ESTABLISHING AND ASSESSING EDUCATIONAL OBJECTIVES FOR ENGINEERING PROGRAMS

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Abstract

Changes are often very difficult. The Accreditation Board for Engineering and Technology (ABET) has changed the criteria for accrediting engineering programs. This paper describes the process for developing and assessing an engineering program educational objectives. In particular it discusses the educational objectives attributes that an acceptable program should have in view of the requirements of criterion 2 of Engineering Criteria (EC2000). Examples of using surveys results are included. Finally, the interaction between the assessment coordination and curriculum committee is discussed.

Introduction

The engineering practice continues to evolve, but engineering education has not changed at the same rate. The need to change engineering education has led industry and constituents to question the relevancy of engineering programs. Therefore, ABET initiated the formation process for an ABET Industry Advisory Council (IAC). ABET needed more proactive involvement of industry leaders. Industry expectations of new engineers resulted in ABET to lessen its preoccupation with quantitative criteria and to respond to the challenges facing engineering education in the twenty-first century. Thus, the ABET Board of Directors approved the Engineering Criteria 2000 on November 2, 1996[1], a radically new set of criteria for accrediting engineering programs. At the same time, ABET authorized a two-year pilot study and three-year phased implementation period, making the new criteria effective for all engineering programs beginning in fall 2001. A survey of fifteen companies conducted by the Industry-Government Roundtable for Enhancing Engineering Education ranked in importance knowledge elements, skills, and experiences that can be expected by engineering managers and engineers for BS entry- level engineers[2].

During the eighties and nineties accreditation visits, ABET program evaluators focused on resources heavily[3]. These resources included faculty member's qualifications, curriculum details, and the adequacy of laboratory facilities. However, EC2000 takes a broader approach by focusing on both resources and processes. The goal is to provide engineering programs with flexibility and to encourage innovation in designing the curriculum. ABET used to require

engineering programs to have published goals and mission statements. Furthermore, engineering programs were required to have an assessment plan to measure the effectiveness of the programs. This has been replaced by criteria 2 and 3 of the EC2000.

ABET Criterion 2. Program Educational Objectives

Each engineering program for which an institution seeks accreditation or reaccreditation must have in place:

(*a*) *detailed published educational objectives that are consistent with the mission of the institution and these criteria*

ABET has reduced its rigid descriptive requirements so that educators can establish their programs uniqueness that are consistent with the institution's mission. Indiana University-Purdue University Fort Wayne (IPFW) is a state-assisted university serving Indiana's second largest city and the surrounding region. The core mission of IPFW is to provide quality postsecondary education in northeastern Indiana by focusing on student learning, while fostering intellectual exploration and attainment, and serving the region. The overwhelming majority of our engineering graduates are from and employed in Northeastern Indiana and the surrounding areas.

(*b*) *a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated*

The potential constituencies of an engineering program include:

1. Alumni
2. Employers
3. Industrial Advisory Committee
4. Parents
5. Students

At IPFW the student body includes traditional and nontraditional students. Since the majority of engineering students are part time and returning adult students, the parents are not considered as a major constituent in determining the educational objectives. Educators disagree in regard to the involvement of the students in the establishing the educational objectives. The engineering program educational objectives are statements that can describe the expected accomplishments of graduates during the first few years after graduation[4]. Alumni, employers, and industrial advisory committee members input is more vital than the students input. However, the students' input is a very important tool in measuring the outcomes of the program. The students at IPFW are considered as a key element in establishing and assessing the outcomes of the program rather than the objectives.

(c) a curriculum and processes that ensure the achievement of these objectives

Prospective students, parents, and sponsors want assurance that universities are providing assessed quality higher education. Program educational objectives describe what the faculty believes their graduates are capable of doing after graduation. The faculty of the department have the ultimate responsibility in developing the curricula. A strong interaction between the assessment coordination and curriculum committee is vital in achieving the objectives of a program.

(d) a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program.

Much has been written and discussed regarding the assessment and revision of a program curriculum. Results of many studies have shown the positive effects of well integrated curricula where assessment methods were applied consistently[5]. To achieve the objectives of a program, the assessment information must be fed to the curriculum committee. Also, the faculty must link the program outcomes to the program educational objectives in developing the long term assessment plan

After approving the educational objectives of a program, educators are required by ABET criteria 3 to establish the program outcomes. The outcomes should describe an area of knowledge that a person can possess, be stated such that a student can demonstrate before graduation, and be supportive of one or more objectives. In addition, the program outcomes are to encompass the following eleven outcomes specified in Criteria 3.

(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
(d) an ability to function on multi-disciplinary 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 and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Establishing the educational objectives

Establishing measurable objectives and assessing the outcomes require much work which most engineering educators have had little experience, but it worth the effort. After deciding on the program's constituents, the following short list can be used by educators when developing the objectives:

1. Each objective addresses one or more needs of one or more constituencies.
2. The objectives are understandable by constituency addressed.
3. The number of statements should be limited.
4. The objectives should not be restatement of the program's outcomes. Total reliance on outcomes may indicate a lack of understanding of the determination of objectives.

It is important to remember that there are two types of educational objectives:

1. What all graduates expected to accomplish. For example, the ability to apply the knowledge of basic chemistry, math, physics and engineering fundamentals.

2. That some graduates expected to gain such as the industrial experience through cooperative education experience.

Both criteria 2 and 3 are vague because it is expected that the engineering programs will develop their own processes and methods for improving the program's effectiveness. Educational objectives state broadly how a program will satisfy the needs of its constituents and educational mission. ABET has reduced its rigid descriptive requirements so that educators can establish their programs uniqueness that are consistent with the institution's mission. In the process of formulating the objectives and determining the uniqueness, educators should ask the following question: How important is design or ability to work on multi-disciplinary teams, for example, to our constituents? There is no perfect start. An alumni survey is always a good start. The Engineering Department at IPFW conducted an alumni survey to find out the importance of several educational components as well as to learn our department's niche with the northeastern Indiana industry. In this article, three of the six engineering programs educational objectives are discussed.

The Survey

In the Spring of 2001, the department sent questionnaires to the alumni regarding the relevancy of different topics to their jobs: engineering design, multidisciplinary teams, and ethics. The faculty wanted to gauge the importance of the knowledge of the engineering design process[6], the results are shown in Fig. 1.

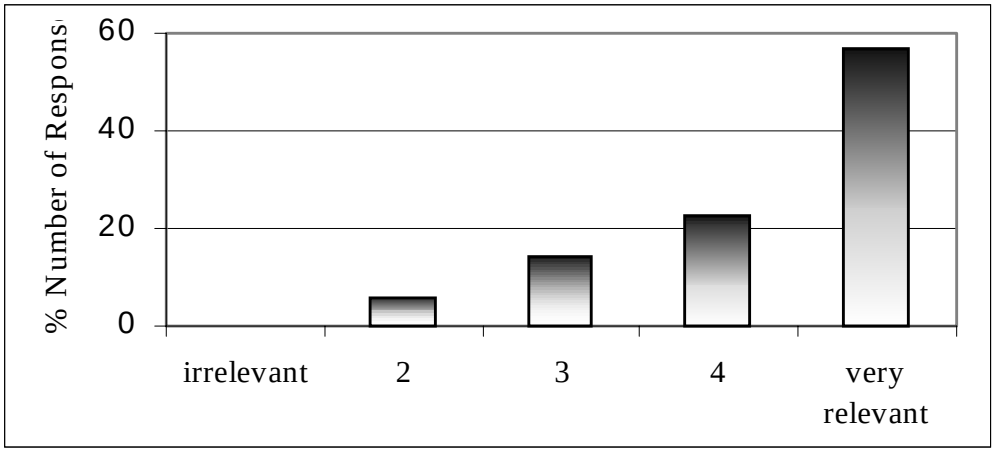

Fig. 1. Importance of the knowledge of the engineering design process to the performance of job

The results show that deign is needed by our program's various constituencies. In fact, the knowledge of the engineering design process is very relevant to the performance of more than half our alumni jobs. Thus, based on the need of our constituent and to satisfy ABET criteria 2,

the engineering design is weighted heavily in our objectives as one of our educational objectives is “To develop students’ skills in the design process and the product design.”

The results of some of the attributes we surveyed were expected to certain extend. The importance of engineering design was expected since ABET required a minimum of sixteen credit hours in engineering design under the old criteria. However, the very high degree of relevancy to the overwhelming majority of industry in Northeastern Indiana that employed our graduates is not expected. On the other hand, no prior knowledge was anticipated regarding other attributes. No data was available from our constituencies in regard to the importance to function on a team based design project, participation as a team member, and participation in evaluating team products. Therefore, the importance to work on multidisciplinary teams to the performance of our alumni job was included in the survey when establishing the educational objectives of our engineering programs. The results are summarized in figure 2.

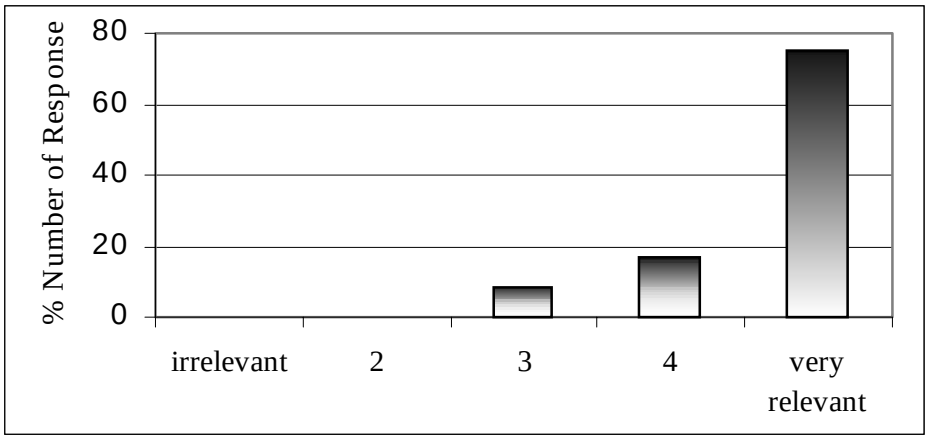

Fig. 2. Importance of ability to work on multidisciplinary teams to the performance of job

It is obvious that the ability to work on multidisciplinary teams is important to all respondents and more relevant than design. Furthermore, seventy-five percent believe it is very relevant. Hence, the faculty agreed to add “To provide students with experience in team work and multidisciplinary projects” to the programs educational objectives. It is worth mentioning that the importance of multidisciplinary issue was neither assessed before nor was part of our goals under the previous ABET criteria. This survey resulted in lucid transition from the old ABET criteria to EC2000 for our programs, but the curriculum did not include multidisciplinary component. The use of this assessment result in changing the curriculum will be discussed later.

Next, a non technical issue, ethics, was analyzed. Engineering educators always stressed, and will continue to do, the importance of honesty in engineering. Usually, the engineering code of ethics were discussed briefly in an engineering course. Some students learn more bout an individual’s responsibility associated with an agreement to recognize proprietary, rights and copyright in a general education course. Students that are members of professional societies

have an understanding regarding the code of ethics of a specialty engineering society. One of the leading trends in ethics pedagogy today is to have an ethical component incorporated in the professional course to supplement the free standing course. Freestanding course is a course in engineering taught by an ethicist, engineer, or both[7]. The importance of ability to identify and analyze ethical issues to the performance of job related to our constituents and the mission of the university is examined by studying the results plotted in figure 3.

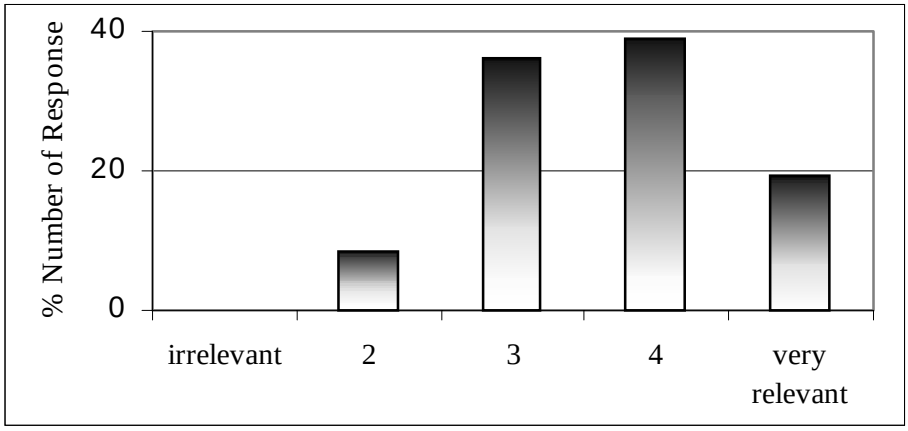

Fig. 3. Importance of ethical issues

Data analysis indicates that awareness of professional responsibilities regarding product liability and education in professional ethics and conduct as well as awareness of ethical issues are important to engineers in the region where IPFW is serving. Also, the relevance of the ethical issues is not as high as design and multidisciplinary issues. The faculty of the department realize the importance of ethics and believe that ethical problems in engineering practice should be incorporated in the curriculum. The faculty approved to combine ethics with other components that have equivalent weight. One of our educational objectives is "To instill in students a recognition of the need for life-long learning, an understanding of professional and ethical responsibility, and professional registration."

Industrial Advisory Committee

The department is advised by an Industrial Advisory Committee which consists of high-level executives from engineering industries at North Eastern Indiana. The purpose of this committee is to advise and assist the department in maintaining strong engineering programs. Indeed, the members of this committee are considered as a vital constituent for our programs. The department consults with the committee on issues such as industrial trends in the region, curriculum matters, cooperative education program, and assessments. Upon the approval of the educational objectives by the faculty, it was presented to the Industrial Advisory Committee.

Assessment of Preparations of our graduates:

Educational measurement represents a field of study that has been intensely researched and that provides a framework for designing assessment programs[8]. Educators recognize the need for purposeful experimentation in validating a set of measures for assessing the educational goals and prepareness of graduates in their professional practice. The alumni were asked to response to how effective IPFW engineering programs was at developing the skills related to the engineering design, multidisciplinary teams, and ethical issues. The results are summarized in figures 4-6.

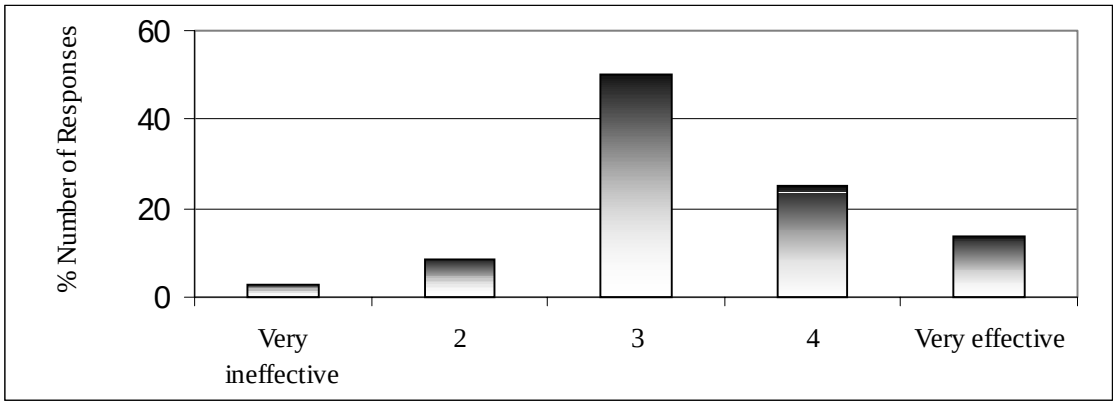

Fig. 4. Effectiveness of the program at developing the knowledge of the engineering design process

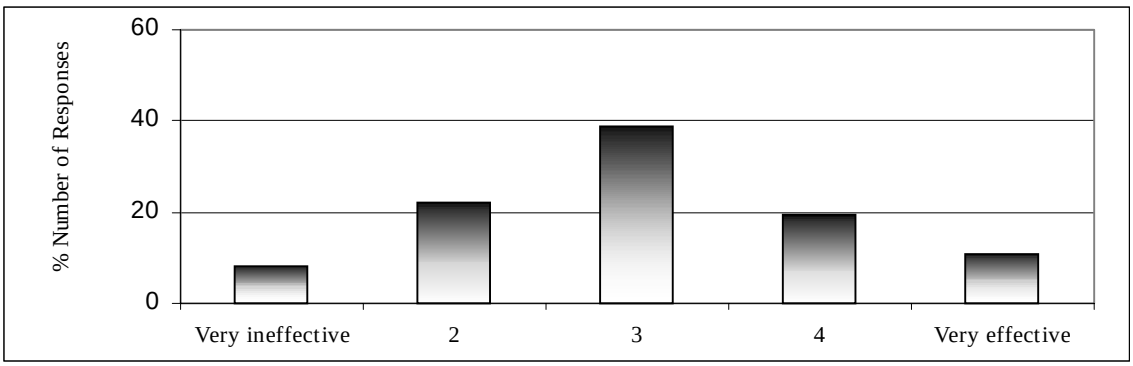

Fig. 5. Effectiveness of the program at developing the ability to work on multidisciplinary teams

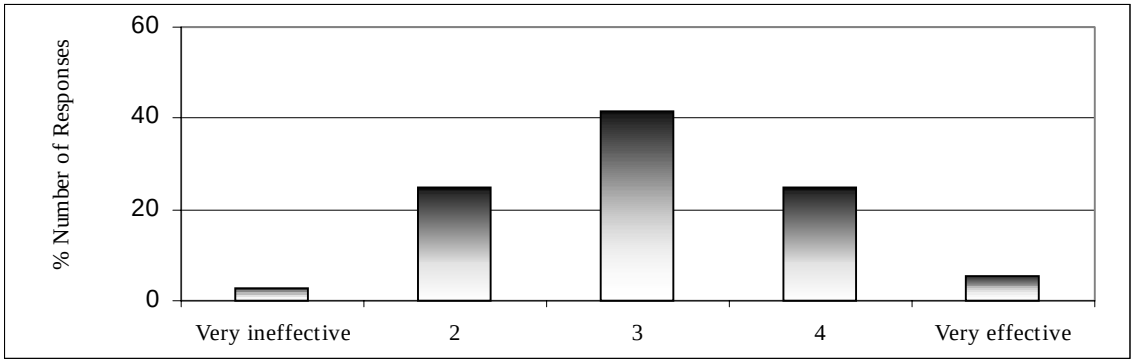

Fig. 6. Effectiveness of the program at developing the ability to identify and analyze ethical issues

Although the results of the program effectiveness of design are positive, it was decided that there is room for improvement in enhancing the knowledge of design process. The mean response to the effectiveness of the program at developing the ability to work on multidisciplinary teams was calculated and found to be 3.14. This mean was expected to be lower since the curriculum did not contain strong multidisciplinary courses. The mean response to the effectiveness of the program regarding ethical issues was calculated and found to be 3.16. The performance of our engineering students in ethics on the Fundamental of Engineering Examination (FE Exam) supports the alumni response.

Communication between Assessment and Curriculum

Design content: According to EC2000 Criteria, the graduates of an engineering program should be able to design a system, component, or process that meets specific requirements. However, the criteria is silent on the number design credits required. Educators should ask the following question: How important is design for our graduates? Next, after establishing the importance of the design component, the faculty decided on the design content in the curriculum. As mentioned before, ABET does not specify the number of minimum design credits required for an engineering program. However, we used the old ABET category content as a tool in defining the number of design credits in the courses. The number of design credit hours required for the new BSME curriculum is 20.5 credits which is approximately 28% of the required and technical elective engineering courses. More details about the design content at IPFW can be found in reference[6].

Multidisciplinary: The results of the alumni survey indicate that this is important to our constituents and there is room for improvement. The Mechanical Engineering and Electrical Engineering curriculum committees developed the following two new courses[9]:
1. Electronics and System Engineering through Robotics. Class 4, Lab 0, Cr. 4.
The objectives of this course are to provide the students with the principles of digital logic, electronics, and control system analysis, through the design of mobile robots.

2. Electronics and System Engineering through Robotics Lab . Class 0, Lab 3, Cr. 1.
The objectives of this course are to provide students with hands-on experience of digital logical, electronics, and control systems. A main component of the course is the design, building, programing and testing of mobile robots.

In addition, the direction of the capstone design projects has been shifted to a multidisiplinary projects that combine Electrical and Mechanical Engineering concepts.

Ethics: The previous curriculum has no specific Ethics component. Also, the results of the survey and FE Exam show that this was an area of deficiency. For the FE Exam, the material for this subject, as given in NCEES Reference Handbook essentially covers the NCEES "Model Rules for Professional Conduct". Review questions indicate the purpose is to judge students' ability to understand proper interpretation of the Rules in specific situations. As a short term measure, help sessions for the students to cover Ethics were organized by the Fundamental of Engineering Examination Committee. In the long term, the new ME and EE curricula addressed this question. Ethics was introduced in the capstone design courses. One of the goals for these courses is to provide students with an understanding professional and ethical responsibility.

Closing the loop

We conducted a new survey of the educational objectives. We sent the survey to all alumni that had graduated since spring of 2001; these alumni were not involved in our last survey. We had enclosed two surveys, one for the alumni to complete, and one for their employer to complete. of our resent graduates. The response rate of the survey by the alumni was only sixteen percent. Although the return rate was not significant, the results are shown in Table 1.

Educational objective	Strongly agree (percent)	Agree (percent)	Disagree (percent)	Strongly Disagree (percent)
To develop student's skills in the design process and the product design	40	60	0	0
To expose students to the experience of team work and multidisciplinary projects	20	80	0	0
To instill in students a recognition of the need for life-long learning, an understanding of professional and ethical responsibility, and professional registration	40	60	0	0

It is concluded that the resent graduates agree with the programs established educational objectives based on the input from our constituents. Unfortunately, the response rate from

employers was poor; the low response rate made the responses received statically insignificant and no solid conclusions can be made. However, it is worth mentioning that respondents generally agreed or strongly agreed with the objectives.

Summary and Conclusions

Although the educational objectives state broadly how a program will satisfy constituency needs and its educational mission, they must be specific to differentiate the program. The input of the various constituencies to identify their needs is presented and discussed. Systematically gathering, analyzing, and interpreting the data result in establishing a sound educational objectives. The objectives should tailored such that to provide students with a broad education necessary for many types of employers.

Finally, an engineering program educational objectives can be developed and improved by using the input from various constituents as well as the communication between assessment and curriculum committees.

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