Development of Energy Design Projects at Buffalo State College
to meet TAC/ABET Outcomes

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Students completing their studies in the Mechanical Engineering Technology Program at Buffalo State College (BSC) are required to complete a senior design project. The Accreditation Board for Engineering and Technology (ABET) has developed a set of learning outcomes used to guide faculty in assessing the effectiveness of academic programs. The Mechanical Program uses the ABET's Technology Accreditation Commission's (TAC) criteria to help assess student learning in our courses. TAC/ABET learning objectives help students understand what general skills and knowledge they are expected to have demonstrated upon completion of the course. Prior to entering the senior design course at BSC, students will demonstrate their basic mechanical engineering technology skills by presenting a portfolio of work and passing a comprehensive test. This paper examines the process for students in the energy areas.

Once in the course, students use their skills to propose an applied thermal sciences project to a board consisting of their professor, industry sponsor and student representatives. Their industry-sponsored project requires the student to participate in a small team that designs, builds, tests, analyzes and reports results of various thermal science projects. Several project case summaries will be presented with attention given to student reaction, sponsor grading and instructor comments. Details of the process will be discussed with little emphasis on the technical aspects of the projects. A discussion of anticipated changes to the process will also be presented.

In recent years the makeup and background of students in most engineering programs has changed dramatically. Programs are very diverse in both student motivation and background. In the 1960’s and 70’s the major deviation from the traditional undergraduate student was being a female in an engineering program. The year 2004, brings individuals from various races and countries, some with learning or physical disabilities, traditional students that work part time, nontraditional students (older individuals, supporting a family, working full time - going to school part time), single parents, students transferring from other institutions, students seeking a second degree, and the list goes on. In addition the economic disparity between students is greater than at any other time in the past. While it is said that outside factors do not affect the grade that a student receives in a course, these factors may certainly effect some evaluations. Occasionally a course requirement may be softened because of some unusual circumstance.

Employers require our graduates to be better prepared in more diverse areas. As a result institutions must somehow ensure that their graduates are at least capable of several fundamental skills. Thus the motivation for the Mechanical Engineering Technology Program at Buffalo State College...
College requiring the capstone senior design course. Along with this senior design course comes the problem of effectively evaluating the performance of the student in that course.

Introduction

College enrollment is growing and the make-up of a college classroom is changing with more students attending college in a nontraditional manner. The diversity of students in the mechanical department at BSC (see Table 1) is similar to many institutions. It is made up of males and females, African Americans, Hispanic Americans, Native Americans, Asian Americans and foreigners. However, the typical individual enrolled in our program is a caucasian, employed (working full or part time in an industrial position), male student that is a resident in our geographic area. Many of our students are transfer students that may have a college degree. Almost any course on a student’s transcript can be transferred from a previously attended institution. Students currently in our department have transferred as much as two years of college credit from more than fifty different institutions. Along with accepting transfer credit comes the question of preparation for the next course in the technical sequence. While a student may have received credit for a course in thermodynamics or fluid mechanics taken at another institution, it is important to know what was covered and in what depth? Faced with this mix, the main concern that we are facing is how to ensure that the students that we are sending into industry are truly prepared and ready to contribute.

Table 1. Student Ethnicity Data at Buffalo State College

<table>
<thead>
<tr>
<th>BSC</th>
<th>African American</th>
<th>Asian</th>
<th>Caucasian</th>
<th>Hispanic</th>
<th>Native American</th>
<th>Non Resident Alien</th>
<th>Undisclosed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.4%</td>
<td>1.3</td>
<td>69.2</td>
<td>3.7</td>
<td>0.5</td>
<td>0.8</td>
<td>14</td>
</tr>
</tbody>
</table>

When a degree is granted to a student, it is important that the student be familiar with several important principles from each course. To certify to potential employers of our graduates that our student’s posses certain basic skills upon graduation, a diagnostic test is taken by seniors before they are allowed to take the senior capstone course. Many institutions have a senior design course, each having their unique requirements and taking on its own look. For many institutions the course is mainly a design project that is completed by a senior during the students last semester. Emanuel and Worthington¹ discuss how the senior design course evolved at Bradley University and discuss potential changes that need to be made in the course. Experiences at Purdue University/Calumet are discussed by Pierson². Here a two course sequence, utilizing the team approach, is in place. Projects involving the design, construction and testing of a device is used to bridge the university-industry gap. Neff, Tickoo and Abbas Zahraee³ discuss the advantages of the urban setting in creating "real life" senior projects at Purdue. Like Purdue, Louisiana State and the University of Alabama also utilize two semester courses. Yannitell and Cundy⁴ describe Louisiana's experiences while Parker, Midkiff and Kavanaugh⁵ discuss
Alabama's program. At Alabama, students participate in a competitive design project during the first part of the first course and during the rest of that course, as well as the second course, the students focus on a single, external, industry-sponsored project. Rochester Institute of Technology's (RIT) College of Engineering is a co-op based program that encourages their students to seek projects for their "Design for Manufacturing" course from their co-op based sponsors. Freckleton\textsuperscript{6} talks about design course experiences at RIT. Senior capstone courses are not unique to only mechanical or manufacturing programs. Hodel and Baginski\textsuperscript{7}, Emery and Lin\textsuperscript{8}, Rude\textsuperscript{9} and Bekkala, Higgins and Lekhakul\textsuperscript{10} describe their senior design courses in electrical engineering. Wheeler and Anderson\textsuperscript{11} discuss experiences since 1985 at the University of Memphis in the senior design course for Civil Engineering. McDonald et al.\textsuperscript{12} discuss the relatively new concept of a multidisciplinary design team that is used at Lake Superior State University. This is an excellent approach for the senior capstone course, but one that is very difficult to coordinate.

The Accreditation Board for Engineering Technology (ABET) currently requires a capstone design requirement for programs. This senior design course is probably the most critical course in the student’s education. It requires a considerable time commitment by students, sponsors and instructors. The course at Buffalo State College provides mechanical majors with interdisciplinary creative design and problem solving experience. The ability of the student to effectively manage a project, as well as to interact with the other team members on projects that stretch over several disciplines are hard lessons to learn early in a career. It is felt that this exposure to these concepts while still in school better prepares our students for their early positions and advances students currently employed. Some students become very interested in the project that they are assigned to and go well beyond the requirements of the project.

At the Buffalo State College, the design project is completed utilizing a design team that is responsible for the project from conception to completion. Additionally several other aspects have also been included in the course that help us ensure a quality graduate in the mechanical field. The most talked about requirement amongst students is the “diagnostic exam”. In order to sit for the exam, the student must first provide a detailed portfolio of student work that demonstrates their experience in the various required courses. When that requirement is satisfied, the student is allowed to sit for the exam. Exam content varies from year to year and includes multiple choice and long hand solution problems. The test is open book, approximately 6 hours (over two sessions) in length, with questions coming from all the required courses in the curriculum. A student has three attempts (the test changes each time) to pass (> 60%) the diagnostic test before being allowed to register for the course. After three attempts, if the test isn’t passed, the student must take the course the next time it is offered. The next major task in the course is the design project. This usually takes place in local industry, with the team of students reporting back to the class on the progress of the project. Additionally, there are several minor design projects, one of which is to develop a web site that is used to report the results of the project. The culminating senior course changes slightly each year, but utilizes the same basic requirements.

The senior design course was structured to include several engineering principles that are covered indirectly in the various core courses. It is designed to give the student the necessary tools so that an efficient design can be arrived at regardless of the product or process being
developed. A partial list of the course topics include: design process, design teams, engineering management, engineering ethics, professionalism, project management, failure analysis, optimization in design, concept generation, financial considerations, concept evaluation, product design, product specification, product generation, product evaluation, proposal generation, final project assembly and oral/written presentation. Creativity of the design is emphasized with imagination and learning from mistakes is also encouraged. The course takes a product from proposal through concept development to final production and product evaluation. This process is completed by a team of three or four students within the semester. Results are presented in a student developed web site.

There is a certain amount of group work involved in the senior design course; however the weak student cannot hide in the group. All group members are required to be part of the group’s oral and written presentations. Upon completing this course, students perform a self evaluation of goals achieved and discuss the difficulties of attaining the goals that were set forth at the onset of the project. Professors and sponsors evaluate each student in a number of different skill areas. Student members evaluate each others skills in those same areas.

Evaluation

Diagnostic Exam
The comprehensive exam is a two part (six total hours) exam that evaluates the students knowledge of the required courses in the curriculum. A student may have taken these courses at BSC or another institution. The topics are fundamental in nature, however because of the nature of the test and the breadth of the subject areas, it makes for a very difficult evaluation. Therefore the students are allowed three attempts at passing this test. The three sets of tests are offered within a four week period of time. Each time the test is offered the makeup of the test changes. Roughly 25 - 30 percent of the students receive a passing grade each time it is offered. The students that do not pass the course are not allowed to register in the course and are required to take the course the next time it is offered. As one can imagine this adds even more stress to the taking and evaluation of this course.

The evaluation is a written with several areas tested during each session. Three long calculation areas and one set of short answer questions typically make up the format for a single test session. Question content comes from instructors that teach the courses at BSC as well as old test questions from EIT review books. Graded tests are returned to the students for review (tests are kept on file by the instructor), and correct solutions are posted for limited viewing (during classtime). If they did not pass the test they must take another test during the next test session.

Senior Design Project
After passing the exam, the students start work on their senior design project. They are presented with a variety of potential projects or they may come up with an approved project from their employer. A sponsored project from the student’s employer must be unpaid and at a technical level higher than the student’s responsibility level. Initially students will spend some time developing a proposal that outlines the work they hope to accomplish during the project. An evaluation board is made up of the class professor, student members and representatives from the
sponsoring organizations. The students must answer to this board and ultimately to the sponsor that they are doing the project for. Initially the students must present their work to the board, with the board members ensuring that proper procedures are being followed. Each board member evaluates the work and writes comments. Evaluations are given to the students after their presentations. If the board requires additional work, the group would have to resubmit their proposal before they could proceed to the sponsor submittal step.

Once the proposal has been accepted by the board, the proposal must be submitted to the sponsor. This proposal is the agreement between the student group and the sponsor on what is required by the group, when it will be delivered and the various responsibilities on the project. A good deal of work is done in the proposal stage, this virtually eliminates any problems that may come up when the students think they have completed their project.

Each group is required to make a short weekly presentation to the board and the presentation is evaluated using a rating system with the results being returned to the group. A mid-project report and final report similar to the initial proposal is also required. The final report is a summary of results and includes a recommendation for future work. Periodic video taping of the oral presentations are made and the video is self evaluated. Additionally these videos are utilized for ABET site visits. If the groups have done their work all along and have taken the suggestions of the board and industry supervisors into consideration this final report is very easy to put together since it is simply an assembly of all their previous work.

Summary

As one can imagine this course is not a course that the students initially think they would like. However it does evolve into certainly the course that students have the most memories of and for many students their most meaningful course. It is well received by all sponsoring industrial members not only because of the exceptional work that our students provide, but because it allows many of the companies to pick the best MET graduates. Many nontraditional graduates either change positions or receive promotions as a result of their project. All in all it is a very demanding, yet a very satisfying course to teach.

Some written comments from recent self evaluations performed by graduates regarding the senior design course include:

- “I think that this was the best class in the program.... The objectives of the course were clearly defined at the start and seemed very consistent with how our design project evolved. The class format emphasized the real world rather than a traditional class.... I think that the hands-on project was definitely an important exercise in preparing oneself for the real world of engineering.”
- “I felt the way that everyone in the class was forced to get up in front of the class every week and give a small presentation is one of the greatest things that this class can offer to an undergraduate student getting ready to go out into the work force.”
- “Truly this course has been the greatest challenge for me. To balance work, school, community commitments while at the same time forget the family and home

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Responsibilities. I speak as a part time student with these sacrifices but would hate to experience this (senior design course) as a traditional student taking a full course load”

- “Although challenging, time consuming, and all encompassing, this class was a great learning experience. The refresh of what was learned in previous years via the diagnostic exam is a great way to evaluate a student and a great way for a student to evaluate him/herself.”
- ".... I enjoyed my experiences in this class. From the diagnostic exam to the senior design project this class gave the chance to experience a large portion of what it is like to be an engineer.... I believe that the diagnostic exam was a very important part of this class. It forced me to review all the subjects that I have taken and may have forgotten about...I don't believe that the exam was all that difficult, it was just a lot of material to cover."
- "It (the senior design course) gives the student experience and confidence in the acquired education."

One comment from a first generation college student that was important to receive went on to say..."I know it seems that I got off to a bad start.....This semester has been a great learning experience and it is very clear that this is the beginning of a much larger experience..." The same student when discussing the evaluation of the final project by his peers: "...they even gave me a complement on the final product. That was a big reward. I had never received that before. Now that I know what it involves, I know more of what is expected and of what to expect. I am being compared to men who have been in the field for years, or men who have resources through their business.... I am graduating this semester and I'm looking forward to a better life of hard work, accomplishments and respect."

As can be seen from the comments, this course has offered a little something for everyone. Not every student liked every portion of the course; however the course provides a challenging environment that upon completion produces a well qualified student. BSC students are well received in industry and sponsoring companies are eager to participate in the program.

Bibliography


