The Experience of a First ABET Evaluation

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Abstract

Southeast Missouri State University has had an Engineering Physics Program since the early 1980's, but only recently became positioned to request evaluation for accreditation by ABET. Two sets of circumstances, one intentional and one fortuitous, enabled this; namely, the addition of a third bona fide engineer to the faculty and the implementation of Criteria 2000 by ABET. In this paper, we describe our program, the preparation for the visit by ABET in September 2000, and the preliminary results of the visit.

I. Introduction

The Engineering Physics Program at Southeast Missouri State University began in the early 1980's in order to serve the needs of a constituency of students who were in the Pre-engineering Program, but who would prefer to finish an engineering degree without leaving the southeast Missouri area. The Physics Department offered Bachelor's degrees in Physics and Physics Education and operated the Pre-engineering Program in which students spent two years at Southeast Missouri State University then transferred to an engineering school, usually the University of Missouri at either Rolla or Columbia, to complete their engineering degree. With the addition of the Engineering Physics Program, the Physics Department could offer students the opportunity to complete an engineering degree locally.

The faculty members at that time were all physicists, but one member had some systems engineering experience in industry and another was very interested in digital electronics and computers. Based on that faculty expertise and interest, the program was developed with an electrical engineering flavor. Accreditation by ABET was always a goal for the new program, but the accreditation criteria [1] for non-traditional programs in effect at the time required that at least four faculty members be educated as engineers or have significant engineering experience. Further, the criteria for technical content were rather specific, and the new program minimally satisfied them. So, over the next decade or so, as faculty members who were physicists retired, they were replaced by faculty members who were engineers. In 1994, the third engineer was added to the faculty. The previously mentioned faculty member with systems engineering experience and one of the physicists who had an engineering physics undergraduate degree together constituted the fourth engineer, or so we hoped.

The Engineering Physics Program did not have as much technical content as a typical engineering program primarily because Southeast Missouri State University has a larger general education requirement than most engineering schools. We viewed this as somewhat of a drawback for our program. We surveyed non-traditional programs around the country and found that the technical content of our Engineering Physics Program was at the very low end of the range for such programs whether or not they were accredited. Further, we thought that if we were going to successfully compete against engineering schools for students, we had to be competitive in terms of technical content. The average number of technical hours we found to be 101, so the curriculum was revised over the next couple years to bring the technical content to near that level while keeping the total number of hours comparable with other engineering programs. We added eighteen credit hours of technical courses, primarily second semesters of circuit analysis, electronics, systems analysis, and a senior capstone design sequence. Additional design emphasis was also placed in several courses. The net result was to add thirteen hours to the Engineering Physics Program, which now totals 138 credit hours compared to 125 previously. The new program was now a strong hybrid of physics and electrical engineering that also had a strong general education component. We began offering the new courses in Fall 1997, and the new program became effective for students entering in Fall 1998. We prepared to begin writing the self-study in 1999 under the old criteria [1]. We knew that the new Engineering Criteria 2000 [2] was being phased in, but all our efforts to date had been based on the old criteria so we thought being evaluated under the old criteria would be best for us. However, we did have some concerns regarding the faculty makeup and the large general education component.

After several discussions with people familiar with ABET at various conferences, we decided to delay one year and submit the self-study under Engineering Criteria 2000. This decision was based primarily on the greater flexibility permitted under Engineering Criteria 2000, which we felt might benefit our program. Specifically, the number of engineers on the faculty was no longer specified, and we felt that our large general education requirement could be turned from a weakness into a strength. We began developing program educational objectives and an assessment plan throughout the spring of 1999. The assessment plan was implemented in the fall of 1999. The request for evaluation was submitted to ABET in January 2000, the self-study was written during Spring 2000, and the self-study was submitted to ABET in July 2000. The visit from ABET evaluators occurred early September 2000.

This paper will describe our program in detail, the preparations made for the evaluation by ABET, and the preliminary results of the visit.

II. The Engineering Physics Program at Southeast Missouri State University

The Engineering Physics Program integrates a typical physics program and a typical electrical engineering program. The Program has a core set of courses and two options. The Applied Physics and Engineering (APE) Option consists of additional physics and electrical engineering courses and the Computer Applications in Physics and Engineering (CAPE) Option consists of computer science and digital electronics courses. The listing of courses in the program is shown in Table II and Table III. As previously mentioned, all programs at Southeast Missouri State University also include a rather large general education program.

A. General Education

The general education requirement of the University, which is called the University Studies Program [3,4], is a skills-based program built around the nine objectives listed in Table I. The University Studies Program consists of forty-eight hours of course work that includes a three-hour freshman seminar, three hours from each of twelve categories of courses, six hours of interdisciplinary courses, and a three-hour interdisciplinary senior seminar. Of these 48 hours, only 9 hours are satisfied in the Engineering Physics Program leaving 13 courses for 39 hours of general education. Although none of these 13 courses are specified, we do suggest 6 courses for 18 of the 39 hours. This is about twice the amount of general education compared to a typical engineering program, but we believe that under Engineering Criteria 2000 the additional general education actually strengthens our program because it helps us produce more well-rounded engineers.

Table I. Objectives of the University Studies Program	
1	Demonstrate the ability to locate and gather information
2	Demonstrate capabilities for critical thinking, reasoning, and analyzing
3	Demonstrate effective communications skills
4	Demonstrate an understanding of human experiences and the ability to relate them to the present
5	Demonstrate an understanding of various cultures and their interrelationships
6	Demonstrate the ability to integrate the breadth and diversity of knowledge and experience
7	Demonstrate the ability to make informed, intelligent value decisions
8	Demonstrate the ability to make informed, sensitive aesthetic responses
9	Demonstrate the ability to function in one's natural, social, and political environment

The stereotype of an engineer as someone who could do math, couldn't communicate with normal people, and had never read anything outside science and engineering is passé. Of course that stereotype has always been inaccurate, but today perhaps more than ever, engineering educators must ensure that our graduates are formally equipped academically to compete in the modern, global, and communication intensive world of engineering. As such, greater emphasis is being placed on what used to be called the "soft skills." This increased emphasis is reflected in the Engineering Criteria 2000 Criteria 3 outcomes. Our University Studies Program clearly emphasizes these outcomes and prepares our students well for success in the modern world.

B. Preparation for the ABET Visit

In preparation for evaluation of our program under Engineering Criteria 2000, we needed to develop a set of educational objectives and an assessment plan for the Engineering Physics Program. We decided to adopt a set of objectives that would apply to all departmental programs. The objectives along with specific outcomes for each objective were developed through a series of faculty meetings during the spring of 1999 and are shown in the Appendix. These were formally adopted by the Department in April 1999. During this same time, an assessment plan was developed and adopted in October 1999. The highlights of the assessment plan include keeping portfolios of student work in each course, completing an assessment form for each student in courses where assessment is done, exit exams for graduating seniors, exit interviews with graduating seniors, and surveys of alumni. The first assessments were done in Spring 2000 on courses taught in Fall 1999. We also assembled an External Advisory Committee consisting of individuals from local industry and high schools, some who were alumni, to provide input on our Educational Objectives and Outcomes, as well as general issues related to our programs. Two meetings were held before the ABET visit, primarily for committee members to get acquainted with the Departmental Programs.

Each course in the curriculum addresses one or more of these objectives. The Departmental Assessment Plan specifies in which courses and/or in what manner each of these outcomes will be assessed. Each outcome is assessed at least once during the Program. Table II shows the courses in the core of the Engineering Physics Program and which objectives they each address. Table III gives the same information for the two options.

III. The Visit from ABET Evaluators

The evaluation team consisted of two academics, the team chair and an electrical engineer, and an engineer from industry. The visit followed what seemed to be the typical schedule with the team beginning on Sunday evening looking over course portfolios and touring the facilities. Since there were three individuals reviewing only one program, we received a very thorough review. The evaluation team found one deficiency, two weaknesses related to the deficiency, another weakness not related to the deficiency, and several concerns.

The deficiency related to the fact that the new curriculum had been in place officially only since Fall 1998 and there were still students in the pipeline under the old curriculum that did not require the senior capstone design sequence. Most of these students had taken the capstone design sequence or were planning to take it, but no system was in place to ensure that every student did. In fact, one student was planning to graduate in December 2000 without taking it. After looking into the legal question of whether requirements could be added to a student's major even if not in the catalog the student was under, and determining that they could be, we were able to officially change the requirements for all students in the pipeline to require the capstone sequence. Because the evaluation visit took place in the fourth week of the semester, we were able to add the student graduating in December 2000 to the capstone course being taught that semester. We think these actions will mitigate the deficiency as well as the two related weaknesses.

The third weakness had to do with the size of our program. We average about four graduates per year from all three of our programs - Physics, Physics Education, and Engineering Physics. Evaluators were concerned about our ability to provide experience on multidisciplinary teams with such small numbers and also with our ability to offer required courses in a timely manner. We are addressing this by a proactive recruitment effort that is now underway to see if student numbers can be increased. Some time will be required to see if these efforts result in increased enrollment, but we think they will. Receiving accreditation should also boost enrollment. We are also working to establish an interdisciplinary capstone course. A committee consisting of faculty members from the Departments of Biology, Chemistry, Computer Science, Geosciences, Math, and Physics is developing the course at present. If successful, a course of this type will certainly be interdisciplinary, probably in a broader sense than ABET expects.

There were nine concerns identified. Most of the concerns dealt with the Educational Objectives and the Assessment Plan and how thoroughly it had been implemented and documented. Since these had just been developed during the year before the visit, we were not surprised that the evaluators thought our processes were not completely implemented. Surprisingly, one concern dealt with our large general education requirement. The concern related more to the fact that the large general education requirement meant that our program requires about thirteen more hours than most programs on campus, which they felt put us at a competitive disadvantage when compared to other majors on campus. In fact, there are several other programs on campus, such as secondary education, with a comparable number of hours required. Of course, since the general education requirements apply to all programs at Southeast Missouri State University, we will not be able to address this concern. Actions have been taken to address each of the other concerns expressed by the evaluators.

We learned several important things as a result of the ABET visit. First, our curriculum and our courses meet the criteria. None of the problems identified involved criticism of either the curriculum or of any individual course in the curriculum. Second, our faculty is adequate in size and expertise for our Engineering Physics Program. We had some concern about this since prior to Engineering Criteria 2000, four engineering faculty were required in a nontraditional program such as ours. Finally, despite hearing many and varied horror stories about ABET visits, ours went quite well. We found the evaluators to be very reasonable people who genuinely made an effort to understand our program and to apply the criteria to it as objectively as possible.

Overall, we believe the visit by the evaluators was a very positive experience. They were quite encouraging on aspects of the Program and the University that they thought were strong, and they were candid and forthright on aspects that they thought needed improvement. They even offered suggestions for improvement. We believe our program benefited by going through this process, and since we think we were able to mitigate the one deficiency identified, we are optimistic that our Engineering Physics Program will be accredited.

IV. Summary and Conclusion

We have described the development and current status of the Engineering Physics Program at Southeast Missouri State University. We described the process used to develop educational objectives and assessment procedures in preparation for an evaluation visit by ABET under Engineering Criteria 2000. We found the evaluation visit to be a very positive experience and believe that our program benefited significantly from it. Despite issues identified by the evaluation, we believe we have mitigated the most serious of them, and we are optimistic that our Engineering Physics Program will be accredited.

Table II. Courses in the Core of the Engineering Physics program												
Educational Objectives → **Courses ↓**	1. Apply knowledge of science, math, & eng	2. Design & conduct experiments	3. Acquire & analyze data	4. Communicate effectively	5. Use modern tools	6. Engage in self education	7. Understand professional ethics	8. Work effectively in a group.	9. Conduct & present research/design work	10. Demonstrate design ability	11. Understand engineering in broader context	12. Tutor and explain concepts
Physics												
PH230 General Physics I	✓		✓	✓	✓			✓				
PH231 General Physics II	✓		✓	✓	✓			✓				
PH341 Optics	✓			✓	✓	✓			✓	✓		✓
PH345/UI330 Exp. Methods I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
PH360 Modern Physics	✓			✓	✓	✓					✓	
PH370 Mechanics	✓				✓					✓		
PH371 Electromagnetics	✓				✓					✓		
PH445 Experimental Methods II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Engineering												
EP100 Phys & Eng Concepts	✓			✓	✓		✓					
EP260 Circuit Analysis I	✓				✓							
EP342 Electronic Circuits I	✓	✓	✓	✓	✓			✓		✓		
EP372 Signals & Systems	✓				✓					✓		
EP461 Computer Applications	✓			✓	✓					✓		
EP480 Capstone Design I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
EP481 Capstone Design II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Mathematics												
MA140 Calc & Anal Geom I	✓				✓							
MA145 Calc & Anal Geom II	✓				✓							
MA240 Calc & Anal Geom III	✓				✓							
MA245 Vector Calculus	✓				✓							
MA334 Computer Programming	✓				✓					✓		
MA350 Differential Equations	✓	✓			✓							
MA544 Numerical Analysis	✓				✓					✓		
Other Courses												
CH185 General Chemistry I	✓		✓	✓								
TG120 Comp Aided Eng Graph					✓							

Table III. Courses in the Options of the Engineering Physics Program												
Educational Objectives → **Courses** ↓	1. Apply knowledge of science, math, & eng	2. Design & conduct experiments	3. Acquire & analyze data	4. Communicate effectively	5. Use modern tools	6. Engage in self education	7. Understand professional ethics	8. Work effectively in a group.	9. Conduct & present research/design work	10. Demonstrate design ability	11. Understand engineering in broader context	12. Tutor and explain concepts
APE Option												
EP265 Circuit Analysis II	□				□							
EP352 Electronic Circuits II	□	□	□	□	□	□	□	□	□	□	□	□
EP361 Thermal Analysis	□				□							
EP374 Control Systems	□				□					□		
EP462 Material Science	□				□	□						
PH473 Quantum Mechanics	□				□							
EP/PH Electives	□				□							
CAPE Option												
CS155 Computer Science I	□				□	□				□		
CS165 Computer Science II	□				□	□				□		
CS285 C & Unix Environ or	□				□	□				□		
CS365 Comp Org/ Assembly	□				□	□				□		
EP305 Dig/Anal System Design	□	□	□	□	□	□		□	□	□		
EP310 Microcomp Interfacing	□	□	□	□	□	□		□	□	□		
EP/PH Electives	□				□							

Appendix

Following is the list of educational objectives along with their associated outcomes. Upon completion of a Program of Study in the Physics Department, students should:

1. be able to apply basic and advanced knowledge of science, mathematics, and engineering to identify the physical phenomena affecting a system and to solve both conceptual and analytical problems in physics and engineering.

- *a) Students will have a sufficient GPA in required courses in their major.*
- *b) Students will demonstrate an increasingly sophisticated and synthesized understanding of physical systems as they progress through the programs of the Department.*
- *c) Students will demonstrate the ability to solve both conceptual and analytical problems in physics and engineering.*

2. be able to design and conduct experiments to answer open-ended questions in physics and engineering.

- *a) Students will demonstrate the ability to devise, design, assemble, and conduct an experiment in order to investigate open-ended questions.*
- *b) Students will demonstrate the ability to identify the causal relationships involved in the investigation, identify the pertinent parameters to be measured, determine the appropriate range of experimental parameters, and determine the appropriate resolution of the data needed.*
- *c) Students will demonstrate an understanding of experimental error and its propagation in an experiment.*

3. be able to acquire, analyze, and interpret data obtained by experiment.

- *a) Students will demonstrate that they can acquire data and analyze that data by manual and by automated means.*
- *b) Students will demonstrate an ability to interpret experimental results and to compare them with theoretical models of the phenomena under study.*

4. be able to communicate effectively in writing and orally.

- *a) Students will exhibit correct grammar, punctuation, and spelling in written assignments*
- *b) Students will demonstrate the ability to clearly, concisely, and logically present their technical work in writing.*
- *c) Students will demonstrate the ability to write in a style which is common to technical writing including the use of figures, tables, and references.*
- *d) Students will demonstrate the ability to present technical work orally in a confident, concise, and well-organized manner.*
- *e) Students will demonstrate effective use of visual aids in presenting technical work.*

5. be able to use the techniques, skills, and modern tools necessary for a career in science or engineering.
   a) *Students will demonstrate the ability to use computers as tools in science and engineering work. Specifically students will be proficient in the use of:*
      i) *word processors, spreadsheets, and presentation software*
      ii) *mathematical packages such as Mathcad and Matlab*
      iii) *programming in a high level language such as FORTRAN, C++, or TurboBasic*
      iv) *drafting/drawing packages such as Autocad*
      v) *simulation software such as Micro-Cap VI and BEAM-2*
   b) *Students will demonstrate the ability to use email for technical communications.*
   c) *Students will demonstrate the ability to use the World Wide Web as a research tool.*

6. be able to engage in self education and to appreciate the need to remain current in their field throughout their careers.
   a) *Students will demonstrate the ability to locate, gather, and use relevant information for the purpose of self-education on a topic.*
   b) *Students will recognize the importance of the ability to conduct research on a topic for the purpose of self-education.*
   c) *Students will recognize the importance of remaining current in their chosen field throughout their career.*

7. understand their professional and ethical responsibilities as scientists or engineers.
   a) *Students will demonstrate an understanding of the Code of Ethics for Engineering and appropriate statements by the American Physical Society (APS) (statements 87.1, 88.1, 91.8, 94.3).*
   b) *Students will demonstrate that they recognize situations where ethical dilemmas may arise in the workplace.*
   c) *Students will demonstrate an ability to resolve ethical dilemmas in a manner consistent with the Code of Ethics for Engineering and the APS.*

8. be able to work effectively in a group.
   a) *Students will demonstrate that they understand the various roles necessary for effective functioning in a group endeavor.*
   b) *Students will demonstrate the interpersonal skills necessary to work effectively in a group. These include: leadership, presenting and defending ideas orally to other group members, planning, assigning of tasks, and giving and receiving constructive criticism.*

9. be able to demonstrate through experiential learning the ability to conduct research and/or design work and to present the results of this work.
   a) *Students will conduct original research and/or design work and present the results orally and in writing.*

10. be able to demonstrate through experiential learning the ability to design, build, and test a component, system, or process (EP).
    a) Engineering Physics students will design, build, and test a component, system, or process in their capstone course.

11. be able to use their liberal arts education to understand science and engineering in the broader context of society and the world.
    a) Students will review case studies which highlight the impact of scientific and engineering decisions on society as a whole. Such issues as public safety, environmental impact, and economic impact will be considered.

12. be able to tutor and explain concepts in their field of specialization.
    a) *Students will tutor, grade, serve as lab assistants, or make tutorial presentations to an audience of their peers.*

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