AC 2009-1926: GOOD JOBS, BAD JOBS: DESIGNING PROGRAM EDUCATIONAL OBJECTIVES

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Good Jobs, Bad Jobs:
Designing Program Educational Objectives

Abstract

Industrial Engineering programs prepare graduates for a wide range of jobs in a wide range of industries. Having faculty members choose a focus for a program, design a new program, or redesign an existing Industrial Engineering program can be contentious. This paper presents a method, using descriptions of real jobs, to help faculty members talk about the types of jobs for which the program is preparing graduates and to talk about how well the program is preparing graduates for those jobs. The method allows agreements and disagreements to emerge and provides a way to talk about them. This method has obvious applications in designing program educational objectives and in reviewing and updating program educational objectives to reflect current needs of industry. Using current job descriptions focuses these conversations and helps maintain currency of the program.

Introduction

To design a curriculum based on ABET-EAC criteria, one works backward, as shown in Figure 1.

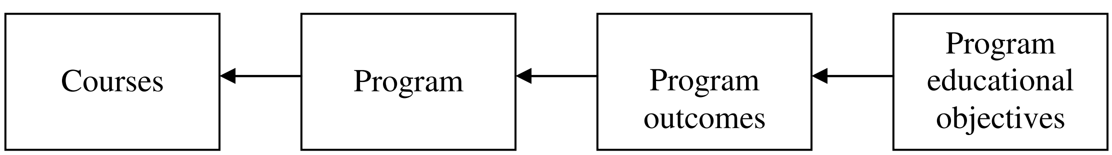

Figure 1: Flowchart for curriculum design

Program educational objectives (PEOs), which are "broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve," are used to determine program outcomes, which are "narrower statements that describe what students are expected to know and be able to do by the time of graduation." Since program outcomes "relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program," they are used to design the program, which consists of courses, designed to make up the program.

Thus, Criterion 2 is the starting point for designing a program. The most recent ABET statement[1] about Criterion 2 is:

> **"Criterion 2. Program Educational Objectives**
>
> Each program for which an institution seeks accreditation or reaccreditation must have in place:
>
> (a) published educational objectives that are consistent with the mission of the institution and these criteria

(b) a process that periodically documents and demonstrates that the objectives are based on the needs of the program's various constituencies
(c) an assessment and evaluation process that periodically documents and demonstrates the degree to which these objectives are attained."

In particular, the program should be designed using PEOs that "are based on the needs of the program's various constituencies."

This paper focuses on designing PEOs that meet the needs of employers who might hire graduates of the program. Most ABET-accredited programs include employers as one of several constituencies. Others often include students, faculty, alumni, and parents.

Designing PEOs to meet the needs of employers can be difficult for three reasons. First, obtaining detailed enough information on what employers want can be difficult; certainly using input from an industrial advisory board is crucial, but small programs like ours may have difficulty obtaining board participation from large companies who do hire our graduates. Also, we want to design our program to meet the needs of potential employers as well as actual employers. Second, some companies lack the understanding of what entry level engineers should be doing, especially in fields like industrial engineering. Guidance from a pool of the wrong experts could be misleading. Third, getting faculty to turn such industrial input into clearly stated PEOs *on which they agree* can be difficult.

We have twice successfully used the following process to create and to revise PEOs:

1. Obtain job descriptions from company websites and from job search websites.
2. Circulate these job descriptions among the faculty having each faculty member rate each job on job quality and on the preparation of program graduates for the job.
3. Consolidate and summarize the data obtained in step 2 and provide a summary to the faculty.
4. Have the faculty discuss the results.

In this paper I provide details on each step, but first I review what others have written on how to create PEOs.

Literature review

Carter, Brent, and Rajala[2] agree with the centrality of the PEOs in program design, but state:

> Despite this crucial role, very little attention has been paid to Criterion 2 in the engineering literature. For example, in the ASEE Conference Proceedings from 1998-2000, only four papers addressed Criterion 2 in any detail, and in each of those the treatment was a brief part of a consideration of all EC2000 criteria, inadequate to provide meaningful guidance to programs trying to manage Criterion 2. In contrast, 52 articles dealt with some aspect of Criterion 3 (Outcomes a-k).

The authors describe "a two-part procedure for operationally defining Criterion 2, a procedure we have developed and used as a guide for diverse engineering programs within North Carolina State University College of Engineering." In that procedure, they state: "Most constituencies are too large to be used as a whole, so the program needs to identify suitable representatives for the groups and/or describe methods, such as a survey, for gaining the participation of the representatives." My review of the literature since the Carter, Brent, and Rajala paper also uncovered little written advice on how to create or update PEOs.

Younis[7] describes how the Department of Engineering at Indiana University-Purdue University Fort Wayne "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." However the three components examined (for example, the "ability to identify and analyze ethical issues [related] to the performance of job") are closer to outcomes than to objectives; they do not express what graduates should achieve.

Petersen *et al.*[6] confirm that the PEOs are the starting point for designing a program. In particular, "The professional/occupational niche must be identified that the graduates of the program are to 'occupy.' The institution identifies a specific range of careers for which its graduates will be primarily prepared."

Johnson[4] reports on how a department at Rochester Institute of Technology used their industrial advisory board to explore how changes in global manufacturing should be reflected in changes to the PEOs. They note: "This situation highlights the critical importance for programs in manufacturing not to just react to the needs of current employers but to consider the new roles, challenges and opportunities that technical and business changes will create for graduating manufacturing engineers." Also, "we need to be sure that our continuous improvement process continues to look for shifts in technology and business processes that can impact our students. If we sit back and wait for external constituents to tell us what is required it will typically be too late for us to react and change to meet the challenge. As engineers we are comfortable with reacting to changes in technology; however the issues we face are just as likely to be in the soft skill areas. Therefore we need a process that not only considers new technology but new skills, behaviors and business practices that will impact our students."

Most programs seem to generate PEOs from the faculty, with advisory board input or review. For example, Mayes and Bennet[5] in their review of ABET Best Practices state: "Advisory Boards are used in a variety of ways, but primarily to validate that the program has the right objectives and, sometimes, outcomes." Felder and Brent[3] stress the value of faculty of involvement: "The engineering criteria constitute an antidote to curricular chaos. The exercise of constructing a clear program mission, broad goals that address the mission (program educational objectives), and desired attributes of the program graduates (program outcomes) requires the faculty to consider seriously—possibly for the first time—what their program is and what they would like it to be."

The problem thus is to ensure that the faculty who develop and revise the PEOs are sufficiently aware of what industry wants. Not previously identified in the literature is the need to help the faculty reach consensus, if possible, on the PEOs.

Our process

We have twice successfully used the following process to devise and to revise PEOs:

1. Obtain job descriptions from company websites and from job search websites.
2. Circulate these job descriptions among the faculty having each faculty member rate each job on job quality and on the preparation of program graduates for the job.
3. Consolidate and summarize the data obtained in step 2 and provide a summary to the faculty.
4. Have the faculty discuss the results.

Some background is necessary to understand the following discussion. We are a small department, with seven faculty members, offering a BS in Industrial Engineering, BS in Engineering (with specialization in Mechatronics), and the MS in Industrial and Systems Engineering. We have four faculty members with PhDs in Industrial Engineering, two with PhDs in Electrical Engineering, and one with PhD in Mechanical Engineering. In terms of teaching focus, three identify primarily with the BSIE, three primarily with the BSE, and 1 with both. However, these distinctions are stated too strongly and we all feel responsible for students in both programs; the BSE and BSIE programs share most of the courses in the first two years and many higher level courses as well.

I will now explain each step in more depth.

Obtain job descriptions

First, we asked the faculty to obtain job descriptions from company websites and from job search websites. Each faculty member searched job web sites such as Monster.com and Engineeringjobs.com using specific key words; we used a faculty meeting to plan that search and split up the keywords among us. Faculty members also find jobs on the websites of specific companies that we hope will hire our graduates. Each faculty member searched for jobs that he/she thinks are good ones for our graduates, jobs that should be used to design the PEOs, but the chair also adds “ringers,” that is, jobs that probably are not good jobs for our graduates. The idea is to have a range of jobs so there can be agreement and disagreement about good jobs and bad jobs.

For example, in applying the process to the BSE-Mechatronics program, one faculty member used mechanical engineering keywords; another used words such as controls, testing, measurement, instrumentation; a third used electrical engineering and mechatronics words; and a fourth used words related to robotics and automation.

Faculty rate the job descriptions

Next we circulated these job descriptions among the faculty, having each faculty member rate each job on job quality and on the preparation of program graduates for the job. We circulated the jobs as a printed packet, with each job given a unique number. Each faculty member is emailed a spreadsheet to fill out and send back to the chair using the following rating schemes.

1. Quality of job - is this the type of job you think our graduates should aim for after 0-5 years experience? Should we design our program so our graduates can get this job after 0-5 years experience?

 0 = no way, not what our grads should aim for
 1 = Ok job, but we shouldn't design our program for it.
 2 = below good, but acceptable. Our program should have this job as the lower bound of what our students can do.
 3 = good job
 4 = very good job
 5 = exactly the type of jobs our graduates should aim for

2. Preparation - how well prepared are our graduates to get the experience needed to get this job 0-5 years after graduation?

 0 = no way, our grads would be clueless
 1 = our grads would have to work hard to get the experience required for this job
 2 = with a little luck, our grads could get this experience
 3 = our grads are prepared to get the experience required for this job
 4 = our grads are very well prepared to get the experience required for this job
 5 = our grads are perfectly prepared to get the experience required for this job

The scales are expressed in colloquial language, which captures well the distinctions we wanted to make. The phrasing of these questions reflects the phrasing of PEOs. These may be jobs that require experience; the point is to determine if our graduates will be able to gain the experience, skills, and knowledge called for by these jobs. What do we want our graduates to be able to do in those first years? The first rating is meant to help us identify good jobs, that is, jobs for which we want to design the program. The second rating is meant to help us identify gaps in our program, that is, places where we need to improve the program so our graduates can get those good jobs.

Organize the results

After receiving input back from each faculty member, the chair consolidated and summarized the data obtained in step 2 and provides a summary to the faculty.

The summary has included how each faculty member rated each job on Quality and on Preparation, without faculty names. For each job the average Quality, range in Quality, average Preparation, and range in Preparation are given. In addition, jobs are sorted or labeled into three categories:

- Jobs uniformly rated high on quality
- Jobs with mixed ratings
- Jobs uniformly rated low on quality

Jobs are identified in which there are large gaps between Quality and Preparation, especially jobs receiving high ratings in Quality, but low ratings in Preparation; such jobs suggest that program revisions are needed.

In our experience, each faculty member is an outlier on at least one job; that is, each faculty member rates very high in Quality a job rated low by everyone else, or rates low in Quality a job rated high by everyone else. Given that our faculty members have diverse backgrounds, this result is not surprising. Psychologically, this result has been important as evidence that factions among the faculty members, if any exist, are not perfectly coherent. Also, each person notes that he or she is an outlier, and thus realizes that he or she may need to defend a ranking against all other faculty members; this realization may make each person gentler in questioning others about their rankings.

The faculty discuss the results

We next met and discussed the results. After discussion, which was sometimes heated, good things emerged.

At this point in describing the process, I am reminded of the cartoon showing two researchers in front of a blackboard containing a complicated proof. One researcher points to the part of the proof that says "Then a miracle occurs," and says to the other researcher, "I think you should be more explicit here in step two."

What do we discuss during the discussion and exactly how have good things emerged from this discussion?

When we used this process to develop our PEOs for the BSIE program, we classified jobs into three categories:

1. We design our curriculum so our students can get these types of jobs 0-5 years after graduation
2. Our curriculum is robust. While not designed for these jobs, the curriculum prepares our students to get these types of jobs.
3. These jobs are not ones our curriculum should be designed for.

Sometimes disagreements ended up being the result of misunderstandings. In one case, one faculty member, after educating us about the meaning of the word "firmware," convinced the rest of us that his ratings (which had been extreme outliers: Quality=0 and Prep=0) were correct. Another job helped us distinguish between a job that would be good for an industrial engineering graduate and a job that would be good for an engineering management graduate. Some jobs were ones that our graduates could be hired for and would even enjoy and flourish in, but we still did not want to design our curriculum for those jobs. For example, one job focusing totally on safety led us to conclude that a strength of our curriculum is the inclusion of a strong safety class, but that we still would not design our curriculum for this job. We also discussed electives that we could offer if we had more students, electives that could help graduates aim for certain jobs; but again we concluded we would not design our required curriculum for those jobs.

We always struggle with keeping our curriculum up-to-date in computer tools and with selecting the correct tools to teach them: Inventor or SolidWorks or ProEngineer? We found that jobs used all of these and concluded that we are correct to pick one (SolidWorks, in our case) and teach the students how to transfer their skills. Such a situation provides an opportunity to stress lifelong learning.

Our differences in ranking of the Preparation of our graduates led to interesting discussions in which some of us actually learned what is covered in some courses outside of our expertise. Some had rated certain jobs high in Preparation under the mistaken belief that we cover certain topics; some had rated certain jobs low in Preparation under the mistaken belief that we do not cover certain topics.

We usually end up discussing each job, but some take less time than others; we can usually quickly discuss ones on which there is uniform agreement in rating it high or low in Quality, but even those discussions are important in building consensus.

In the review of BSE-Mechatronics jobs, our discussion led to conclusions on priorities for changes to be considered to the curriculum: more programming in C; a microcontroller course; a course in hydraulics. We concluded that our standardization on Matlab and Labview were excellent decisions and that we should consider requiring students who transfer into the BSE-Mechatronics program to take our programming class (in Matlab) if they have not had Matlab but another programming language. We saw that jobs tended to be split into two hardware/software worlds, (NI world and Matlab world) and concluded that a strength of our program is that we teach them about both worlds. We concluded that we had lots of agreement in our disagreement and our program is "right on the money" in helping our students to be prepared to get the jobs we identified as good ones.

Several years ago our Advisory Boards strongly recommended that we add Project Management to both programs and we did so; review of the jobs helped us understand how good that recommendation and decision were.

Some jobs had good technical content, but were at the technician level; we are not designing our program for our graduates to take such jobs. Some jobs had specific industry niches and we decided not to design our program for a specific industry.

One of the real benefits of these discussions was that the jobs provided a focus for disagreement. Rather than having lofty discussions about hypothetical jobs, faculty members argued about specific jobs. We had to discuss with each other exactly what features of a job made it a good or bad one. Such disagreement uncovered hidden assumptions and differences of opinion, but these were easier to discuss, and often to resolve, in the context of the specific job. Also, since every faculty member had searched for and contributed job descriptions, we all had gained knowledge of the types of jobs that actually exist. It was harder, therefore, to argue for preparing our students for hypothetical jobs that we didn't find represented in our pool.

Conclusion

Program educational objectives are the starting point for designing or revising an engineering program. What do we, the faculty, want our students to be able to achieve in the first few years of employment? We have twice used with success a process involving the identification, ranking, and discussion of specific jobs on their quality as a job and the preparation of our students for these jobs. We recommend this process to others as a way to focus discussion, and, hopefully, to reach consensus.

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