Teaching Self-Evaluation Skills in a Team-Based Project Class

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ABSTRACT

Recent industry feedback indicates that graduating engineers need better preparation in solving open-ended problems and communication. In response to this feedback, we have developed a team-based design project class that emphasizes self-evaluation, peer-evaluation, and group evaluation of problem solving strategies, as well as written and oral communication skills. The course is built around unique team-projects that each group creates. The course also includes significant writing-to-learn activities that encourage students to reflect on and develop an awareness of their problem solving processes and communication skills. The students also work in teams, and in pairs, to evaluate the process of solving problems. Their written and oral presentations are also self-evaluated and peer-evaluated. This emphasis on students becoming more self-aware of the strengths and weaknesses of their problem solving abilities, and on students becoming capable of evaluating the effectiveness of their communication skills, will prepare our students to better evaluate their future work in industry.

INTRODUCTION

Results of a survey conducted by Arizona State University that asked its engineering seniors, alumni, faculty, and industry representatives that employ new engineering graduates to rank the relative importance of a set of ten desirable attributes and the performance of new graduates in these attributes, indicate that the ability to recognize and solve problems is significantly more important than any other attribute ranked by the four rating groups [1]. Additionally, both industry and alumni rated communication skills second in importance over mathematics skills, science skills, and depth and breadth of technical skills.

What is more interesting, is the relative performance ratings of new graduates in these attributes. With regard to problem solving, industry rated graduates' preparation as 7 (l-First, 10-Last) and alumni rated it 4. The rating for performance in communication skills was 8 for both rating groups.

If our goal as educators is to produce the desired attributes our engineering graduates will need to perform successfully in their careers, we must listen to this feedback and modify our curriculum design accordingly.

Teachers in the Department of Electrical and Computer Engineering at the University of Arizona have been working on ways to better educate and prepare our students specifically in the areas of problem

solving and communication. In 1989, we initiated an upper division engineering design and communications course to combat some of the shortcomings in our students' ability to solve open-ended problems and to communicate orally and in writing. The course has been co-taught by an engineering professor and an adjunct professor whose background is in English composition. Students work on a semester long technical design project in randomly assigned groups and practice problem solving, writing, and speaking as part of their project and in response to other class activities. It should be mentioned that this course is an elective course, but it does satisfy a student's senior project requirement.

This semester we have attempted to incorporate into the course practical experience in self-evaluation, peer-evaluation, and group evaluation of problem solving strategies, writing skills, and oral communication skills, This emphasis on students becoming more self-aware of the strengths and weaknesses of their problem solving abilities, and on students becoming capable of evaluating the effectiveness of their communication skills, we believe, will prepare our students to better evaluate their future work in industry. This paper describes our experiences this semester with introducing students to the self-evaluation process.

COURSE GOALS

We had several hypotheses (goals) in mind when we planned the course this semester.

1. Students will become better designers if they use a road map containing the essential design steps.

2. More effective communication occurs when the communicator clearly understands their purpose and audience.

3. Student writing, speaking, and problem solving improves with practice.

4. Making students better evaluators of their own and others' process and work product will make them better employees when they graduate.

These hypotheses were approached by using the following pedagogical methods.

METHODS

The methods used to address the above goals centered around the two major components of the course: writing and design. In general, the first author was more strongly concerned with the writing component of the course, while the second author focused on the engineering design component.

Course goal number one was obviously addressed in the engineering design component of the course. In particular, five simple design steps (define, think, plan, do it, and look back) were identified early in the semester as the road map for design. These steps were then discussed individually during different class periods and incorporated routinely during subsequent activities in the course. For example, the topic of thinking about a solution or generating solutions was addressed by having the different groups create a device that would measure the physical parameters of a mass-spring-damper system. Likewise for the look back or evaluation phase of a design, the students were asked to evaluate their own designs

of a carnival-type booth. The carnival-type booth exercise actually evolved through all three types of evaluation. First, the students generated a design individually. In the next phase of this exercise, pairs of students evaluated each other's design and tried to create a winning design from the two initial designs. The third phase of the exercise focused on small groups of 4-6 students evaluating the designs that resulted from the pair-based evaluation phase. This group-based evaluation was supposed to end up with one winning design from each group. Finally, the exercise concluded with each group presenting their winning design and the class, as a whole, trying to select or create one overall winning design.

For an exercise like this to succeed, each and every class member must "buy into" the design goal and be motivated to achieve the goal. Unfortunately, it only takes one class member's nonparticipation to spoil the completion of the exercise. For this reason, setting-up, explaining, and performing this exercise successfully takes a great deal of planning, patience, and persistence from the instructors.

To address our second goal, the students were given individual and group writing assignments that were related to their engineering design project. These formal writing assignments were introduced and discussed thoroughly during class, with respect to structure, style, organization, and content. These writing assignments helped focus the students' attention on the purpose and the audience when communicating ideas with others.

In response to course goal number three, we tried to provide as many writing activities throughout the semester as possible. Nearly every week, the students were required to write a brief response to some question or topic that was currently being discussed in the course. These exercises were meant to force the students to put their thoughts and ideas down on paper. For example, could they formulate an opinion or hypothesis and then strongly support this thought with well structured and clear prose. Some typical writing activities were (1) commenting on their videotaped oral presentation, (2) having each group evaluate another group's final report, and (3) self-evaluating their own abstract. The style and content of these writings were not discussed. Instead, the student was responsible for determining the manner in which they would respond to each assignment.

To help address course goal number four, both the writing and design activities were accompanied by the opportunity for each student and/or different groups of students to evaluate or assess their product or process. The evaluation might take the form of a self-evaluation, a peer type evaluation, or a group-based evaluation. Several times during the semester, all three forms of evaluation were used on one particular activity, as in the carnival-type booth exercise, to help illustrate the importance or benefit associated with the evolution of an engineering design or a written document. The students also learned how to develop criteria that can be used for assessing an engineering design or a written document. As another form of evaluation or assessment, we had each team hold three informal status meetings during the semester. These status meetings were meant to generate more ideas, inputs, and suggestions for each of the unique design projects. Also, these status meetings were created to help expose the students to more than just their own engineering design process and it allowed another opportunity for them to learn how to more clearly communicate their ideas verbally.

In addition to the writing and design activities during the semester, outside speakers were brought in to discuss topics of interest and importance to the students. The outside speakers spoke on business (finance, accounting, and economics), problem solving, office interactions and assignments, technical debating, and creativity. These speakers helped break up the routine in the classroom and provided a

different perspective on the engineering environment.

Besides the writing, the design, and the outside speakers, we tried to introduce the students to topics that might be important for their future development. For example, we discussed ethics, how to run an effective meeting, six sigma performance, concurrent engineering, project scheduling, and optimization. These topics were not presented in a typical lecture format. Instead, we tried to get the class more actively involved in the learning process by breaking the class down into smaller groups and having these smaller groups engage in activities centered around the particular topic being discussed. The goal was to provide an environment that would enhance the learning and retention of these additional topics.

Our interpretation of how well these methods worked will be discussed in the next section.

OBSERVATIONS

At the beginning of the semester, we observed that students' written assignments reflected the bare, minimum notation to communicate what they had concluded was the most important idea from a particular text or lecture. There was no exposition of how they came to have an idea about some subject. Their writing seemed specifically focused on presenting the "right answer" in as few words as possible.

Additionally, the majority of the students' composition skills were weak in the areas of spelling, punctuation, diction, and basic grammar. The average of the class scores for the second writing assignment was 72%.

After practicing their writing, and receiving constant feedback on the strengths and weaknesses of their skills, the average of the class scores for the eleventh writing assignment was 92%. We observed that the mechanics as well as the content of their written assignments had improved remarkably over the course of one semester. A further observation of this improvement was the class average for the finished portfolios of their written work. The average of their grades for all the first versions of these assignments was 82% and the class average for their final versions, which were graded as finished pieces, was 84%. Although the improvement seems minor, the portfolios were graded more rigorously. Thus, this slight numerical improvement represents a significant improvement in their written work.

With regard to their oral communication skills, we observed that the students started out stronger in this area. The average score for the class on their first oral presentations was 89%. The average class score on their final oral presentation was 91%. Students seem better able to communicate their ideas orally than in writing.

We have several observations on students' ability to self-evaluate and peer-evaluate their work. We noted that when students were given the criteria for grading an assignment, they tended to see their own work in the best possible light. Student grades for their own work were generally higher than the grades given by the instructors for the same assignments. Also, students were generally uncomfortable with grading each other's work and tended to inflate those grades even more than they did when grading their own work. The students were, however, comfortable and capable of determining appropriate criteria for grading specific assignments. We concluded from this that they understood what each document should include, but were unable to accurately self-evaluate their own work accordingly.

A final observation on our teaching of communication skills was that the students did seem to develop a clear sense of the importance of understanding the audience and purpose of any communication. This awareness should benefit them in their future work as engineers.

With regard to their problem solving skills, we observed that students were capable of using and adapting the five-step model we provided in both their group, technical design project and other class work on real-world engineering problems. Having a road map to follow seemed to make them sensitive to their process of solving problems. As part of the midterm exam they were asked to work through a design problem explaining their process of solving the problem as they went along. For the most part, students correctly identified and explained the five design steps we had given them for problem solving and were using these guidelines to reflect upon what they were actually doing at each step in their work. The class average for this part of the exam was 89%.

CONCLUSIONS

We are unable to provide quantifiable data on the effectiveness of these new educational goals and teaching methods after one semester. It is similarly difficult to draw significant conclusions based on the performance of a single class. One thing we will need to do in subsequent semesters is to design assignments that will quantify both their skills levels and their self-awareness of those abilities throughout the semester. This need for better quantifying their efforts is especially true with respect to their problem solving skills. However, having said this, we would like to offer some comments on this semester's experience.

First, it seemed that students became more comfortable approaching open-ended design problems when they had a well-defined set of steps to follow. Engineering students like structure. Having a specified strategy for approaching problem solving seemed to get them over the obstacle of being intimidated by the problem and eased them into the design process. Whether providing them with this simple, five-step strategy makes them better problem solvers will need to be measured independent from the cumulative benefit of practicing these skills. We can only say that their engagement in the process of solving problems did improve over the course of one semester.

Along these same lines, we noted that if students have a clear sense of the purpose and audience for their communications, they are better able to plan and prepare these oral and written presentations. They also seem capable of evaluating their own work accordingly.

The improvement of their writing and speaking skills was noted through the use of grade comparisons in the Observations section. In the coming semester, we will try to better quantify their problem solving skills.

Recommendations for improving the course include explaining, at the beginning of the semester, the objective behind teaching and practicing self-evaluation and peer-evaluation skills. When we mentioned this objective towards the end of the semester, the students were interested in discussing the relevancy of developing these skills for their future work in industry. Explaining to the students our purpose behind these evaluation exercises should strengthen their desire to learn and develop these evaluation skills.

We are also planning to incorporate "expert" models of written documentation and problem solving exercises into the course. It seems important that the students see and better understand the process that goes into preparing a finished product. We are also considering requiring the students to holistically grade variously successful example documents and design studies during the course. We would hope that objectively grading these anonymous models and then discussing these grades to try to reach a consensus would improve their ability to evaluate their own and other's work.

We are convinced that students need to learn how to critically evaluate their own work and other's work without being judgmental or condescending. Students who possess effective evaluation skills will be better prepared for their future real-world assignments. Although this one semester effort cannot justify the process we used to help teach these evaluation skills, we are encouraged by the outcomes we observed and plan to improve upon the process in subsequent semesters.

REFERENCES

[1] D.L. Evans, G.C. Beakley, P.E. Crouch, and G.T. Yamaguchi, "Attributes of Engineering Graduates and Their Impact on Curriculum Design," ***J. Engr. Educ.,*** October 1993, pp. 204, 205.