Active Learning and Increased Faculty Involvement to Improve Design Instruction and Retention in a First-Year Introductory Engineering Design Course

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Abstract **- We are implementing a strategy to improve students' ability to understand and apply fundamental design methodology techniques introduced in our introductory Mechanical Engineering course, taken during the first fall semester of the ME program. In this course, students learn design methodology, mechanical hardware, physics and modeling concepts in lecture, and then apply those concepts to a team-based design project that culminates with an end-of-semester design competition. Based on our assessment of students both in this course and in the follow-on spring semester course, we are concerned that students struggle with basic design methodology concepts despite our efforts to utilize active learning and project-based learning strategies in both courses. In Fall 2012, we attempted to address this issue by (1) increasing the time spent on project-related active learning activities during lecture and (2) implementing an "Adopt-a-Lab" program in which additional ME faculty join individual lab sections to provide design feedback at critical points during the semester. We expected that this twofold strategy would help to improve both student comprehension of design concepts and the quality of design project assignments (DPAs) submitted by student teams [1]. We also anticipated that the increased faculty involvement would improve retention from the first semester to the second semester of the ME program [1]-[3]. With the help of nine volunteer faculty members, we piloted our strategy during the Fall 2012 semester. This paper presents our motivation, strategy, implementation, assessment, and future plans.**

Index Terms – Active learning, Faculty involvement, Feedback and revision, Freshman design, Retention.

INTRODUCTION

In our introductory Mechanical Engineering course, taken fall semester of the freshman year, ME students learn the basics of design methodology, mechanical hardware, physics, and modeling concepts during course lectures. They then apply these concepts to a team-based design project that culminates with an end-of-semester design competition. Based on our assessment of students both in this course and in the follow-on course (taken spring semester of the freshman year), we are concerned that students struggle with basic design methodology concepts despite our efforts to utilize active learning and project-based learning strategies in both courses [4]-[6].

Part of the difficulty in effectively teaching this material is that the design process is abstract with no "right" answers, making it very difficult for freshmen engineering students who are used to more "black and white" math and physics concepts. In the last two years, the enrollment in our introductory course has grown to 180+ students. The large numbers in combination with scarce resources for graders and teaching assistants make it challenging to provide both adequate feedback to design teams and fast enough turn-around to positively impact subsequent assignments. Historically, we have been able to provide only one or the other, and thus we are addressing these difficulties by (1) increasing the time spent on project-related active learning activities during lecture and (2) implementing an "Adopt-a-Lab" program in which additional ME faculty join individual lab sections to provide design feedback at critical points during the semester.

We have previously implemented video lectures (assigned as pre-lecture preparation) and active learning activities during lecture to improve our design instruction [4]. For Fall 2012, we revised the active learning activities to make them more directly relevant to the design project. For example, instead of developing a project statement for a better mousetrap, the students spent time in class developing the project statement for their competition designs. In addition, we coordinated the active learning activities with the Adopt-a-Lab faculty visits such that the students prepared for their in-lab team meetings during a preceding lecture. We expected the direct relevance to the design project (and associated graded assignments) to motivate student preparation, participation and learning. The project-based activities also allowed us to provide feedback, albeit in a large group setting, on design outputs before the corresponding project assignment was due.

The primary goal of the in-lab faculty interactions was to provide individualized design feedback prior to project assignment due dates. We expected that this would motivate students to learn from the feedback, which does not happen when feedback is provided post-submission with no opportunity for revision. In past years we have had difficulty providing feedback that is both adequate and timely even post-submission due to the large class size. We also expected that the individualized feedback would improve students' understanding of design concepts and the quality of the submitted design work, both in the introductory class and in future design classes.

In addition to individualized design feedback, the Adopt-a-Lab strategy also provides first-year ME students with valuable "face time" with a faculty member, which is expected to have a significant positive impact on retention in the program. Many studies have shown that faculty/student mentoring programs improve students' academic performance and retention [1]-[3] and that students are more likely to stay in a major if they feel like one of their professors knows them. Although our introductory design class is typically co-taught (two instructors), we have found it difficult to get to know the names of 180+ students during the course of the semester. In the smaller lab setting, we expect that the Adopt-a-Lab faculty will get to know their group of 20-24 students reasonably well, and these relationships will be strengthened when these students take a class from them in future semesters.

Detailed Strategy

The detailed strategy for our Fall 2012 pilot program was as follows: (1) Cover key learning objectives using interactive lectures (existing strategy); (2) Utilize lecture time to help students apply design concepts to their team design project; (3) Provide informed and personal faculty feedback on a key piece of each team's Design Project Assignment (DPA) before the assignment is submitted for grading; (4) Allow student design teams to constructively apply faculty feedback by providing time to make improvements before the assignment is submitted. This work flow is illustrated in Figure 1, and described in more detail below.

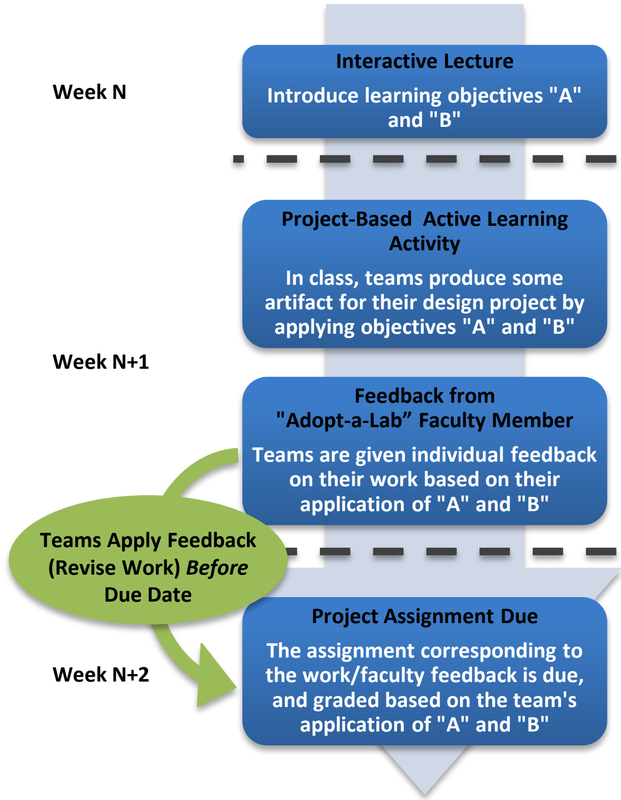

FIGURE 1
CHRONOLOGICAL FLOW OF THE LECTURE/ACTIVITY/FEEDBACK/ASSIGNMENT STRATEGY.

I. Interactive Lectures

Student Response System ("clicker") quizzes, worth 10% of the overall course grade, are given at the start of each class. The quizzes cover material from the previous lecture and from the assigned pre-lecture reading and/or video lecture. In addition, lecture-related clicker questions, worth participation points regardless of the student's answer, are posed throughout lecture. These "participation questions" help to keep the large class of students engaged and allow students to self-assess their understanding of the learning objectives [4], [7]. Additional active learning strategies are utilized as often as possible and appropriate in order to keep students involved and engaged, thereby promoting student comprehension [4].

II. Project-Based Active Learning Activities

Students are grouped into their assigned design teams at the start of lecture, and a portion of the lecture time is dedicated to a cooperative team-based active learning activity. The activity is designed to both reinforce learning objectives and help student teams complete a portion of a required team-based project assignment during the lecture period.

During the active learning activity, student teams are loosely guided through the process of applying lecture concepts to their design project. As a team, they produce a rough version of a document or artifact (e.g, objectives tree or decision matrix) that they will turn in as part of a DPA the following week. After each section of the in-class activity is explained, the course instructor(s) and teaching assistant(s) disperse throughout the classroom while students work on that section of the activity. This provides student teams with the opportunity to ask questions about design methodology concepts or DPA/project requirements, and gives them access to feedback as they work. Students are instructed to bring the resulting document or artifact with them to their next laboratory period (typically the same week) for faculty feedback.

III. Faculty Feedback

Prior to each lab visit, the volunteer Adopt-a-Lab faculty members are provided with a "Lab Visit Overview" document that details (1) what document/artifact the teams are expected to bring to lab, and (2) specific evaluation criteria that should be used to provide feedback. The intentionally brief overview documents were designed to sufficiently prepare the faculty volunteers to provide feedback with no prior understanding of the course, specific design concepts, or the design project itself. Evaluation criteria were included to help the faculty members provide feedback that was both accurate relative to the intended student understanding of the learning objectives and uniform across different lab sections.

Volunteer Adopt-a-Lab faculty members visit their assigned lab sections at key points throughout the semester. The faculty members work with individual teams for about 10 minutes each, providing feedback on each team's work based on the provided Lab Visit Overview document. This strategy allows us to provide face-to-face feedback from a faculty mentor one week before the assignment is due rather than as an impersonal annotation on the document one to two weeks after it has been submitted.

IV. Revision of Assignments

After receiving faculty feedback, student teams typically have one week to revise and improve their work before the corresponding DPA is due. This timing provides an opportunity for the students to learn from their mistakes, improve their understanding of the learning objective(s), and improve their work prior to being graded. Teams that opt to utilize faculty feedback constructively to improve the quality of their submitted work are presumably rewarded with a higher grade on the assignment.

IMPLEMENTATION OF PILOT PROGRAM

One major challenge in implementing this strategy was the coordination of lecture topics and activities, lab visit schedules, and project assignment due dates. In addition, we needed to restructure many of the course lectures in order to free up time during lecture for teams to work on DPA-related tasks. Since we had previously implemented active learning strategies, in many cases we simply replaced an existing activity with a revised activity that covered the same learning objective(s) but allowed teams to start working on a piece of a design project assignment. In our first iteration of restructured lectures and revised and new project-based active learning activities, the activities tended to be rushed. In future semesters, we plan to address this by "flipping" even more of the lecture content to pre-lecture preparation (e.g., in the form of video lectures).

Another challenge was getting the most benefit from the least amount of faculty time, since the participating faculty assumed this role as a voluntary addition to normal teaching and research responsibilities. In our Fall 2012 pilot, each Adopt-a-Lab faculty member committed to nine one-hour-long lab visits throughout the 16-week semester. With five or six teams per lab section, the faculty member was able to spend about 10 minutes with each team during each visit. In order to streamline the faculty preparation for each visit, we created a website with various faculty resources, including a "Semester Overview" describing the date and purpose of each lab visit and the "Lab Visit Overview" document for each lab visit. As discussed above, the overview documents detailed what should be expected from the students, the key learning objectives that should be emphasized, and the criteria for providing feedback. Additionally, the faculty participants were sent a reminder email prior to each scheduled lab visit.

We assessed the effectiveness of the in-class activities and Adopt-a-Lab visits by surveying both students and participating faculty, and by comparing the quality of submitted project assignments and performance on relevant final exam questions to quality and performance in the previous offering of the course. We also assessed the impact on retention by comparing the number of Fall 2012 ME EN 1000 students who continued on to ME EN 1010 in Spring 2013 to retention numbers for previous semesters. Our assessment results are discussed in detail in the following sections.

SURVEY RESULTS AND GENERAL FEEDBACK

At the end of the Fall 2012 semester, we administered surveys to help us understand the general consensus and perception of the program from the point of view of both the students and the participating faculty members. We also hoped to gain an understanding of what worked well for the students and faculty, and what changes could be made to improve the program in the future.

I. Student Survey Results

Students were asked to complete an optional course survey for extra credit, and 125 (of 184 enrolled students) chose to do so. In order to obtain quantifiable survey results, the survey consisted mostly of statements (rather than questions), and students were asked to rate their level of agreement with each statement on a five-point scale, where 5 = Strongly Agree and 1 = Strongly Disagree (Table 1). All of the statements with the exception of statement 2 were phrased in such a way that a large rating value indicated student satisfaction with the program. One question was a multiple-choice format that involved a statement with a "blank" for the students to complete (Figure 2). Finally, two questions were formatted as an open response, allowing students to elaborate on their quantitative answers. In order to evaluate 125 varying student comments/responses, each response was reduced to its crucial statement(s), and the most common student statements were identified. The results of this reduction are shown in Table 2.

Overall, the student ratings for this pilot program were neutral to positive, with the average rating for statements 1 and 3-9 falling somewhere between "Neutral (3)" and "Agree (4)" (Table 1). These ratings suggest that students generally had fairly positive feelings about the pilot program's impact on their educational experience. The average rating of 3.20 for statement 2 ("After the in-class DPA-related activities, my team had to redo that same work outside of class") seems to indicate that students were unable to produce quality documents or artifacts during class. This could be the case since the activities tended to be rushed, and also because some students seem resistant to working productively during class. On the other hand, we were expecting the students to revise (although hopefully not entirely redo) their work based on faculty feedback, so some students may have interpreted the question in this way, which would flip the statement back to the positive. Interestingly, the highest average student rating was for statement 9 ("The faculty lab visits should be continued next fall in ME EN 1000"). This suggests that the students found the program valuable, but with room for improvement (as suggested by the lower ratings on the other more specific statements).

TABLE I
END OF SEMESTER STUDENT RATING SURVEY RESULTS

	Survey Statement	Average Student Rating (± Std Dev)
1	The in-class DPA-related activities saved my team time outside of class.	3.49 (± 1.10)
2	After the in-class DPA-related activities, my team had to redo that same work outside of class.	3.20 (± 1.06)
3	Getting DPA-related faculty feedback in my lab was valuable.	3.45 (± 1.02)
4	The faculty feedback from lab improved the quality of the work that my team submitted for the corresponding DPAs.	3.35 (± 0.97)
5	The visiting faculty member provided feedback that helped improve my team's final design.	3.35 (± 1.09)
6	Working on some components of the DPA in-class, then getting feedback on these components in lab helped my team get a jump-start on the corresponding DPA.	3.37 (± 0.94)
7	I enjoyed getting to know the faculty member who visited my lab.	3.72 (± 0.90)
8	My interactions with the faculty member who visited my lab have given me a greater sense of belonging in the ME program.	3.39 (± 1.10)
9	The faculty lab visits should be continued next fall in ME EN 1000.	3.94 (± 0.92)

From Figure 2, the majority (75%) of students felt that ME EN 1000 would be better with "more" or "the same number of" in-class DPA-related activities (i.e., those developed for the "Adopt-a-Lab" pilot program). Less than 8% indicated that they wished that no such activities were included in lectures.

The students provided good suggestions for improving the in-class DPA-related activities, including allowing more time for the activities (which we have already mentioned) and providing more information pre-lecture to help students prepare. The responses requesting clearer expectations are a bit surprising, since we already provide the students with checklists and rubrics for each assignment. We do plan to increase the number of examples provided, either via the

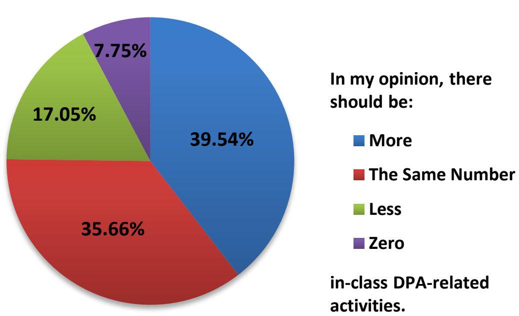

FIGURE 2
STUDENT OPINION ON NUMBER OF IN-CLASS ACTIVITIES.

pre-lecture preparation or during lecture. Although the questions were written to solicit suggestions for improvements, some of the comments indicated that the activities were already beneficial and saved time outside of class.

Student comments about faculty feedback indicated that either our brief overview documents were insufficient to prepare the faculty participants for the lab visits, or that perhaps the faculty participants were not taking the time to read these documents. Some students felt that the faculty were too harsh, which perhaps is not surprising considering that only two of the nine participating faculty have experience teaching and interacting with freshmen. This is something we would certainly address with faculty in future iterations of the program. Finally, the students who requested longer lab visits presumably found the visits and feedback to be valuable.

TABLE II
STUDENT RESPONSES FOR OPEN RESPONSE SURVEY QUESTIONS

	Question	Most Common Responses
1	What changes would make the in-class DPA-related activities more valuable?	• Provide more time for teams to work on each portion of the activity (too rushed) • The activities were good as-is/provided good direction to teams/saved students time outside of class • Post templates or outline of activity online before class to give students time to prepare
2	What changes would make the DPA-related faculty feedback more valuable?	• Faculty member should be more familiar with the topics that they are providing feedback on (didn't seem well-informed) • Provide more constructive feedback (and guidance on improving work) and less harsh criticism (entry-level students) • Make the lab visits longer, they seemed too rushed

II. "Adopt-a-Lab" Faculty Volunteer Survey Results

The faculty survey also consisted of statements (rather than questions), and faculty members were asked to rate their level of agreement with each statement on a five-point scale (Table 3). Five of the nine participating faculty members completed the survey. All of the statements with the exception of statement 6 were phrased in such a way that higher ratings indicated positive feelings about the program. Additional survey questions were formatted as an open response, allowing faculty to elaborate on their answers.

The results of the faculty Adopt-a-Lab survey (Table 3) were also neutral to positive in general. The one negatively trending faculty response was for statement 4, indicating frustration that students were not always prepared to receive feedback (e.g., teams did not bring the expected design document or artifact to lab with them). Statement 6 was phrased such that a lower rating was better, so the 2.8 average response to this statement indicates that in general the faculty were able to limit their time with each team to approximately 10 minutes. The faculty members felt more prepared to provide DPA feedback (statements 2 and 3) than to answer questions about the design project (statement 4). This is not surprising, since our intention was for them to provide DPA feedback and not general guidance for the design project, and so we did ask them to be experts on the project rules.

TABLE III
END OF SEMESTER FACULTY RATING SURVEY RESULTS

	Survey Statement	Average Rating
1	The website that was provided for this pilot program was helpful to me as a participating faculty member.	3.80
2	I felt that the "Lab Visit Overview" documents provided on the website were helpful in preparing me to provide feedback to students.	4.00
3	I was generally prepared to provide DPA-related feedback to students during lab visits.	3.80
4	Students in my lab section were generally prepared to receive feedback on the items that were to be discussed during each lab visit.	2.20
5	I knew enough about the design project to answer students' questions related to the design project.	3.40
6	Overall my average lab visit took more time than I expected.	2.80
7	I enjoyed participating as an "Adopt-a-Lab" faculty member.	3.60
8	I would be willing to participate in this program again in the future.	3.40
9	Most of the students in my "adopted" lab section seemed to appreciate my feedback and input.	4.00
10	I felt that most students in my lab section gained something from my lab visits.	3.40

From the open response questions, the faculty indicated that they enjoyed getting to know the students and seeing them demonstrate their designs. Most of the Adopt-a-Lab faculty volunteers were able to attend the ME EN 1000 Design Competition to watch their teams compete. However, the faculty also expressed frustration that students did not come to lab prepared to receive feedback (e.g., they didn't bring the expected artifact or document with them, or even acted like they had no idea what was supposed to be happening during the meetings). This was disappointing from an instructional point of view, as we felt that we were very deliberate and clear during the in-class preparation activities about what was going to happen in lab and what they were expected to bring with them to lab. In the students' defense, however, they were being asked to think about and work on more than one DPA at a time. For example, in a given week they likely needed to submit DPA X, while also starting DPA Y in lecture and getting feedback on DPA Y in lab on the same day that DPA X was due. As such, we may need to rethink the flow or redesign DPA assignments to reduce confusion.

SUMMARY OF OTHER RESULTS AND OUTCOMES

In an effort to assess whether or not our pilot program improved students understanding of and ability to apply design methodology concepts, we looked at both performance on relevant final exam questions and grades on Design Project Assignments (DPAs). Specifically, we compared Fall 2012 grades to corresponding grades from Fall 2011. Based on similar student pass rates (84.8% in Fall 2012 compared to 84.1% in Fall 2011), we assume that the make-up of the class in terms of student quality was similar for these two years. We also looked at retention data, specifically for retention from ME EN 1000 in the fall to ME EN 1010 in the spring.

I. Student Comprehension of the Design Process

All students are required to take a comprehensive final exam covering all learning objectives from the course. For the past several years, we have not returned ME EN 1000 final exams to students so that we can reuse questions (for assessment purposes) with minimal concern that students are aware of the test content. Two questions on the written portion of the final exam – having to do with Decision Matrices and Objectives and Functions – were identified as relevant to our efforts to improve students' ability to understand and apply design methodology concepts. We compared scores on these two questions from Fall 2011 and Fall 2012, with the results shown in Table 4.

TABLE IV
AVERAGE FINAL EXAM GRADES FROM 2011 TO 2012

Learning Objective Covered on Final Exam	Change from 2011 to 2012
Decision Matrices	+5%
Objectives and Functions	+3%
Written Portion	-1%

A Mann-Whitney U test on these data sets showed that while the improvement on the Decision Matrices question is statistically significant (95% confidence), the improvement on the Objectives and Functions question is not statistically significant. Our data showed a 1% decrease in overall performance on the written portion of the final exam from 2011 to 2012, but this decrease is also not statistically significant. It should be noted that two-thirds of the material that was covered on the written portion of the exam was not explicitly covered as part of the active learning/Adopt-a-Lab strategy.

II. Quality of Student Work Submitted for Grading

In order to evaluate this pilot program's impact on the quality of student work submitted, we attempted to compare average DPA grades from 2011 to 2012 (the pilot program year), with the results shown in Table 5.

Interestingly, the average score on DPAs with corresponding "Adopt-a-Lab" faculty feedback increased, but the average score on all DPAs increased even more. A Mann-Whitney U test on these data sets showed that both of these results are statistically significant (99+% confidence). These results may look as though faculty feedback actually decreased the quality of submitted student work. However, since many learning objectives apply to more than one DPA, it could be argued that faculty feedback contributed to improvement in all DPAs, even the ones that were not directly tied to an Adopt-a-Lab visit.

TABLE V
AVERAGE DPA GRADES FROM 2011 TO 2012

Assignment Type/Description	Improvement from 2011 to 2012
All DPAs	+3.5%
DPAs with "Adopt-a-Lab" Faculty Feedback	+1.9%

Unfortunately, although the results are statistically significant, we cannot claim that the improvement is a direct result of the pilot program, since the DPA grades were also affected by other factors, including: (1) different graders, (2) more grades coming from TAs vs. faculty in Fall 2012, (3) the introduction of more structured rubrics in Fall 2012, and (4) a non-linear shift to higher numerical values for the same descriptive metric (e.g., the numerical value of "Meets Expectations" was shifted from 85 to 88). Items (3) and (4) in particular make it difficult to compare DPA grades between the two years. Note that (3) corresponded to a transition to a new course management system, while (4) corresponded to a new co-instructor for the course.

III. Student Retention in the ME Program

Our department as a whole is striving to improve student retention in the ME program. As part of this pilot program, we hoped to see an improvement in student retention from the fall semester to the spring semester. We have two sources of retention data – student survey data, which tells us what students are planning to do, and actual enrollment data. Table 6 compares student survey data from Fall 2011 and Fall 2012. Note that since the survey was administered before final grades were posted, all three response groups include students who were unable to progress to ME EN 1010 because they did not pass ME EN 1000 or another prerequisite of ME EN 1010 (e.g., Calculus I). Table 7 shows actual retention data for Fall 2009 through Fall 2012. Here we report the percentage of students who passed ME EN 1000 with a C- or better who then enrolled in ME EN 1010 in the following spring semester.

TABLE VI
STUDENT RETENTION SURVEY DATA

Response to "Are you planning to take the follow-on ME course next semester?"	Average Student Response from 2011	Average Student Response from 2012	Change From 2011 to 2012
Yes/Maybe	82.78%	82.86%	+ 0.08%
No, I am taking a leave of absence and/or I have already taken an equivalent course	3.97%	3.57%	- 0.40%
No, I am switching to a different major and/or other reasons	13.25%	13.57%	+ 0.33%

From both the student survey data and the actual retention data, it is apparent that the pilot program did not improve retention from ME EN 1000 to ME EN 1010. In fact, there is a slight increase in the number of students who, when surveyed at the end of the semester, said that they were planning to switch majors, as well as a slight decrease in actual retention from Fall 2011 to Fall 2012. However, these differences are very small, and could be attributed to any number of other things (e.g., students leaving the program for personal reasons). Therefore, we conclude that our pilot program did not negatively impact student retention.

TABLE VII
STUDENT RETENTION DATA

Semester	Number of students who passed ME EN 1000 with a C- or better	Percent of students who passed ME EN 1000 who enrolled in ME EN 1010 in the following semester
Fall 2009	125	71.2%
Fall 2010	127	71.7%
Fall 2011	153	75.8%
Fall 2012	156	75.6%

EVALUATION OF PILOT PROGRAM SUCCESS

Our program plan was to increase time spent on project-related active learning activities during lecture and implement an Adopt-a-Lab strategy in which additional ME faculty members "adopt" a lab section to provide design feedback at critical points during the semester. Through this program, we hoped to achieve several primary objectives: (1) Improve student comprehension of the engineering design process, (2) Improve the quality of the work submitted by students, and (3) Improve student retention in the ME program. Here we evaluate the success of the pilot program in light of these objectives, based on the assessment data presented above.

I. Student Comprehension of the Design Process

By providing more active learning opportunities and timely faculty feedback, we hoped to help students come away with a deeper understanding of fundamental design concepts that have consistently been difficult for many of our first-year students to master. The final exam data in Table 4 was our best measure of success for this objective. While students did perform better on the two written questions that should have been impacted by the pilot program, only the improvement on one of those questions was statistically significant. While this outcome is somewhat disappointing, it is not surprising. In our first attempt to restructure lectures and provide more project-based activities during lecture, we found ourselves constantly rushing through lectures and then rushing students through the design activities. In addition, a new co-instructor taught all of the design lectures in Fall 2012, compared to the Fall 2011 co-instructor who had several years of experience teaching ME EN 1000, and had also developed much of the design content (both lectures and assignments) for the course.

II. Quality of Student Work Submitted for Grading

With the implementation of this pilot program, we hoped to see students improve not only their understanding of the material, but also the overall quality of their design work.

While the DPA grade results shown in Table 6 look promising and are statistically significant, other changes made (e.g., to grading rubrics and the scoring system) are just as likely (if not more likely) the cause for the reported improvements in DPA grades. To better assess improved quality of submitted work, we may in the future reevaluate specific assignments or parts of assignments from the two years using identical criteria and scoring.

Statement 4 in the student survey ("The faculty feedback from lab improved the quality of the work that my team submitted for the corresponding DPAs") provided feedback on the student's perception of the quality of their submitted assignments. The average student rating of 3.35 (between neutral and agree) indicates that the faculty feedback was viewed by the students as at least somewhat useful in terms of improving their DPAs before submission.

III. Student Retention in the ME Program

Lastly, by increasing faculty interactions during the freshman year, we were hoping to increase student retention from ME EN 1000 into ME EN 1010. Both student survey data (Table 6) and actual retention data (Table 7) show that retention was essentially flat between 2011 and 2012. While these results are somewhat discouraging, they are probably not surprising for a pilot program.

Statement 8 ("My interactions with the faculty member who visited my lab have given me a greater sense of belonging in the ME program") received an average student rating of 3.39 (between neutral and agree), indicating that the faculty lab visits did have at least a small positive impact. Students responded more favorably to Statement 7 ("I enjoyed getting to know the faculty member who visited my lab") with an average student rating of 3.72. While this does not directly assess feelings of belonging in the program, we are hopeful that these positive student-faculty interactions will be the seed for an improved sense of belonging as students progress in the program.

FUTURE PLANS/PROGRAM REFINEMENTS

Based on the analyses above, it appears that our pilot program at worst did not negatively impact the students (based on comparisons of final exam scores and DPA grades), and at best had a small positive impact on the students (based on student survey data). In future semesters, we hope to refine and revise our strategy and implementation plans in order to better achieve our desired outcomes.

In response to student and faculty feedback, we will look into the following:

- Improving the existing in-class DPA-related activities so that teams walk away with a usable artifact/document (so that they don't have to redo this work to be prepared to receive feedback in lab), as well as developing more such activities.
- "Flipping" more of the lecture-type instruction to pre-lab videos to provide a more realistic amount of time to complete active learning activities during lecture.
- Better integrating our team-based active learning activities into the structure of the course, and restructuring assignments and the lecture/ activity/feedback/assignment flow to be more clear and streamlined (e.g., less overlap of assignments).
- Providing more preparation materials (e.g., video lectures and templates or outlines of the activities) so that students are more prepared when they come to lecture, as well as more examples of the application of design methodology concepts and tools.
- Holding student teams accountable for bringing their work to lab for feedback.
- Better preparing the faculty members to provide DPA and general design feedback, specifically with the freshman audience in mind, so that the provided feedback is well-informed, accurate, and constructive.

We will also consider replacing the faculty volunteers with ME undergraduate upperclassmen or ME graduate students. We initially chose faculty for our Adopt-a-Lab strategy because we expected retention to improve as a result of increased faculty involvement. However, faculty time constraints may make it difficult to recruit volunteers in the future, and also limit the amount of preparation time we can expect prior to each lab visit. Getting to know ME upperclassmen might also be expected to give freshmen an increased sense of belonging in the ME program, thereby positively impacting retention. In fact, other studies (e.g., [8]) have found that student-student (e.g., peer mentoring) relationships are more significant in terms of student satisfaction and retention than are student-faculty relationships. Additionally, the upperclass or graduate students would be more familiar with the material that they would be providing feedback on (since they learned it recently) and could also be expected (e.g., if paid) to spend more time preparing for each lab visit. The freshmen may also feel more comfortable discussing their ideas and design outputs with an advanced peer than they do with a faculty member [8].

CONCLUSION

In engineering design, there is no single "right" answer. Instead, students must learn to utilize design objectives, constraints, target specifications, and metrics in order to reduce an infinite "design space" (all possible combinations of design solutions) to a smaller pool of possible solutions. From this limited pool, students must practice using tools (pairwise comparison charts, decision matrices, etc.) to help them systematically select their "best" design option. This design methodology comes as second nature to most experienced designers, but freshman ME students often have difficulty grasping the idea that "for any design problem there is no single 'right' answer, but there are many wrong answers." Based on ongoing assessments of students in our ME EN 1000 and 1010 classes, we felt that students in ME EN 1000 needed timely, individualized feedback on their application of these design concepts in order to become comfortable and confident with the design process. Providing this feedback is a challenge due to the large class size (180+ students, 45+ design teams).

To address this need for feedback, during the Fall 2012 offering of ME EN 1000 we (1) increased the time spent on project-related active learning activities during lecture and (2) implemented an "Adopt-a-Lab" strategy in which additional ME faculty joined individual lab sections to provide design feedback at critical points during the semester. We expected that this pilot program would improve student comprehension of basic design methodology concepts as well as the quality of DPAs submitted by student teams. We also hoped that, as an intended side effect of increased faculty involvement, student retention from ME EN 1000 to ME EN 1010 would improve.

We have assessed our primary outcomes using student and faculty survey data as well as final exam and DPA grades. We can claim a slight improvement in student comprehension of design methodology concepts, with one relevant question on the final exam showing statistically significant improvement in Fall 2012 compared to Fall 2011. Due to other changes made between Fall 2011 and Fall 2012, we do not feel confident claiming that the pilot program improved the quality of student work based on the DPA grade data that we have in hand. However, survey data indicated that students viewed the faculty feedback as at least somewhat useful in terms of improving their DPAs before submission. Lastly, we observed no significant change in student retention from Fall 2011 to Fall 2012, but survey data indicated that the faculty lab visits had at least a small positive impact on students' feelings of belonging in the program. The students and faculty volunteers both enjoyed getting to know each other, and students felt that the program should be continued in the next offering of ME EN 1000. Based on these results, we are excited to continue this program and implement the changes outlined above. By doing so, we hope to achieve each of our primary objectives and ultimately improve the overall educational experience of students in our introductory ME course.

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