

TEACHING NEW ENGINEERING STUDENTS ABOUT THE DISCIPLINES: A DISCIPLINARY OR MULTI-DISCIPLINARY APPROACH?

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Abstract

Most students entering into the world of engineering encounter the difficult task of choosing an appropriate engineering discipline. How should an instructor approach this important topic? One proposed technique is to cover each discipline one at a time, giving examples of what an engineer in that discipline might do (disciplinary approach). A second proposed technique is to convey the disciplines through multidisciplinary engineering problems (multidisciplinary approach). This technique may seem desirable as a majority of engineering problems are multidisciplinary. Seeing how each type of engineer can contribute to the solution of an engineering problem could be an effective method of getting a general idea of what engineers in each discipline do. Each of these techniques (disciplinary and multidisciplinary) was used in consecutive years in an introductory engineering course at the University at Buffalo. Data was taken to measure the effectiveness of each of these techniques. The data shows that, despite the attractiveness of the multidisciplinary approach, the students did not gain as much insight into each of the engineering disciplines as they did using the disciplinary approach. This paper will discuss the advantages and disadvantages of each technique as well as what we have learned by introducing methodical changes in these techniques over the past several years.

Introduction

Many first year engineering students face the dilemma of choosing which engineering discipline fits his or her interests and career goals the best. Because of this, it is common for engineering schools to have a course early in the curriculum to introduce engineering students to each of the engineering disciplines. The choice of engineering discipline can have a very important effect on the futures of these students. This poses a daunting task to the instructors of these courses: How does one portray as many disciplines as possible in an unbiased fashion, and how does one explain each discipline in adequate detail in the allotted time? Two different methodologies were tested in a first-year engineering course at the University at Buffalo. The first approach, called the disciplinary approach, covered each of the main disciplines one at a time. The second approach, called the multidisciplinary approach, covered each of the main disciplines through a series of multidisciplinary projects. The results and discoveries of this experiment are presented.

All freshman engineering students at the University at Buffalo (with the exception of computer engineers) take a course called Engineering Solutions. The goals of this course are threefold: to increase student understanding of engineering, to develop teamwork and communication skills, and to establish peer networks that the students can utilize through their engineering educational careers. This course has an average enrollment of approximately 400 students each year. Of these, a fair portion each year are general engineering majors without a declared discipline (approximately 20% the last time the course was

offered). Many of the rest end up changing their minds about which discipline to pursue during the first year or two of college. Engineering Solutions seeks to ease the decision-making process by introducing the students to the various fields of engineering in an unbiased fashion. For the past several years, this has been accomplished through the use of engineering case studies and projects. Surveys of the students in the course are taken at the end of each semester in which the course is offered to gauge the success of the methodologies used during the course. These results, as well as a discussion of observations over the years, follow.

Approach

Two different approaches were taken to introduce the students of Engineering Solutions to the engineering disciplines. The first approach is called the disciplinary approach. The second approach is called the multidisciplinary approach. Each technique will be described in detail.

A. Disciplinary Approach

The first technique utilized in the course covered each of the main engineering disciplines one at a time through the use of engineering case studies and projects. For each discipline, a representative of that discipline (often the chair of that department or an industrial contact) came to class to speak to the students about his or her experiences. In addition, he or she tried to enlighten the students on the other possibilities of the field. This was then followed up by a case study or project that related to the field. In this way, each of the main disciplines of engineering (chemical, civil, electrical, industrial, and mechanical/aerospace) was covered. Computer engineering was not covered because students declared as computer engineers do not take Engineering Solutions. Table 1 shows a breakdown of each project and its corresponding discipline.

Table 1. Breakdown of disciplinary project topics and associated discipline

Discipline	Topic
<i>Civil</i>	Millenium Bridge Study
<i>Chemical</i>	Reactor Optimization
<i>Electrical</i>	Hydrogen Fuel Cells
<i>Industrial</i>	Traffic Light Coordination
<i>Mechanical</i>	Parabolic Sculpture Design

This technique carries with it several advantages and disadvantages. One advantage of the technique is that it compartmentalizes each discipline. The students can clearly identify certain career paths with a certain discipline. For example, when learning of electrical engineering, the students can learn about career paths in alternative energy, nano-electronics, communications systems, power distribution, etc. When learning about industrial engineering, they are introduced to careers in process optimization, resource management, quality assurance, etc. The association of the career path with the discipline is very direct. There are several disadvantages, though. One disadvantage is that covering all of the main disciplines takes a lot of time. If each discipline has a corresponding case study or project, then 5 or more projects have to be fit into a one-semester

course. To ensure that the course-load does not prove too heavy, the projects must be kept relatively simple without compromising integrity. In 2005, approximately 25% of the students commented that there were too many case studies/projects during the semester. Another disadvantage is that, since each discipline has a corresponding project, the interest of the project can have a large influence on student perception of the discipline as a whole. For example, the chemical engineering project was simulation-based whereas the mechanical engineering project was construction-based. This could lead to more students being interested in mechanical engineering *because* its project was construction-based and not simulation-based. Lastly, it is possible that this approach could lead to a very “tunnel-vision” view of engineering. By seeing each discipline presented as a separate entity, it promotes a very divisional view of engineering. This could be harmful if interdepartmental cooperation is desired.

B. Multidisciplinary Approach

The second technique that was tested for the course introduced each of the engineering disciplines through several multidisciplinary projects. ABET has emphasized the need to incorporate multidisciplinary teams into engineering education¹. Therefore, it is desirable to convey the multidisciplinary nature of engineering problems. The projects for the course were chosen so as to cover all of the main disciplines at least once. Table 2 shows a breakdown of the disciplines covered by each topic.

Table 2. Breakdown of multidisciplinary project topics and associated disciplines

Discipline(s)	Topic
<i>Mechanical, Industrial, Environmental, Civil</i>	Portable Shelter Design/Implementation
<i>Electrical, Ethics</i>	Power Grid Design/Management
<i>Chemical, Mechanical, Electrical, Environmental</i>	Biodiesel Synthesis/Analysis
<i>Aerospace, Industrial, Mechanical, Civil</i>	Hot Air Balloons/Air Travel

As can be seen, many of the disciplines are covered by more than one topic (and some smaller disciplines are also included). The multidisciplinary nature of the projects was emphasized. One advantage of this technique is that it offers a much broader view of engineering, thus appealing to the global learning style². The students can see that most engineering problems are not solved by engineers of only one kind. It also promotes the concept that teamwork is essential in engineering problems. In addition, it allows more disciplines to be covered with fewer projects. Because each of these projects can be more in-depth, it is less challenging to develop high integrity projects. Lastly, it reduces the possibility of biasing the disciplines as the attitude concerning any given discipline is not dependent on the success of a single project. For example, mechanical engineering and environmental engineering are both in a hands-on project and a simulation project. This means that one cannot say that more students came to like mechanical engineering because they had the opportunity to build something. There is one major disadvantage to the multidisciplinary technique, however. The major disadvantage is that this technique *does not* compartmentalize each of the disciplines. Students are shown that industrial engineers can work on process optimization, resource management, and quality assurance. But

this is done piecemeal throughout the course of the semester. Therefore, it is more difficult to associate certain career paths with a given discipline. So, although the students may be obtaining a more holistic view of each engineering discipline, and indeed of engineering in general, they perceive that they understand less about the specifics of each of the disciplines than in the more compartmentalized disciplinary approach.

Results

Survey data were taken at the conclusion of each of the semesters in which the two techniques were employed. Two of the questions posed were: “How successful was the course in increasing your understanding of engineering?” and “How successful was the course in helping in your decision of engineering discipline?” The results of these questions for each of the two techniques follow.

To each of the questions posed, the possible answers were “Very successful”, “Somewhat successful”, “Not very successful”, “Not at all successful”, and “Not Important”. According to survey data taken over the years, 29% of students declared that the disciplinary technique was very successful in increasing their understanding of engineering. In contrast to this, only 18% of students felt that the multidisciplinary technique was very successful in increasing their understanding of engineering. As far as the success of each of the techniques on helping in the decision on engineering discipline, 27% of students felt that the disciplinary technique was very successful, and 23% of students felt that the multidisciplinary technique was very successful. This information is shown in graphical form in figure 1.

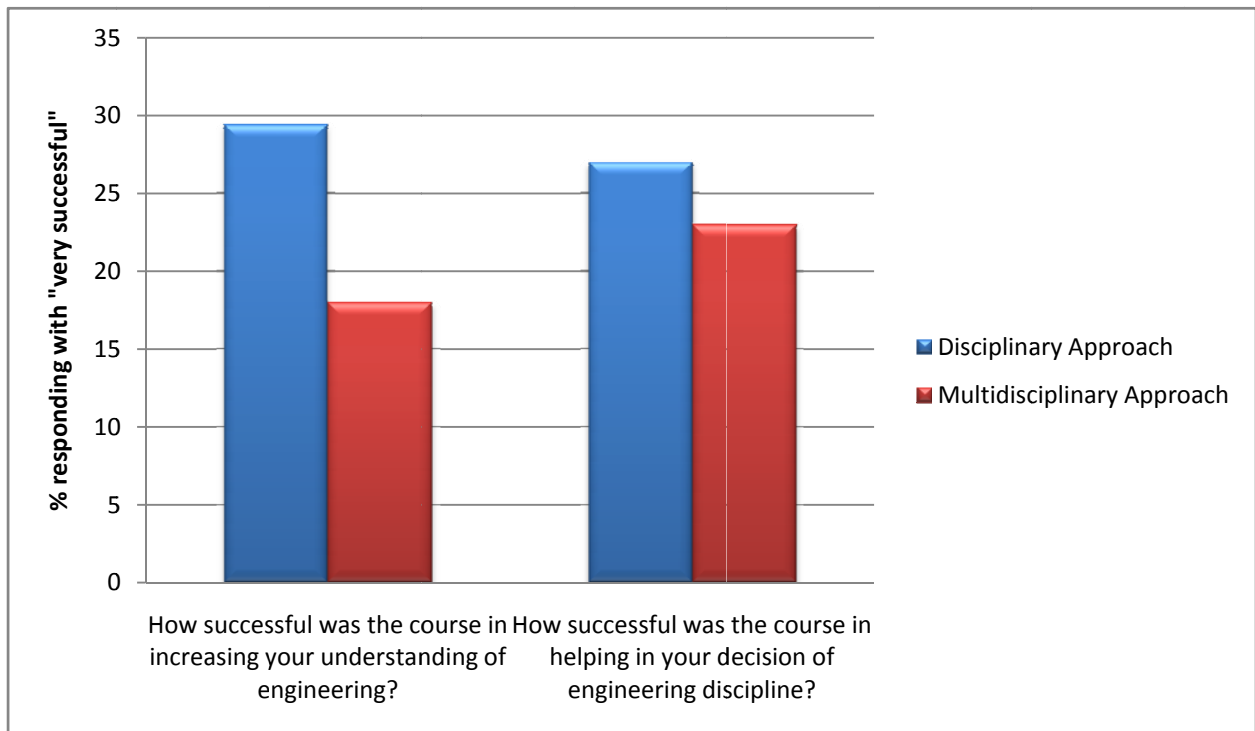


Figure 1. Assessment results of the success of the techniques

The assessment of the ability of the course to increase understanding of engineering and help in the decision of engineering discipline shows that the disciplinary technique was more successful. It is believed that the reason for this rests on the fact that the multidisciplinary technique does not compartmentalize information as well as the disciplinary technique does. The disciplinary technique adheres to the sequential learning style whereas the multidisciplinary technique appeals to the global learning style³. With the multidisciplinary technique, the connection between a career path and its associated engineering discipline is not as direct and clear. This would lead to the perception that the obtained understanding of engineering is not as strong.

It should be noted, however, that true assessment of understanding of engineering is quite difficult. The survey data reflects the students' perceptions of their understanding more so than it does their actual understanding. However, it can be argued that the students' perceptions of their levels of understanding of engineering are crucial to their abilities to make important decisions early in their engineering careers. Perception of understanding leads to confidence in decision making. Therefore, a student who believes he understands engineering is more likely to be comfortable with the decisions he makes in engineering than is someone who does not believe he has an adequate understanding of engineering. Although some may say that a more holistic view of engineering is preferable to a compartmentalized view, the time frame in which most students must make their choice of engineering discipline makes it difficult for the holistic view to have ample time to "set in."

Conclusions

Two techniques were employed in an attempt to assess the best technique to teach first year engineering students about the engineering disciplines. The first technique (called the disciplinary technique) introduced each of the main engineering disciplines individually. The second technique (called the multidisciplinary technique) introduced the main engineering disciplines, as well as a few of the smaller disciplines, through multidisciplinary engineering problems. Survey data taken at the conclusion of the course indicates that the disciplinary technique was more successful in increasing student understanding of engineering and in helping in the decision of engineering discipline.

The multidisciplinary technique has many advantages. If one desires to use this technique, it is suggested that each multidisciplinary project has a component that focuses on the tasks of different types of engineers. For example, the following questions can be posed: "How do industrial engineers fit into this project?", "What types of tasks would a chemical engineer have on a project like this?", and "How would the involvement of a civil engineer and an environmental engineer differ?" In this way, the connections between engineering tasks and engineering disciplines may be stronger and more direct.

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Biographies

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Jennifer Zirnheld received her Ph.D in 2004 and is a Research Assistant Professor in the Department of Electrical Engineering at the University at Buffalo and the Deputy Director of the Energy Systems Institute. Dr. Zirnheld teaches two senior technical electives in the fields of power engineering and electrical devices. She is also the coordinator of and teaches a section of EAS 140, which is the introduction to engineering for freshman in the School of Engineering and Applied Sciences at UB. Dr. Zirnheld's technical expertise is in the areas of, but is not limited to, dielectric phenomena, Power and Energy Management, Generation and Distribution, multifactor stress aging, partial discharge analysis and systems of systems integration. Dr. Zirnheld has been an instructor for, and the course coordinator of, the Engineering Solutions course for the past several years.

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Adam Halstead is a Ph.D student at the University at Buffalo. He received his B.S. in 2005 and his M.S. in 2007, both from the University at Buffalo. His research interests lie in multifactor stress aging of electrical systems and partial discharge analysis. He is also very interested in the investigation and analysis of novel teaching techniques in the engineering field. Adam has been actively involved in the course Engineering Solutions as a teaching assistant for 3 years and as a student assistant for an additional 3 years.