DEVELOPMENT OF 'SOFT SKILLS' IN A TECHNICAL ELECTIVE

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1. INTRODUCTION

ABET Engineering Criteria program educational outcomes (or educational outcomes for any well-structured engineering program) can be grouped in two broad categories for practical purposes:

- 'hard skills' (e.g., applying knowledge of mathematics, science, and engineering; designing and conducting experiments, analyzing and interpreting data; designing a system, component, or process to meet desired needs; identifying, formulating, and solving engineering problems; and using the techniques, skills, and modern engineering tools necessary for engineering practice) and
- 'soft skills' (e.g., appreciation for realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability in the design process; functioning on multi-disciplinary teams; understanding professional and ethical responsibility; communicating effectively; understanding the impact of engineering solutions in a global, economic, environmental, and societal context; life-long learning; and knowledge of contemporary issues).

The first set of examples corresponds to ABET Criterion 3 Program Outcomes a, b, c (partly), e, and k while the second set corresponds to c (partly), d, f, g, h, i, and j.

A literature survey reveals that the development of 'hard skills' in project- or laboratory-oriented courses (Aung, 2005; Gerhart and Gerhart, 2005) or in engineering science courses has received a great deal of attention in numerous educational papers over the years. There are papers covering the development of various 'soft skills' as well (Tebbe, 2005). This paper intends to contribute to the latter.

'Soft skills' typically include a large range of items. One can expand the list of examples given earlier in this section to include leadership, persuasion, ability to defend ideas, and ability to think fast. Among many mechanisms that can be used to develop such skills, this paper discusses how to develop a set of 'soft skills' in the student in a senior-level mechanical engineering technical elective course (Power Plant Design). After discussing the course goals, the following sections will focus on three student-centered activities: student team debates, student presentations on special topics, and student self-reflection essays. For each activity, the goals (or benefits) are discussed with relevant examples. This paper is intended for engineering faculty members who are looking for additional methods of incorporating more 'soft skills' development into their classes with a student-centered approach. Student feedback has been most positive and encouraging.

2. COURSE GOALS

It would be useful to provide information on the specific course so that the context in which certain 'soft skills' are developed in the student are understood better. Mech. Engrg. 4520 Power Plant Design is a three-credit senior-level technical elective course in the Mechanical Engineering Program at the University of Wisconsin-Platteville, which is on a semester system. The class has two "lecture" hours per week plus two discussion hours per week. This format allows sufficient time for course topics, a term project, and the activities described in this paper. The course covers analysis and design of steam power plants; environmental aspects and economics of power generation; renewable energy; basics of nuclear power; and recent developments, future trends, and societal issues in power industry.

Course objectives can be summarized as follows: to develop the ability to apply thermosciences to solve steam power plant problems; to develop the ability to solve open-ended power plant design problems (to be able to generate design solutions to meet required performance and to be able to deal with realistic design constraints); to develop effective communication skills (to develop skills for effective written documentation and to develop skills for effective oral presentation); to increase teamworking skills of students; to develop awareness of societal issues (e.g., economic, environmental, legal, safety, social) and their effect in power plant design, operation, and economics; and to develop the ability to use computer software to solve power plant problems and to simulate power plants. In addition to progress (or interim) project reports, final written report, and oral presentation of project results; the following three sections will discuss three methods used in the development of the student 'soft skills' listed earlier.

3. STUDENT TEAM DEBATES

The goals of student team debates are to develop skills in the following areas: knowledge of contemporary issues; teamworking; understanding the impact of engineering solutions in a global, economic, environmental, and societal context; appreciation for constraints such as economic, environmental, social, political, ethical, health and safety; understanding professional and ethical responsibility; effective oral communication; leadership; persuasion; ability to defend ideas; ability to think fast ; and life-long learning.

A student debate team typically comprises of three or four students. The debate format and length of time can be quite flexible and are up to the instructor. Clear ground rules are announced in advance. The essential elements of the debate format used are presentations by the two sides, responding to questions from the other team, and responding to questions from the audience.

It is best to word a debate topic in a neutral tone. Some examples of debate topics are:

Power deregulation in the United States was/is a good idea.
Power deregulation in the United States was/is not a good idea.

The United States should build new nuclear power plants.
The United States should not build new nuclear power plants.

Proceed with oil drilling in the Arctic National Wildlife Refuge.
Do not proceed with oil drilling in the Arctic National Wildlife Refuge.

A properly-worded statement can be used for a debate on the subject of global warming as well.

Another idea is giving an ethical dilemma and asking the student teams to defend the opposite sides of what is most appropriate to do. Such a topic has the additional advantage of sensitizing students to ethical issues.

Team debates are quite effective in achieving the goals listed above in the beginning of this section. The element of competition in the debate structure serves as a good motivator. The discussions are completely free and wide open. The instructor encourages free discussion and expression, but stays away from taking a political or ideological stand on any issue so that free flow of ideas is not inhibited. The goal should never be indoctrination, it should be providing a fine and purposeful educational experience for the student.

4. STUDENT TEAM PRESENTATIONS

The goals of student team presentations are to develop skills in the following areas: knowledge of contemporary issues; teamworking; understanding the impact of engineering solutions in a global, economic, environmental, and societal context; appreciation for constraints such as economic, environmental, social, political, ethical, health and safety; effective oral communication; ability to defend ideas; ability to think fast; and life-long learning.

A student presentation team typically comprises of three or four students. The length of time can be quite flexible and is up to the instructor. Clear expectations about the scope of the presentation are announced in advance. The essential elements of a student team presentation are introduction, technical aspects, economic aspects, environmental aspects if relevant, main conclusions, and responding to questions from the audience. Additional expectations can be set depending on the topic. The team is expected to provide the class with a list of references they used in their preparation.

Some examples of presentation topics are wind energy, solar electric power, geothermal energy, energy from the oceans, California power crisis around 2000, fuel cells, the Kyoto Treaty and the subject of global warming, and power deregulation.

Student presentations on selected topics are quite effective in achieving the goals listed above in the beginning of this section. In their preparation, students read numerous articles and books, and search the Internet. In addition, they need to be prepared to respond to questions from the audience. They report that, as a result, they grasp the fundamental issues in a strong way and develop an interest in the topic to keep up with future development and news.

5. STUDENT SELF-REFLECTION ESSAYS

In engineering education, writing experience is usually limited to laboratory and projects in engineering courses. Sometimes students may be asked to write about a high point or a key concept in a lecture. For this reason, the scope of purposeful writing in engineering classes is narrow. Writing Across Curriculum (WAC) and writing assignments in engineering classes (Ceylan, 2005; Cantor, 1992; Katz and Warner, 1988) have been around for some time.

Student self-reflection papers (i.e., thinking about course-specific topics and writing a meaningful essay about them) lead to a careful and thoughtful analysis of course topics, which results in an enhanced and deeper appreciation of the course material. Such assignments increase the student's ability to express technical subjects to a nontechnical audience. If a course or student portfolio is being constructed, student self-reflection papers make a valuable addition to it.

Self-reflection paper topics should be inspiring and challenging. The length of an essay may be two or more pages. Some examples of essay topics are:

What is the most important thing you learned in this course and why?

Choose a course-related topic (e.g., air or water pollution, energy conservation) and discuss its impact on society.

Choose a course-related topic (e.g., nuclear power, power deregulation) and discuss its economical (and/or environmental and/or ethical) aspects.

If implemented properly, this idea brings numerous educational benefits. It contributes to the development of thinking and written communication skills in the student.

6. CLOSURE

The three methods discussed in this paper have been found to be very effective in developing a set of desirable 'soft skills' in the student. The student response has been most positive and gratifying. This is evident in written anonymous responses to end-of-semester questionnaires and in informal oral feedback received. Based on solicited and unsolicited comments from students over many years, I recommend using at least one or more of these methods in appropriate engineering courses. It should further be noted that, in addition to being educationally-sound and effective methods, this approach helps in satisfying various program outcomes required by ABET for accreditation of engineering programs.

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