Jump-Starting Lifelong Learning

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I. Introduction

Every year the regional sales representative for the publisher of a popular chemical engineering periodical requests an audience with our department's junior class. The purpose of his visit is clear; he comes to sell his company's magazine. Besides being a clever marketing strategy, this sales pitch also provides a great "teaching moment" for the course instructor--an ideal context in which to discuss with the class the need for lifelong learning.

Today's rapidly developing technologies and competitive economy require the continuous training and education of engineers throughout their careers. Engineers need new skills and competencies that will help them understand and meet new work-related requirements[1]. As more engineers are employed in smaller companies and the work force in down-sized, individuals must take on a wider variety of duties. In addition, since the number of students studying engineering is decreasing[2,3], the aging work force must be kept up-to-date in order to maintain high levels of productivity throughout their careers. In the U.S., the responsibility for this maintenance of technical competence and career growth has largely been the individual's[1]. ABET Engineering Criteria 2000 (EC2000) embrace these concerns and, therefore, include within the required program outcomes of Criterion 3 the instilling of lifelong learning skills in our engineering graduates[4].

Questions are often raised about the means used to substantiate attainment or, at least, the development of these skill sets in our graduates. Frequently programs rely on alumni surveys to provide such evidence. However, a more important issue deals with proactive strategies that engineering programs may use to jump-start interest in and appreciation for lifelong learning in its students. This can be done as a part of traditional engineering courses on campus.

Students in the undergraduate fluid flow and heat transfer course in chemical engineering at Michigan State University (MSU) research and prepare short reports on practical, everyday applications of fluid flow or heat transfer principles. The learning objectives of this exercise are for the students to:

1) understand that learning takes place outside the confines of the textbook and the classroom;
2) become familiar with engineering tools and resources that are available for their use;
3) realize that engineering analysis learned in the classroom can be applied to understand the design and operation of a wide variety of everyday devices;
4) further develop cooperative learning skills; and
5) practice oral and written communication.

II. Integration into the "Traditional" Course

The fluid flow and heat transfer course at MSU is a four-credit course (four lectures plus a one-hour recitation/discussion section). It is taken in the fall semester of the junior year. At the beginning of the semester, students are divided into base groups of three or four individuals. Barring major irreconcilable conflicts, these groups work together for the entire semester. The course material is fairly traditional, but cooperative learning techniques are used in the classroom on a regular basis.

Early in the semester, the magazine sales pitch is presented, and the ensuing discussion focuses on the necessity for continued, on-the-job learning throughout one's career. When possible, a recent alumnus/a is invited to the classroom to affirm these concepts. The students are now primed to exercise their burgeoning lifelong learning skills.

About two to three weeks into the course, each of the student groups is asked to develop a problem statement around some practical everyday device or concept in which principles of fluid flow or heat transfer are applied. Half of the groups develop fluid flow problems and the other half concentrate on heat transfer. Examples of topics include the analysis of a coffeemaker, a drinking fountain, an aquarium, lawn irrigation systems, a "Lava" lamp, hot water heaters, and wind-chill charts. Even if the underlying principles have not yet been studied in the class (e.g. heat transfer is covered during the second half of the semester), the students are motivated by their abilities to independently identify practical engineering problems outside of what has been taught. Guidance on problem selection is given when requested.

After review of the submitted problem statements by the instructor--and some minor adjustments in some cases--the problems are then re-assigned at random to other groups. The groups are required to submit a five-page written report and to deliver an eight to ten minute oral presentation on the results of their analyses. The instructor spends some class time reviewing approaches to problem-solving, teamwork strategies, and the basics of oral communication skills. Beyond that, the students are given free reign in the choice of their approaches to researching and analyzing the problem statements and in developing their presentations. All group members are required to participate in the writing of the paper and in the delivery of the oral presentation. The basis on which they are to be graded both in their written reports and their oral presentations is stated up-front.

Beginning two weeks later, the groups begin their presentations, which are spread across the semester, but correspond generally to the material being discussed in class. The recitation period is used for the oral presentations; the groups submit their written reports on the day of their presentations.

III. Content and Grading

The papers and presentations have relatively simple requirements. They are to provide the general background to the problem (its context), an explanation of the relationship of the device (or concept) to the fluid flow and/or heat transfer fundamentals discussed in class, and a technical and, where possible, quantitative analysis of the parameters of the problem. Commentary on safety, environmental or societal impact is required as appropriate for the project. The papers are graded with typical standards for written work (content, organization, style, grammar).

In addition to the above requirements, the oral presentation must also show evidence of good preparation: a) smooth flow from one speaker to another and good budgeting of allotted time; b) clear speaking and effective visual aides; and 3) a professional approach to the assignment. Presentations are graded by the instructor as they are being delivered.

Group participation in the project is evaluated from an accountability report submitted by each group. In this document, each group member identifies his/her role in the preparations, assigns a percentage effort dedicated to this role (as a percentage of the total cumulative effort of all individuals), and signs the document to convey agreement with the percentages as allocated by the group. Where a effort strays too far from an equal proportion, the grade for that individual is adjusted accordingly.

In addition to the traditional grading of content and presentation, project evaluation must also address attributes of the work that provide evidence of lifelong learning skills. These attributes should affirm that the students are able to:

1) learn on their own;
2) learn from others (peers and colleagues);
3) use resources outside the confines of the formal classroom;
4) research the safety, environmental, and social aspects of engineering problems, i.e. view engineering problems beyond their purely technical boundaries; and
5) understand that learning continues beyond the four years of college.

Instructors in other programs may wish to alter this list depending upon the objectives of their course and their engineering program.

It is believed that the type of project described in this paper allows students to demonstrate some level of competence in these skill sets and, at the very least, show an acceptance of the attitude that lifelong learning is needed to maintain technical vitality. Furthermore, programs that are assessing these skills as a program outcome according to EC2000 may wish to use the evidence provided by this project in support of data on lifelong learning obtained from alumni surveys.

IV. Direct Costs and Benefits

Before the idea of using this class exercise to promote lifelong learning came to be, the original, primary goals of the assignment were simply to encourage students to appreciate the relevance of the course material to familiar aspects of everyday life and to develop analytical skills in problem-solving. Secondary goals included the exercise of oral and written communication skills and the continued development of cooperative learning skills.

The unexpected benefits became evident from the enthusiasm shown by the students in learning on their own about topics outside of traditional course content. Not only were the students highly motivated for success in their projects, but they became an eager audience in learning what the other student groups had to present. The creativity, initiative, and humor demonstrated by many of the groups made these sessions a pleasurable learning experience for all. According to student feedback, most saw this as a very pleasant diversion from typical classroom structure.

Student groups were also very creative in their use of resources. These included research on the World Wide Web, in handbooks, trade journals, sales literature and brochures, manufacturer specification sheets, manuals, and personal or mail contact with practicing engineers or other professionals. The fact that the students incorporated these resources into their "toolkits" was evident in the final design project assigned in this course. Many of the same types of resources were listed in the bibliographies of their design reports, an encouraging sign of students willing to seek out information on their own.

An additional benefit comes with the minimal investment of time that is required of the instructor--even for a large course (85 to 100 students). The students generate their own problem statements. Only minor editing of the project statements is needed. Since the final papers are short and are submitted at several points in the semester, they may be graded quickly, thus minimizing the accumulation of tall stacks of papers. The oral presentations are graded as they are being delivered. This mode of grading, which spans the semester, does raise the issue of assurance of consistency. This concern is remedied by maintaining a good record of typical errors, careful accounting of point deductions, and providing opportunities for student appeal.

V. Commentary and Conclusions

Whatever the time spent by the instructor in implementing a project of this type, it appears that the ends justify the means. Not only does the student gain exposure to learning outside the classroom and in taking responsibility for learning, but the same assignment may also be used to practice team skills (Criterion 3d), apply engineering fundamentals to practical problems (3e), exercise written and oral communication skills (3g), and develop familiarity with engineering tools and resources (3k).

As E.T. Smerdon has so clearly stated[1], "Engineers must stop thinking of education as what they did for four years in college and start seeing it as a lifetime project." This paper discusses a simple method in which a typical course assignment is used to jump-start student attitudes toward this line of thinking.

VI. References

1. Smerdon, E.T., "It Takes a Lifetime", ASEE PRISM, p. 56, December, 1996.
2. Otala, L. "Studying for the Future", ASEE PRISM, pp. 22-27, October, 1993.
3. Proceedings of Industry 2000 Workshop: Technical Vitality Through Continuing Education, published by the IEEE, 1995.
4. ABET Engineering Criteria 2000, www.abet.org/EAC/eac2000.html

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