Implementing ABET Engineering Criteria 2000  
for New Programs at a Small HBCU

Abstract

The School of Engineering, Science, and Technology at the Virginia State University (VSU) had three of its programs undergo a joint review by the Engineering Accreditation Commission (EAC) and the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET). These are fairly new programs at a small size HBCU with a student population of 5000. Evaluating all three programs simultaneously allowed synergy, but it also necessitated coordination at the institutional level. Additionally, it required the support and cooperation of non-reviewed programs. The Department of Engineering and Technology had two programs reviewed by the EAC and the Department of Mathematics and Computer Science had one program reviewed by the CAC, respectively. There were many similarities and differences between the two, requiring internal controls, timelines, and processes to ensure correct completion of the requirements. Course and outcome coordinators and other faculty needed guidance in preparing for the visit, managing additional administrative loads during the record year, and in understanding how assessment improves their programs. This paper presents some of the unique challenges of accreditation for new programs at a small HBCU setting and solutions for implementing the required criteria. Although all of the areas mentioned above are discussed in the context of the VSU, they should prove useful to any institution preparing for an ABET visit.

Introduction

The Accreditation Board for Engineering and Technology (ABET) has changed the way computer science, engineering, and technology programs are accredited from a “checklist” approach to an “outcomes-based” approach. While this approach gives more freedom to the program to establish its own set of objectives, it has also created considerable anxiety among people who are responsible for preparing their programs for accreditation. One of the criteria for accreditation set by the ABET requires all undergraduate engineering programs in the United States to demonstrate that their programs produce 11 (a-k) specific learning outcomes (ABET Criterion 3). These outcomes are specific abilities, knowledge areas, skills, and attitudes that all students should possess upon completion of the undergraduate engineering program. ABET reviewers look through self-evaluations and assessments for these outcomes. Engineering and Technology programs conduct annual reviews to determine which outcomes are met by the courses in their respective curricula. If a specific outcome is not met, faculty is required to develop and implement plans for improvement. These plans may include development of new courses or modifications to existing courses. Programs must also document changes and eventually show that the changes resulted in improvements.

Lessons Learned

According to the 2006–2007 Criteria for Accrediting Engineering Programs, engineering programs must demonstrate that their students attain:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for and an ability to engage in lifelong learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Engineering programs must also demonstrate that graduates have the capability to apply advanced mathematics (including differential equations and statistics). ABET 2000 criteria are based on the principles of outcomes assessment and a continuous improvement process relating educational objectives to the curriculum and to educational outcomes. Some lessons learned and innovative approaches in the new ABET accreditation process at VSU in this first visit are presented.

**Capstone Senior Design Course:**

Capstone senior design experience is both a graduation requirement for undergraduate engineering majors and for ABET accreditation of these programs. A senior design course is typically the last bridge for students between undergraduate education and the engineering profession in their respective disciplines. The course differs from other lecture and laboratory based courses in the engineering curriculum in fundamental ways. Many capstone senior design courses include lectures to develop students’ knowledge of the product development process, project management, professional engineering practice, and the regulatory, legal, ethical, and economic aspects of design. They also provide students with the opportunity to develop design, communication, and interpersonal skills through a team based project experience. Many of the ABET Criterion 3 Learning Outcomes focus on the development of the same knowledge areas and skill sets emphasized in senior capstone design courses. Thus, these courses can play an important role in helping undergraduate engineering programs meet many of the ABET learning outcome requirements. A thorough assessment of a well designed senior capstone design course can indicate to what degree the course can assist the program’s efforts to meet the requirements. Self-assessment of the capstone senior design courses can result in a list of performance criteria that could be used to indicate that a specific learning outcome was being produced (performance indicators). Accordingly, a list of assessment tools such as exam questions, final reports, oral presentations, and other course deliverables that could be used to demonstrate that performance criteria were met can be developed.

The faculty at VSU has created an extensive set of guidelines for the senior design course. These guidelines, in addition to directing the students to take the necessary actions to fulfill the requirements of the senior design course, guide them through ABET a-k requirements and how
they can be observed in different stages of design process. The course was also equipped with a comprehensive set of assessment tools. Both self-assessment of the course by students, and assessment by faculty members were considered. The results of the assessment indicated that upon completion of the two semester capstone senior design course most students were demonstrating the abilities, attitudes, and mastery of knowledge required by ABET learning outcomes a–k. There were components of the course that contributed (to different degrees) to the production of each of the learning outcomes. For example, because of the project team experience, the course played an important role in producing outcome d, that is, the ability to function on multidisciplinary teams. However, due to the structure of the course, it played a negligible role in producing outcome i, the recognition of the need for, and an ability to engage in lifelong learning.

In the capstone senior design course, Outcome C (ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability) was assessed using the following performance indicators:

- design constraints
- provide alternative solutions
- define problems to be solved
- define project scope
- compare alternative solutions
- defend selection of final design
- build prototype to meet needs
- validate performance of prototype.

These performance indicators were evaluated using the following assessment tools (team-written documents that are required deliverables of the courses):

- Project Definition Document: contains project objective statement (which defines problem and project scope), existing solutions, customer needs, and design constraints
- Generated Concepts Document: contains potential solutions generated by project team
- Final Concept Document: defends selection of proposed final design
- Experimental Verification Document: contains test protocols, test results, data analysis, and conclusions regarding how well prototype meets performance requirements
- Final Report: contains final design, test results, information regarding how well customer needs were met
- Prototype

Mock Visit:

It is always a good idea to get a second opinion from experts in the field. In this case, Criterion 4 (Professional Component) and Criterion 5 (Faculty) allude to interactions with industrial and professional practitioners as well as employers of students. The involvement of the Industrial Advisory Committee (IAC) provided a very useful resource to the programs in establishing educational objectives and defining associated measurements of student outcomes. Following recommendations made by IAC, data regarding the School’s outcomes assessment and strategic plans was collected. The programs were assisted to define their Program
Educational Objectives (Criterion 2) and Program Outcomes (Criterion 3). This enabled each program to develop or re-define its mission statement, to develop outcomes based course syllabi, and to map the outcomes to program educational objectives. Additionally, this led to an ABET EC 2000 Mock Visit. The objectives of the Mock Visit were to visit the laboratory facilities, conduct interviews with faculty and students, evaluate the first draft of the individual EC 2000 self-study reports, and to offer candid comments and recommendations to incorporate assessment and continuous quality improvements within the programs. The results from the Mock Visit were an eye-opener for many of faculty and provided the vital external feedback on the readiness status.

Outcome Coordination:

Each member of faculty was requested to dedicate a few hours of work a week for this ABET accreditation effort. Each faculty member reviewed course descriptions and stated which outcomes and objectives that course descriptions supports. Individual faculty members took responsibility for two ABET outcomes/components each. They were asked to review the pertinent courses for appropriate inclusion, and bring up courses that were left out that should be included. Most importantly, the faculty came up with a monitoring mechanism and feedback mechanism for each outcome and component. Additionally, each faculty was responsible for a course that uses lab facilities to write up what facilities the course requires, and how these needs are being met. Faculty also provided a brief bio. So, a big task was accomplished while the faculty only spent a few hours a week as outcome coordinators.

Outcome Fusion:

ABET requires all undergraduate engineering programs in the United States to demonstrate that their programs produce 11 (a-k) specific learning outcomes (ABET Criterion 3). Meanwhile, the programs should develop assessment tools to show that these outcomes have been achieved in the designated courses. Lack of evidence to show this compliance will result in deficiency and therefore accreditation will not be granted. While the outcomes can be combined together or decomposed into smaller components, the task of providing evidence for outcome achievement stays the same. That is, every required outcome has to be properly assessed and reported regardless of whether it is joined or disjoint with other outcomes. At VSU, one program decided to combine outcomes a and e so that the faculty would only have to handle 10 outcomes. Another program broke some of the outcomes into 2-3 components and ended up with 14 outcomes. Both programs went through the accreditation successfully. However, the faculty load in keeping up with 14 outcomes was heavier than 10 outcomes. The only challenge in combining outcomes is to do it carefully so that the ABET requirements would not be sacrificed.

Faculty Communication:

Changes in ABET accreditation criteria and processes have changed the emphasis of the preparation for site visit from “auditing” to “information exchange”. One of the most important tasks of faculty in the continuous improvement plan of ABET is to keep up with faculty assessment of courses and program and student self-assessment of learning outcomes from student entry into the college until five years after graduation. Instruments were developed for
this task and were administered to incoming freshmen and graduating seniors. Due to the fact that the programs are fairly new, the alumni survey has not been conducted yet, but an extensive alumni survey has been planned. Engineering faculty were engaged in virtually all levels of planning, implementation and use of the information for instructional improvement and ABET accreditation. This requires strong collegiality and communication between the faculty, and faculty and administrators.

**Surveys:**

Both regional and professional accrediting agencies are placing a stronger emphasis on outcome assessment. As such, the new ABET accreditation criteria puts strong emphasis on outcome assessment. Outcomes assessment means information about graduates is gathered, evaluated, and used to plan future improvements of both courses and curricula. Too often the collection of assessment data is incomplete or biased because it is frequently based upon oral feedback from alumni. Rather than relying on anecdotal information, the faculty at VSU have employed an online system (EBI) for gathering a significant amount of data that can provide meaningful and reliable information about the quality of programs. In addition to data gathering, the system in place also performs some preliminary evaluation of data, both in the quality of data being gathered and in the effectiveness of the process. There are four easily developed sources of data: (1) student exit interview; (2) an external advisory committee; (3) alumni interview for program objectives (3-5 years after graduation); and (4) corporate feedback requests.

Additionally, every semester and in every course, feedback from students is gathered where they are asked to rate how well they have mastered the ABET Program Outcomes in their respective programs. While ABET has gradually advised programs to de-emphasize such sources of evidence, the practice continues, and it was felt that a study related to the validity of such student feedback would be useful to the accreditation process. Preliminary results indicate that students have a limited ability to predict how well they are prepared for or have performed on exams. This feedback along with faculty assessment of the course and program outcomes results in a system-wide continuous quality improvement plan. The plan includes the courses restructuring to reflect meeting the ABET 2000 criteria, providing feedback for faculty members, and for assessing the way in which the educational objectives, program outcomes, and learning outcomes are being met. In order to facilitate the effectiveness of learning outcomes several short surveys were developed for some programs while others are in the process of development. These targeted student performance, faculty perception, and student perception regarding learning outcomes in each specific program and course.

**Industrial Advisory Board (IAC):**

The use of voluntary advisory boards in engineering education programs to give aid and advice is almost universal. External industrial advisory committee plays a crucial role in both implementation and preparation for ABET accreditation of an engineering program. The industrial advisory committee consists of members from both academia and industry that are selected based on their credentials and national standing in their fields. The committee serves as a group of critical friends and provides constructive advice on how to improve implementation of the program, keeping in mind the purposes of the original award: to increase the quality and
quantity of under-represented minorities who earn degrees in science and engineering. Recommendations from the committee have positively impacted the program and the university. Based on the positive influence and recommendations of the committee, the School of Engineering adopted its own student advisory board to reflect student concerns. The School then went to the next level and developed a strategic partnership with some of the companies in the region to prepare for ABET accreditation visit. The IAC at VSU has been very instrumental in providing advice, student mentoring, review of curriculum, review of self-assessment, and providing jobs for graduates.

**Conclusion**

Each course in the curriculum contributed to the production of some of the learning outcomes. However, when assessed along with other courses in the curriculum, the program was shown to produce all of the ABET learning outcomes. Therefore, with a careful identification and assessment of appropriate performance indicators using the appropriate assessment tools the faculty can help engineering programs determine the role of their capstone senior design course in producing the desired ABET learning outcomes. Tables 1-4 show information regarding the assessment process, other course outcomes examples and some sample survey results.

**References**


<table>
<thead>
<tr>
<th>Program Outcomes Performance Criteria</th>
<th>Assessment Tools</th>
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<tbody>
<tr>
<td></td>
<td>Faculty Assessment of Student Work</td>
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<tr>
<td>2. the ability to design and conduct experiments as well as to analyze and interpret data</td>
<td></td>
</tr>
<tr>
<td>i. Experiment design</td>
<td>2.0/4.0</td>
</tr>
<tr>
<td>ii. Execution of experiment procedures</td>
<td>2.0/4.0</td>
</tr>
<tr>
<td>iii. Data analysis</td>
<td>2.0/4.0</td>
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Table 2  Summary of Faculty Assessment of Student Work

<table>
<thead>
<tr>
<th>Program Outcomes Performance Criteria</th>
<th>Courses</th>
<th>4 Ex</th>
<th>3 Pr</th>
<th>2 Ap</th>
<th>1 De</th>
<th>Mean</th>
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<tbody>
<tr>
<td>1. the ability to apply knowledge of mathematics, science, engineering and statistics to identify, formulate and solve engineering problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>i. Applying Math (Calculus, Differential Equations or Discrete Math)</td>
<td>CPEG 413</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>ii. Applying Science (General Chemistry I or Physics)</td>
<td>ENGR 204</td>
<td>13</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>iii. Applying Engineering</td>
<td>CPEG 303</td>
<td>5</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>iv. Applying Statistics</td>
<td>ENGR 204</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3.8</td>
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<tr>
<td>v. Student identified a problem and formed a pathway to the solution</td>
<td>ENGR 204</td>
<td>4</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>vi. Student executed the pathway and came to a conclusion</td>
<td>ENGR 204</td>
<td>4</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>2.6</td>
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Table 3  Summary of Faculty Assessment of Senior Design Projects

<table>
<thead>
<tr>
<th>Program Outcomes Performance Criteria</th>
<th>Faculty Rating</th>
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<tr>
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<td>Fall 2006</td>
</tr>
<tr>
<td>2. the ability to design and conduct experiment as well as to analyze and interpret data</td>
<td></td>
</tr>
<tr>
<td>i. Experiment design</td>
<td>2 1 3 2.0</td>
</tr>
<tr>
<td>ii. Execution of experiment procedures</td>
<td>2 2 3 2.33</td>
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<tr>
<td>iii. Data analysis</td>
<td>1 2 3 2.0</td>
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Table 4  Summary of Senior Exit Surveys

<table>
<thead>
<tr>
<th>Rating of Confidence in the Each Program Outcome Area</th>
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</thead>
<tbody>
<tr>
<td>Seniors 2006-2007 Mean</td>
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<tr>
<td>(1) Very poor, (2) Poor, (3) Fair, (4) Good, (5) Very good, (6) Excellent, (7) Exceptional</td>
</tr>
<tr>
<td>(2) the ability to design and conduct experiments as well as to analyze and interpret data</td>
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<tr>
<td>5.74</td>
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