AC 2007-764: FIRST-TIME ACCREDITATION OF A SMALL, MULTIDISCIPLINARY ENGINEERING PHYSICS PROGRAM

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First Time Accreditation of a Multi-disciplinary Engineering Physics Program

Abstract

In 2006, Tarleton State University successfully achieved ABET accreditation of Engineering Physics, its first engineering program. This Engineering Physics program is a multidisciplinary engineering program with emphases in electrical engineering, computer engineering, and materials physics. Several challenges above and beyond the proof of continuous improvement in Criteria 1-8 had to be overcome to accomplish this accreditation. Tarleton State is a traditionally liberal arts school and serves a predominantly rural area with only a few local engineering industries. Also, the program name, Engineering Physics, is not widely understood by college seekers and even industry recruiters, because these programs often have different foci at different places. Thus, the challenge was to build a quality program that measured up to ABET standards subject to these constraints. The success of the effort lay in the development and implementation of procedures used to address each of the criteria and extensive involvement of an industry advisory board. The author of this paper was the coordinator of this accreditation effort and this paper provides an overview of the structure and process used by this group to address the challenges of a successful accreditation effort.

Introduction

Tarleton State University, part of the Texas A&M University System, began implementing its first engineering program, Engineering Physics, in 2000 with the stipulation that it become ABET accredited by 2006. This Engineering Physics program is a multidisciplinary engineering program with emphases in electrical engineering, computer engineering, and materials physics. Tarleton is a medium-sized, traditionally liberal arts university that serves a predominantly rural area with only a few local engineering industries. Tarleton historically offered calculus, calculus-based physics, and lower level engineering courses prior to 2000, but students were required to transfer to complete an engineering degree. Furthermore, it is not, to this day, widely understood what an Engineering Physics program is. The challenge was to implement a quality educational program subject to the constraints of being a rural university and lack of name recognition.

The key to the success of the accreditation effort was to create a process that demonstrated compliance with ABET criteria while also targeting the constraints of the problem. A team of faculty, called the Engineering Physics Oversight Committee (EPOC) was established to develop and implement the process. A management plan was also developed describing the division of responsibility amongst the team as well as the implementation of an external advisory board.

Training

It was very important to attend sessions and review literature related to ABET accreditation. The ABET workshops[1] and Institutional Representatives Day[2] were extremely useful in establishing terminology and exchanging ideas about assessment techniques. The author attended ABET sponsored workshops, attended sessions at ASEE and FIE Conferences, and reviewed relevant literature. Synopses were presented to the rest of the faculty in the program to ensure everyone was aware of the requirements. This training served as the foundation for the entire process.

Management Plan

First, a management plan for the program was drafted and approved. The objective of the management plan[3] is "to establish the organization and procedures necessary to assure that the Engineering Physics Program of Tarleton State University provides education to our students that meets the educational objectives of this program, Tarleton State University (TSU), the Texas A&M System, The Texas Higher Education Coordinating Board and Accreditation Board for Engineering and Technology (ABET)". The management plan defines the program constituents (students, industries, and graduate programs), establishes the program oversight committee, and establishes an external advisory board. It was established in fall 2003, one year prior to the start of the self-study year.

It is critical that the management plan is a "living document". Each time a change is made in the faculty, the advisory board, or the overall objective of the program, this change is dated and documented. The resulting paper trail makes it easy to document evolution of the program management and external advisory board, which is an important part of the accreditation documentation.

EPOC

An advantage of being a small program is that everyone gets to, or has to, be heavily involved in the accreditation process; thus everyone is in the loop and very aware of the procedures. The first item in the management plan is formalization of the team. The faculty team, EPOC, consists of the Engineering, Physics, and Computer Science faculty, plus the department head. The mission of EPOC as defined by the management plan is to "provide overall program direction and implementation of program management activities for the Engineering Physics program of Tarleton State University".

EPAB

As stated earlier, two challenges faced by the program were the lack of recognition of the name "Engineering Physics" and the rural nature of Tarleton's location. A key to addressing these was the establishment of an external advisory board. Thus, the second item in the management plan is formation of the Engineering Physics Advisory Board (EPAB). The mission of EPAB as defined by the management plan is to "represent the needs of the external constituents of the program (employers, graduate programs and others) that may accept Engineering Physics students by providing guidance to the program in an ongoing process to ensure the achievement of the educational objectives of the program". Initial membership was solicited from local industries (FMC and Fibergrate), the nearest large industries (Lockheed Martin and TXU Comanche Peak), and from faculty connectivity (Motorola and Texas Instruments). Membership continues to grow and now includes graduate programs and other Dallas/Fort Worth industries.

A key component of this accreditation process was the extensive use of the advisory board in the development of the Program Objectives and Outcomes (defined consistently with the ABET definitions). EPOC posed the question to EPAB regarding characteristics of a newly hired college graduate or graduate school admit as well as the characteristics of employees or researchers poised for successful careers. The two groups brainstormed on what the graduates should be able to do 2-5 years after graduation, EPOC compiled the list into a set of program objectives, and EPAB approved it. Although ABET prescribes criteria 3a-k as inclusion in program outcomes, EPOC and EPAB again collaborated to ensure both sides knew the national accreditation expectations plus developed an additional program outcome that reflects the uncommon interdisciplinary nature of this program.

Program Responsibilities

The next item was to establish the responsibility areas and assign faculty. These responsibilities were generated by EPOC and approved by EPAB. The responsibility areas are defined as: each of ABET Criteria 1-7 (Criteria 8 was not applicable to Engineering Physics at the time), ABET coordination, advisory board and industry relations, FE coordinator, and web page coordinator. Each faculty member had at least one area to which he or she was assigned. The EPOC chair managed the overall process, working closely with the department head.

Program Procedures

Once EPOC, EPAB, and the responsibility areas were defined, the associated procedures were developed and approved by EPOC and EPAB. It is important to note the involvement of the constituents in this process and that this was not simply a product of the faculty. The procedures document[4] represents "a systematic approach to continuous improvement of the program and conformation to the requirements of ABET".

The procedures document was developed using a requirements analysis methodology. The top level requirements are the responsibility areas defined in the management plan, which served as an outline for the procedures. EPOC, with input from the advisory board, then established the specific issues and procedures needed for each area.

Assessment Plan

An assessment plan was developed for the data collected related to Criteria 1 through 7. The assessment plan includes an assessment-to-criteria mapping, which is a matrix relating each tool to the criteria it assesses. This matrix allows one to quickly identify tools that are not assessing criteria or criteria that are not being assessed. The assessment plan also defines what information is collected from whom and the frequency the data is collected.

One of the most important parts of the assessment plan is the establishment of "triggers". For each assessment tool, thresholds were set that would cause EPOC to take action on that item. The process must be closed loop, and the means by which the loop closes must be defined.

Student Database

Much of the data and assessments done in this program were initially quite feasible due to the small size of the program. These methods were well received by the visiting team, but the question arose as to how to maintain our level of interaction with students as the numbers grow. To address this, a student database was developed in which data is kept including student characteristics when entering, when the student left the program, academic standing when the student left, program standing, where a student transferred and what major. This allows us to compile data regarding a multitude of factors such as success rate for students who start in pre-calculus, success rate for students from the second quarter of their high school class, trends in student transfer attrition, etc.

Data Compilation and Reporting

It is extremely important in the ABET process to not only have a process, but to use the results from the process for continuous improvement. The implementation of each of these procedures is continuously documented and a summary report is presented to EPOC annually. Based on this report and the results of previous actions, EPOC establishes the following:

- Specific changes to curriculum, facilities, students and/or faculty as appropriate.
- Estimate of the results of changes
- Estimate the length of time necessary for changes to produce desired results

Procedure 1.0 – Criteria 1

Criteria 1 encompass the procedures related to admission, academic advising, and tracking of students. Each of these areas is addressed with specifics in this section of the procedures document. This area is particularly important to the engineering physics program because one of the recruiting points for our program is the close attention we pay to our students and their progress. Furthermore, the discussion here demonstrates the basis on which the procedures were established.

Admission: A three-tiered major declaration system was established to assist with quality control and major management. Several factors contributed to this structure. First, many students in Tarleton's main service area are not sufficiently math-ready to enter engineering coursework, with some requiring math remediation. Our data thus far show that students that are not at least pre-calculus ready have a near zero success rate in engineering. However, we do not want to write these students off, but rather maintain contact with them until they are stronger academically. Furthermore, there is not a large awareness in the K-12 schools in Tarleton's service area about what an engineer truly does. Thus incoming students often think they want to be engineers but are overwhelmed by the math requirements. Incorporating these "false starts" into already small population numbers makes the attrition in the program look very high. To help classify likely false starts and math preparation issues, but not lose track of them, and thus help identify potential retention issues, engineering students who are not pre-calculus ready or better, as determined by placement policy in the mathematics division, must declare their major as PREN (pre-engineering). Incoming engineering students qualified to enroll in pre-calculus or higher, declare their major as ENGR.

Since Tarleton has a long history of offering the first one to two years of the typical engineering curriculum, many students still come here to start their engineering coursework and transfer to another institution to finish in a discipline not offered by Tarleton. Again, this causes difficulty in identifying retention problems because the students are not leaving engineering. For example, our first engineering physics graduate started with a class of 20 freshmen. Graduating one student out of a class of twenty appears to be poor retention, when in reality approximately half of those students transferred in engineering. Furthermore, EPOC noted that true attrition occurred in students that were barely passing their lower level math, physics and engineering coursework. The university defines a grade of D or better as passing, but students earning D's in their foundational coursework were simply too ill prepared to be successful in their upper level coursework. To address the problems of transfer attrition and to establish a quality control point, the third tier of the major declaration system was established. Students must earn a "C" or better in select foundational courses before they qualify to declare their major as ENPH (engineering physics) and obtain admission into upper level courses in the engineering physics curriculum.

Students who are transferring typically do not take upper level engineering physics courses and do not apply for admission. This helps us identify at the midpoint of the sophomore year, the students who will be staying for engineering physics.

Advising: To ensure students have proper guidance through the curriculum, each PREN, ENGR or ENPH student is assigned an academic advisor upon entering the department. Students are required to meet with their academic advisor before registering for the spring and fall semesters. Registration blocks are used to enforce this. Advising records are kept and the advisor checks the student's advising record against the student's transcript at each academic advising session. These advising sessions provide a mechanism by which the faculty meets face to face with the student at least once per semester and discusses relevant issues, such as academic performance, internship opportunities, post-graduation plans, etc.

Tracking: As quality control, student progress and course requirements are thoroughly scrutinized. Compliance with pre- and co-requisites are verified prior to the start of each semester for each course in the curriculum. The Banner registration system handles most of this. The academic performance of each student is reviewed by the student's academic advisor at the end of each semester to ensure the meeting of program requirements. Each student will be classified into one of the following categories: good standing, warning, probation, and suspension. Probation requires a contract with the student for continuation in the program.

Procedure 2.0 – Criteria 2

The procedures in this section define the data to be taken as evidence of achievement of the program objectives. Much of this data is from surveys. Immediate graduates are surveyed to establish a baseline of their perception of their own preparedness. At one, two, and five years after graduation, graduates are surveyed again regarding their preparedness. In this survey concrete data regarding advanced degrees, professional development, and career advancement are also collected. With permission from the graduate, information is collected from their current supervisor (either industry or graduate school) as a third party assessment.

In addition, the procedures document states that EPOC will review the program objectives every two years against the program, department, college, and university missions as well as against the needs of our advisory board.

Procedure 3.0 – Criteria 3

The procedures in this section define the data to be taken as evidence of achievement of the program outcomes. EPOC and EPAB jointly agreed the outcomes to be defined as ABET Criteria 3a-k plus an additional criterion related to the multidisciplinary nature of the program stating "a depth and breadth of knowledge in engineering and physics necessary to work in a multidisciplinary environment".

This data cannot exclusively be graded student work. Data are collected from faculty using a variety of tools.

- Course Evaluation Form: At the conclusion of each semester, this form is completed by the instructor of each course in the curriculum offered that semester. This tool surveys the faculty opinion and proposed modifications to the text(s), facilities, equipment, content, student preparation, or any other aspect of the course requiring attention. The form is kept by the instructor for future reference; a copy of the form is filed with the course in the departmental office. This form is best completed as a running document throughout the semester; as a faculty member encounters something that worked well or didn't work well, or a classroom need, etc., this can quickly be added to the document, rather than trying to remember the issues at the end of the semester.

Part of the course evaluation form asks the instructor to rate the coverage of each of the program outcomes in the course as high, medium, low, or none. This data is then compiled into a course-outcome matrix which lists each course in the curriculum and the outcome coverage. This matrix allows the identification of outcomes that are only weakly covered in the curriculum. Faculty reporting of outcomes should be supported with a correlating number of outcome evidence documents, described next.

- Outcome Evidence: Specific exam, coursework and/or class discussion content is documented and correlated to the Program Outcomes with comments on performance, issues, etc. included. Standard forms were generated (one electronic, one web-based) to record the evidence. For example, if a large percentage of students performed poorly on a particular concept tested, the faculty would generate a form documenting this. Documentation of evidence includes but is not limited to exams, homework, grading rubrics for written/oral communications, research papers, etc. When evidence is in the form of student work samples, a representative sample of the class performance should also be kept (e.g. one or two high, medium, and low graded samples). During Self-Study years, the evidence in the form of student work samples is copied and filed under the respective outcome; during non self-study years evidence forms are sufficient and only capstone material is preserved. Each instructor compiles a summary of the course outcome evidence as part of the Course Evaluation Form.
- Peer Evaluations: In courses involving team projects, the students complete a team evaluation form (content at the discretion of the instructor) assessing the participation of their teammates and themselves in the project.
- Concept Inventories are administered in as many courses as they are applicable, available, and desired by the instructor. Nationally normed exams such as the Mechanics Baseline Test provide a measure of relative performance.
- Fundamentals of Engineering (FE) Exam: Engineering Physics students are encouraged, but not required, to take the FE Exam. Student performance and pass rate data are kept. This also provides a measure of relative performance vs. other engineering undergraduates and helps the faculty identify areas in which the students may be weak.
- Internship data: Data are collected from students who performed summer internships, including their assessment of how often and how proficient they were at the program outcomes. Data are also collected from the employer as a third party assessment of student preparedness.
- Transfer Student Data: to the extent possible, students who transfer to another engineering program are surveyed regarding their preparedness for the remainder of their engineering curriculum.

Procedure 4.0 – Criteria 4

The first procedure in this section ensures the curriculum is reviewed annually for the subject area components required by ABET (math, science, and engineering topics, plus a general education component).

The second procedure in this section ensures that all graduates have a capstone experience during, and not before, the fourth year of the curriculum. It explicitly states that the capstone design experience incorporates engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political. It also prescribes that means of assessment include, but are not limited to: student design project notebooks, reports, and presentations; evaluation of project components by course faculty; evaluation of project components by other faculty, within and outside of the Engineering Physics program; evaluation of project components by one or more engineers or researchers. Faculty use this procedure as a guide for teaching the course.

Procedure 5.0 – Criteria 5

Criteria 5 address faculty numbers and competencies. Faculty numbers are reviewed annually by the department head and each faculty member has an annual performance review with the department head.

Four of the nine faculty members present during the self study year have Ph.D.'s in engineering; of the remaining 5, one has a B.S. in electrical engineering, one had a M.S. in electrical engineering, and one had a M.S. in nuclear engineering. All faculty do have a Ph.D. in one of the interdisciplinary fields represented in this program.

Procedure 6.0 – Criteria 6

Classrooms, laboratories, equipment, tools, and computing resources are reviewed annually, or more frequently as situations warrant. Course evaluation forms described in the Criteria 3 procedures are used as a tool for assessing facilities. Data is kept regarding additions, renovation and upgrades to classrooms, laboratories, equipment, tools, and computing resources. The amounts requested, provided and spent are tracked by the department head.

Procedure 7.0 – Criteria 7

Institutional support and financial resources are reviewed annually to ensure that they are sufficient to assure quality and continuity of the program, to attract and retain a well-qualified faculty, and to acquire, maintain, and operate facilities and equipment. The department head maintains documentation of funding opportunities and amounts requested, provided and spent. Tarleton is not a research intensive institution, so other funding sources must be used and documented.

Procedure 8.0 – Criteria 8

This section of the procedures document is reserved for the pending development of specific program criteria for Engineering Physics programs by ABET.

Procedure 9.0 – Advisory Board and Industrial Relations

This section of the procedures states that on-campus, face-to-face meetings between EPOC and EPAB will occur at least once per academic year. It also prescribes the responsibilities of the Advisory Board Liaison as including the pursuit of scholarships and internships from EPAB members, periodic review of the program objectives with EPAB, and management of EPAB membership.

Procedure 10.0 – Review effectiveness of the Management Plan and make appropriate changes

As stated earlier, the management and procedures presented here are "living documents" and should themselves be reviewed and updated periodically. The management plan, procedures, and assessment plan are reviewed at least every two years. A running list of revisions with justifications is kept for each document.

Procedure 11.0 – ABET compliance tasks

The final procedure, as the document currently stands, was put in place to ensure continued compliance with ABET requirements. For example, ABET requires certain program information be published in the catalog and on the web; annual review and maintenance of these items is described here. Also, ABET publishes an updated policy and procedure manual and criteria definitions yearly. This procedure states that the EPOC chair will stay current on the ABET requirements and keep the other faculty informed of changes; it also prescribes the periodic review of syllabi for courses in the program to ensure the content and requirements are current. This procedure also designates the EPOC chair as responsible for coordinating the Self Study report and ABET visit.

Conclusion

This paper presented the components used in the successful first attempt at ABET accreditation by an interdisciplinary Engineering Physics program. It is the whole package, not any particular item, which made the effort successful. When seeking accreditation, especially for the first time in a non-mainstream program, it is important to have a thorough, all-encompassing process in place, defining what needs to be done and who will do it and when. An external advisory board is very helpful for grounding expectations in reality and allowing the incorporation of real-world expectations into the program. It is important to have multiple techniques for assessing achievement of objectives and outcomes, and these techniques should include both qualitative and quantitative measures, should come from all constituents (students, faculty, and external), and should incorporate third party assessment or external comparisons as much as possible. However it is insufficient to simply have a process and gather data. An assessment plan is needed that describes when action is needed and that action, closing the loop, must be documented; i.e. the process and data must be used to effect continuous improvement of the program.

The author will be happy to share any of the instruments and tools described here and may be contacted by email.

Acknowledgements

The original management structure and organization of the advisory board was done by Dr. Tom Talley, who left the university in July 2004.

The members of EPOC during the accreditation process were Drs. Javier Garza, (dept. head), Jim McCoy, Daniel Marble, Michael Hibbs, Richard Reese, Mircea Agapie, Falih Ahmad, and

Shaukat Goderya. As chair of EPOC, I want to emphasize that this was and continues to be a team effort, and this would not have been possible otherwise.

The members of the ABET visiting team were invaluable to the process. They truly fulfilled their objective of helping a program be successful in their accreditation effort.

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