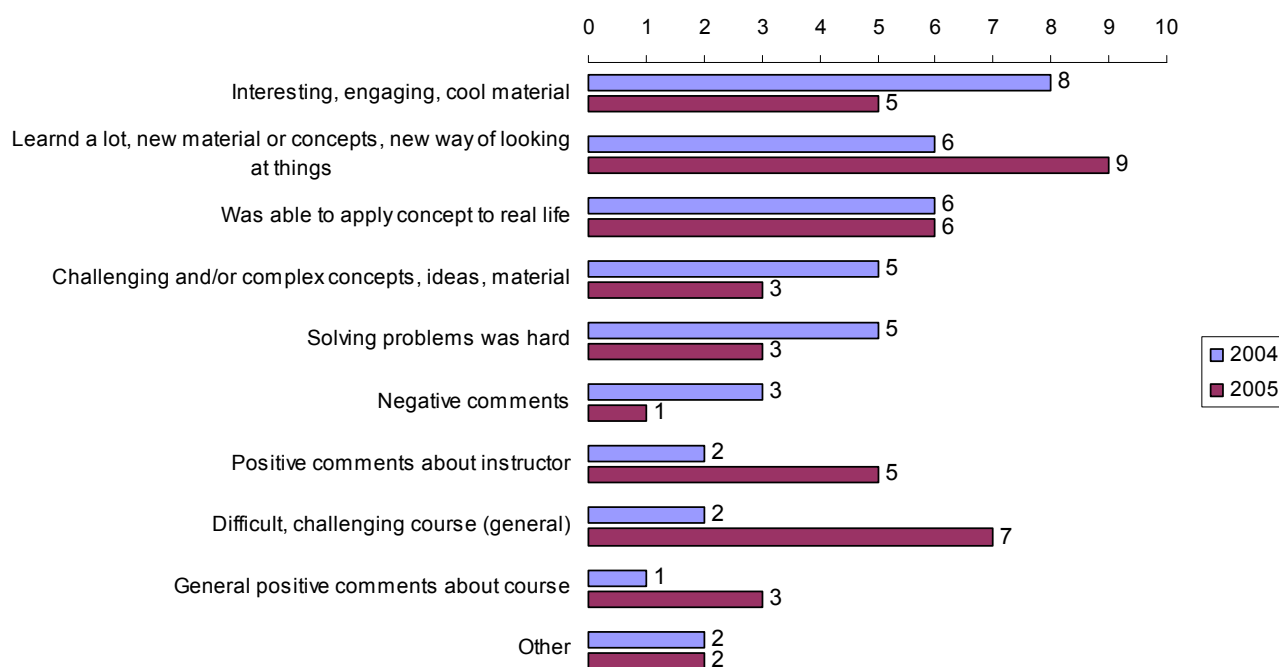


The remaining three questions on the open-ended comment sheet asked participants (Question 2) what aspect of the class contributed most to their learning; (Question 3) what aspects of the class detracted from their learning; and (Question 4) what suggestions they had to improve the class. Figures C10 and C11 summarize participants' responses to Question 2 and 3. A list of suggestions from 2005 is presented after these figures. Suggestions from 2004 were not included here because most of them were no longer relevant (had already been changed or did not apply to the new version of the course.

**Figure C10:  Responses to open-ended question #2:  What aspects of this class contributed most to your learning?**
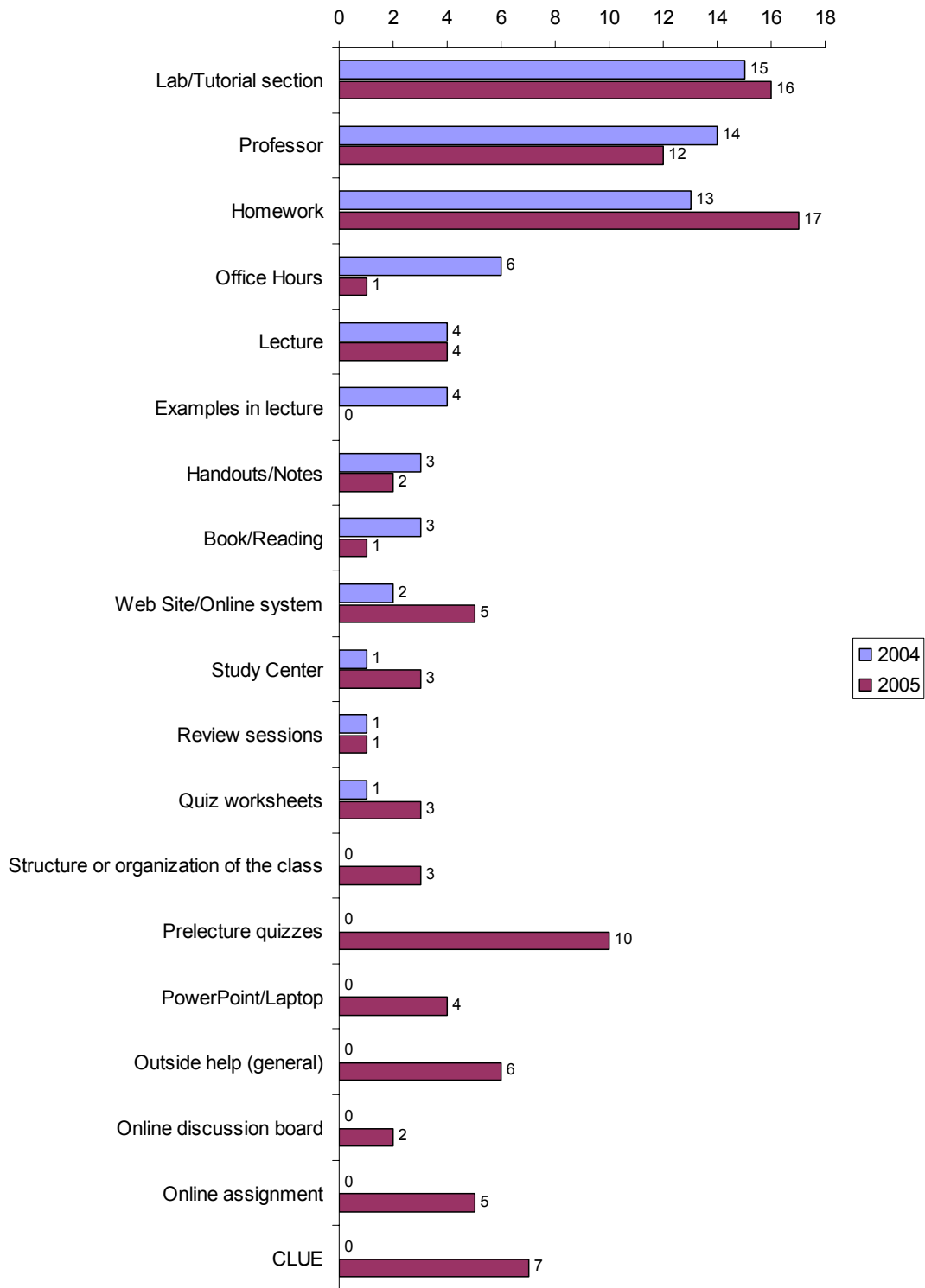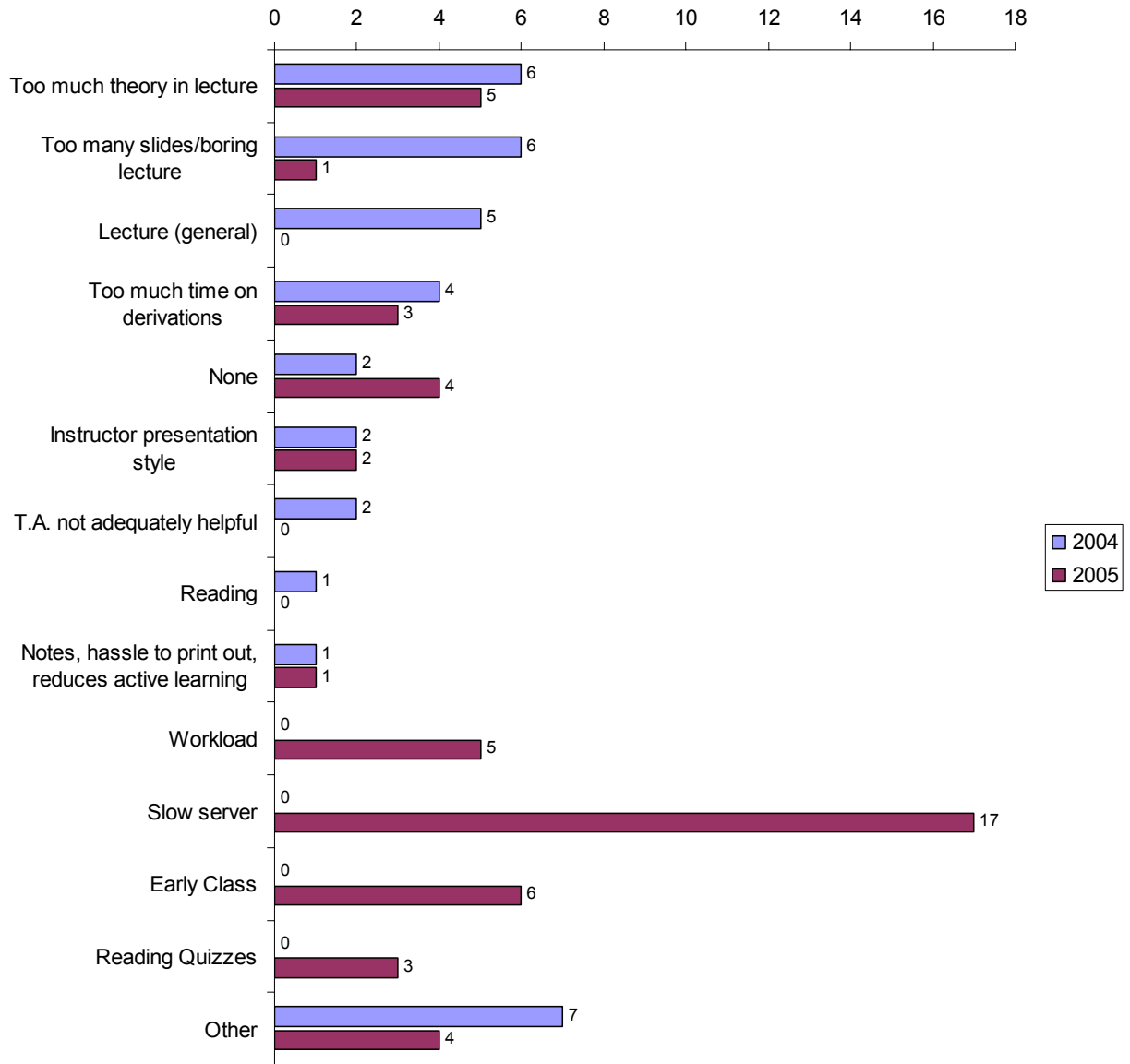
**Appendix C:  Detailed Findings from Course Evaluations**

**Figure C11: Responses to open-ended question #3: What aspects of this class detracted from your learning?**



| | 2004 | 2005 |
|---|---|---|
| Too much theory in lecture | 6 | 5 |
| Too many slides/boring lecture | 6 | 1 |
| Lecture (general) | 5 | 0 |
| Too much time on derivations | 4 | 3 |
| None | 2 | 4 |
| Instructor presentation style | 2 | 2 |
| T.A. not adequately helpful | 2 | 0 |
| Reading | 1 | 0 |
| Notes, hassle to print out, reduces active learning | 1 | 1 |
| Workload | 0 | 5 |
| Slow server | 0 | 17 |
| Early Class | 0 | 6 |
| Reading Quizzes | 0 | 3 |
| Other | 7 | 4 |

**Appendix C: Detailed Findings from Course Evaluations**

**Suggestions from 2005 Comment Sheets**

- None/Positive Comments (6)
- Faster server (22)
- Online quiz suggestions (8)
    - More hints on homework (2)
    - Standard due dates for reading assignment quizzes (2)
    - Reading quizzes, keep answers
    - Get rid of reading assignment quizzes
    - Provide all online quizzes, but only require a few
    - Make quizzes more difficult
- Less theory/More examples (8)
- Course pack instead of printing notes out day to day, at least hole punch (2)
- No long homework assignments right before exams (2)
- Later time
- More options for review sessions
- Fewer chapters in one quarter
- Recommend some class participation during lecture

**Appendix C: Detailed Findings from Course Evaluations**