What are They Thinking? – Assessment and the Questions Students Ask

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Abstract

This paper presents an assessment method whereby an instructor can gain insight into how a student is thinking about a project. The method relies upon the submission of a series of individual progress reports during the course of a semester. Each progress report is submitted as the set of questions that the student has developed and is pursuing in relationship to a course project. By the last progress report, the student must resolve all the questions that he/she has raised during the semester. Each submission is evaluated based on the depth and breadth of the questions and their resolutions. This paper focuses on the use of this reporting method as a potential ABET assessment tool within an individual course offering.

Introduction

One of the challenges of ABET assessment is gaining an understanding of the skills that students are developing in various courses. Such an understanding is important because it is far easier to modify program outcomes by making changes at the individual course level rather than making changes at the program level. To assess and modify at the course level, the instructor must be able qualitatively and quantitatively evaluate the student thought process. This requires something more than the standard collection of technical information (solutions to homework or exam problems, technical reports, etc.). The purpose of this paper is to present one possible format for more completely capturing the student thought process at the individual course level.

The study described in this paper pertains to reporting for a design project in a design intensive course. The reporting format requires the submission of a series of progress reports where each progress report consists of a set of questions and resolutions that the student has developed for a given design project. The goal of this format is to focus more on the student thought process rather than formal reporting style. Students develop their own questions about their design projects and present resolutions to the questions as the resolutions become available. The format allows the instructor to track both the student thought process and progress. While this paper focuses on the use of this reporting method as part of a design project, the reporting format should be easily adaptable to other areas of course work.

The question and answer layout described in this paper is well suited for use as an ABET tool. The format allows the instructor to quantify the student thought process by categorizing the questions according to various program goals. The format also allows for qualitative assessment with the ability to examine the depth of thought related to the questions and answers. The result is that the format can give the instructor an informative "snapshot" of the course effectiveness in making students consider multiple issues and objectives.

The following sections describe the reporting format and results in more detail. The first section details the reporting format and the corresponding course environment. The results of the study are then examined from an assessment perspective. Finally, some conclusions are presented along with recommendations for future implementation of the method.

Course Environment and Reporting Format

The teaching experiment described herein was carried out in the "Mechanical Systems Design" course taught at the University of Wisconsin-Platteville (UWP). This is a junior/senior level course that serves as a precursor to Senior Design. Key elements of the course include a comprehensive "design and build" project, and a lecture focus on developing the complete design process.

In the semester studied, students in the course were required to design and build a laboratory experiment to demonstrate the functioning of a mechanical system. The premise was that the experiment would become part of a "lab kit" to be used in conjunction with an on-line presentation of the Mechanical Systems Laboratory course taught at UWP.

Students worked on design teams of 3-4 people to pursue their project. As part of the reporting process, each team was required to submit 4 progress reports during the semester. In addition to this, each individual student was required to submit an "individual progress report." These individual progress reports are the focus of this paper.

Each individual progress report was to contain a set of design project questions that the individual student had formulated. Students were required to provide resolutions to their questions as the resolutions were obtained. The progress reports were cumulative in nature, with students adding new questions and resolutions to their old ones with each additional report submission. Questions were not required to be resolved in the current progress report with the exception that all questions must be resolved by the final progress report submission. Reports were collected at 3 week intervals beginning with the 5th week of class for a total of 4 individual progress report submissions.

With each report submitted, students were asked to classify their questions according to one or more of the categories shown in Table 1. These categories are representative of the ABET assessment outcomes associated with the mechanical engineering program at UWP. Table 1 also shows the number of questions asked for each outcome and the overall percentage of questions asked for each outcome. The next section examines these results in more detail.

Category (related to program educational outcome)		# of Questions by Report Number [# of Q's (% of total)]				Totals		
		#1	#2	#3	#4	Total	% of Total	
Technical Skills	Technical Analysis	11 (2.9%)	66 (13%)	43 (8.8%)	27 (11%)	147	9.1	56%
	Hardware/prototyping	69 (18%)	92 (18%)	102 (21%)	33 (14%)	296	18	
	Test and experimentation	76 (20%)	111 (22%)	143 (29%)	62 (25%)	392	24	
	Computer skills and issues	12 (3.2%)	33 (6.5%)	26 (5.3%)	9 (3.7%)	80	4.9	
"Soft" Skills	Communication	19 (5.0%)	24 (4.7%)	26 (5.3%)	12 (4.9%)	81	5.0	44%
	Teamworking	28 (7.4%)	34 (6.7%)	23 (4.7%)	9 (3.7%)	94	5.8	
	Project planning and design process	62 (16%)	58 (11%)	30 (6.1%)	19 (7.8%)	169	10	
	Societal issues	72 (19%)	26 (5.1%)	30 (6.1%)	34 (14%)	162	10	
	Ethics, Safety, and Professional practice	1 (0.3%)	22 (4.3%)	23 (4.7%)	6 (2.5%)	52	3.2	
	Student learning	29 (7.7%)	44 (8.6%)	45 (9.2%)	33 (14%)	151	9.3	

Table 1: Summary of Question Submissions by Type

Assessing the Results

The student submissions were assessed with two objectives in mind. The first objective was to examine the student's insight into various design issues. The second objective was to examine the breadth of topics that students considered as part of their design process. This paper focuses primarily on the second objective and its relationship to the ABET assessment process.

The second objective, the evaluation of the breadth of student thinking, can be used for both course assessment (grading), and program (ABET) assessment. Much of engineering coursework relies heavily on the presentation of technical material, thus making evaluation of how well students address nontechnical or "soft" skills difficult. The ability to see the questions that students are asking and to classify them by type, as in Table 1, gives a clearer evaluation of where students are investing energy within a course or project.

While questions are easily correlated with program outcomes, several challenges exist when trying to evaluate the results of the correlation. In the case presented in this paper, the particular project has some impact on the outcome. Because students were designing an experiment, the questions asked were, by nature, somewhat biased toward the "test and experiment" category and the "learning" category as students had to reflect on how other students would best learn a concept through the experiment developed.

A second challenge is the question of how to normalize the results so that they can be compared to similar efforts in other courses and related to overall program effectiveness. One possibility of how this might be done is shown in Table 2. For the particular course under consideration, the course goals are consistent with the idea that students should divide their time equally between technical and nontechnical design issues. If we give equal weight to each of the subcategories, this means that students should be spending about 12.5% of their technical thinking in each of the given technical categories and about 8.3% of their thinking in each of the soft categories. If success is considered to be meeting these numbers at a level of 70% or better, Table 2 then indicates which goals are met and provides a normalized number for comparison with other classes where the emphasis on the various technical and nontechnical goals may differ.

A potential drawback of the evaluation method presented in Table 2 is that it is, in part, a measure of quantity over quality. For example, if students are comfortable in how they communicate, they may not have so many questions related to communication and thus the class assessment may show a low score even though the students are communicating well. On the other hand, the assessment method does enforce the idea of continuous improvement. That is, even if students are already proficient in some area such as communication skills, they can still be interested in posing questions about how to communicate even better.

In spite of the potential problems of making an evaluation strictly on quantity, the results in Table 2 correlate fairly well with the way the course was taught. The areas that score the lowest are, in general, the areas where least instruction emphasis was placed.

The premise of having students ask questions to demonstrate their thought processes is capable of producing significant insight into where and how students are spending their time thinking. The method can be used to assess the thinking and insight of individual students and to assess the overall success of the course in meeting course and program goals. This latter capability has potential implications for tying into ABET assessment processes.

		% goal	Actual %	(Actual/goal)*100%	Learning objective met?	Normalized Value (1-10)
Technical Skills	Technical Analysis	12.5	9.1	73	Yes	7
	Hardware/prototyping	12.5	18	100+	Yes	10
	Test and experimentation	12.5	24	100+	Yes	10
	Computer skills and issues	12.5	4.9	39	no	4
"Soft" Skills	Communication	8.3	5.0	60	No	6
	Teamworking	8.3	5.8	70	Yes	7
	Project planning and design process	8.3	10	100+	Yes	10
	Societal issues	8.3	10	100+	Yes	10
	Ethics, Safety, and Professional practice	8.3	3.2	39	No	4
	Student learning	8.3	9.3	100+	Yes	10

Table 2: Normalized Evaluation of Course Objectives

Future Possibilities

This paper has examined a "first cut" effort at trying to better understand the student thought process associated with design project development. The understanding is gained by having students create progress reports that have a question/answer format to provide the students with an opportunity to present the issues they are trying to resolve in their projects and the resolutions obtained. The methods provide a basis by which a course may be evaluated relative to ABET program goals.

Future implementation of the method presents some opportunity for refinement and improvement. One area of improvement is the question of how to include a "quality" measure in with the quantity measure presented. One possibility is to weight each question/response with a "quality factor" on a scale of: 0.5 = low; 1.0 = medium; 1.5 = high. While somewhat subjective, this would probably provide a slightly better overall measure of student outcomes.

A second challenge is that of normalizing the results to compare with similar efforts in other courses. A method similar to that used in Table 2 has perhaps the best promise. One modification would be, if necessary, to change the weighting of each goal to reflect its relative importance to the course and/or program goals. This was done somewhat in Table 2 by placing a slightly higher individual emphasis on the technical areas.

Collecting questions that students develop forces the students to document their thought process as they proceed through a course. The methods presented in this paper show that this can lead to the ability to quantify these thought processes with respect to various program and course objectives. This feedback should prove useful in modifying course outcomes so that the course makes the desired contribution to overall program outcomes.