Self-reported Instrument for Measuring Student Learning Outcomes

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Abstract

Project PROCEED is dedicated towards providing more hands-on and project-centered classroom learning opportunities in the mechanical engineering department at The University of Texas at Austin. One of the challenges of PROCEED is assessing its impact on student learning. We have been developing and piloting an instrument for assessing how well these PROCEED courses are satisfying the departmental student learning outcomes. Based upon an assessment instrument used by Addington and Johnson at VMI (1999), this instrument measures the quantity and quality of learning opportunities and student achievements relative to the student learning outcomes. All results are self-reported by the students using a 5 point Likert scale. The instrument was first piloted Summer 2002 then extensively revised and given again during the Fall 2002. This paper will describe the considerations during the design of the instrument, the input from the pilot, and the revisions made. A copy of the instrument is included in the appendix.

Introduction

At The University of Texas at Austin, Project PROCEED is focused upon integrating more projects into the mechanical engineering curriculum. While problem-based learning (PBL) has been part of higher education for over thirty years, the traditional lecture-based teacher-centered format still seems to dominate engineering education. For engineering courses, project-based learning may be more predominant than problem-based learning. While some may argue the differences, we distinguish the two by defining project-based learning as culminating with the creation of an artifact such as a prototype or report. One reason that more faculty do not use PBL may be that they do not know how to effectively implement it into their classroom. Those faculty members willing to try to integrate project-based learning into their courses are frequently pioneers with few experts to rely upon for advice. They're out there learning what works and doesn't work through trial and error.

One way to determine what is and isn't working is through feedback from students. Our assessment goals are to provide feedback to these adventurous instructors so that they can make timely adjustments to their courses.

The first step in designing any assessment plan is to determine what is to be assessed. In assessing a course we must first ask "what are we expecting the students to gain from this course?" For traditionally taught engineering courses using a textbook, the desired student learning gains may be obvious. They may even be stated in the textbook. But with project-centered courses, the intended student learning outcomes may not be so clear. Yes, there is technical content to be learned, but there may be other less explicit skills we wish for students to acquire. Projects provide an opportunity for students to develop their professional skills such as project management, communication, and working with others in a group. They are also an opportunity for them to practice being an engineer through open-ended problem solving. As part of our ABET accreditation process, all mechanical engineering courses will be required to have the student learning outcomes listed on the course syllabus. Students will be given this syllabus the first day of class. Students need to become aware of the importance of these outcomes. One way to raise students' awareness of these outcomes is by emphasizing them in the course assessment process.

Projects are perceived to require a large amount of time, sometimes more than in traditional classes. We want projects in the classroom to be effective learning opportunities that not only support the specified student learning outcomes but are also efficient so that time spent on the project is useful, not wasted doing busywork. We want to find the right balance between course effectiveness as indicated by student learning gains and course efficiency as indicated by time well-spent. Given infinite time, probably any course can be effective yet we have only a very brief and finite amount of time for each course thus the need for efficiency. While seeking an existing instrument to use, we came across a description of an instrument at VMI[1] that looked at the quantity and quality of opportunities for learning as well as the students' achievement or learning gains relative to departmental outcomes. Quantity and quality of opportunities measures the efficiency of the course. The student's self-report of their personal achievement in knowledge and skills measures the effectiveness of the course.

Developing the Instrument

Our goal for a course assessment process was not to compare the learning gains of a project-based course to the traditional lecture based course. Ample studies exist to support the benefits of projects for student learning gains. We wanted to provide feedback regarding how well the project-based courses were meeting their learning goals as defined by the course outcomes. The faculty of the mechanical engineering department had already defined ten student learning outcomes for the ME curriculum, consistent with the EC 2000 Criteria. Defining and meeting these outcomes will be part of our ABET

accreditation process in 2004. By then, every course will be required to have learning outcomes defined as part of the course syllabus. Not every outcome was intended to be stressed in every course but every outcome should be adequately stressed within the curriculum.

The VMI instrument[1] asked the students to indicate on a scale of 1 to 5 how well each departmental outcome was met in terms of the quality and quantity of instruction and their own learning gains. Our concerns with the VMI instrument were that the validity and reliability might be low due to the lack of clear definition of both the scales and of what is meant by quality and quantity of opportunity and achievement. I set out to design an instrument based upon the constructs measured by VMI but with a more clear and consistent definition of both the scales being used and the constructs being measured.

Version 1

The first version of the Quality, Quantity and Improvement Instrument, or QQI, was piloted the summer of 2002 in two upper level project-based courses. In an attempt to increase validity and reliability, efforts were made to define what was meant by quantity, quality and improvement as well as a more detailed scale definition than what was used at VMI. Students were also given a "survey of the survey" to provide feedback about the survey. The QQI was given twice during the summer with some of the feedback from the mid-semester "survey of the survey" implemented in the end-of-semester version.

Version 2

The next version of the QQI reflected not only adjustments based upon the student feedback provided over the summer but also recommendations made by measurement and evaluation professionals on campus. We particularly focused upon the wording defining the scales for each construct. One significant change was to depart from the matrix format and instead give each construct – quantity, quality, and improvement – an individual page. This meant that the survey went from one page to three. The directions were also much briefer with less description of what each construct meant. This version was given to students mid-semester in one upper level student-centered course. The students were very confused. After about six or eight students raised their hands and called me over for clarification – something that had not happened in the summer with the matrix format – I realized that I needed to go back to the matrix. The matrix forced them to immediately recognize that three different constructs were being measured and they then distinguished between them. They also were very vocal that the survey was too long.

Version 3

I quickly revamped the format back into a matrix before giving it to two more sections of

the same course during mid-semester. Lesson learned, my intentions are to keep the matrix format. The approximately 70 students who took this instrument, V3, did not experience the confusion about the three constructs being evaluated that were experienced with Version 2. There were still some complaints about length. Version 3 was also given at the end of the semester to the students who had experienced Version 2. While the confusion seemed to be minimized, there were still some complaints that it was too long but also comments that it was better. A sample of Version 3, modified to accommodate the formatting requirements for this paper, is provided in Appendix A. Please obtain permission to use the survey from tljones@mail.utexas.edu.

Discussion of Results

The matrix format appears to be essential to minimize confusion about the three constructs. In Version 2, with the three constructs on separate pages, the students did not seem to focus upon the first construct being evaluated. Instead, they seemed to respond related to their initial general impression of what was wanted. Then when they came across the same outcomes for a different construct, they didn't understand why they were being asked the same thing. That's when the hands went up. Having the three constructs listed together seems to force the student to recognize that they are being to asked to think about three different things. Or, as one student put it on the survey about the survey, "*I was on the 2nd page before I knew what I was supposed to do on the 1st* ." While the constructs of Quantity and Quality are different and may have caused some confusion, particularly the first time the students are exposed to them, the students did seem to grasp them. Repetition of this same format for different courses is expected to strengthen the students' understanding of what the different constructs mean.

Addington and Johnson[1] noted that their students were not familiar with the outcomes they evaluated. They corrected this problem by giving them a handout describing the outcomes at the beginning of the semester. This did not seem to be a problem for our students. Regardless, in the near future the outcomes for the course will be defined on the course syllabus handed out the first day of class for all ME courses. As changes to support the ABET accreditation process become more ingrained in our system, the departmental outcomes will become more prominent to both students and faculty.

Self-reported Data

This instrument collects student self-reported data. While such data may be valid for representing student perception, it may not represent actuality. For instance, the students' self-reported achievement is not necessarily reflective of their actual achievement. However, research supports that student self-reported gains are useful indicators of actual learning gains[2,3,4].

Length/Number of Outcomes

Probably the biggest issue with the survey was the length. For the two different courses evaluated, one survey contained 18 items and the other 22 items. In the latter class, Version 3 ended up over a page long. My recommendation is to not exceed one page or about twelve to fifteen items.

Scales

As part of the survey of the survey, the students were asked about the best gradient on the scale. A Likert scale of 1 to 5, the scale that was actually used, was strongly supported. Some students took issue with the descriptors used for describing the different values on the scales and admittedly this is an area we can probably improve on in the future. One possibly confusing use of this scale, as indicated by a few comments in the classroom, is that "3," not "5," is the optimal response for quantity. Most students are used to "5" being the most flattering value.

Validity and Reliability

Validity can be defined as how well you are measuring what you actually want to measure. To do this requires that the people who are taking your survey are reading and responding to your survey as you intended. The pilot tests and survey-of-the-survey were performed to ensure the validity of the survey. Reliability refers to the repeatability of the survey results. To examine the reliability of the instrument, I used SPSS to calculate Cronbach's alpha for Version 3. For each of the three constructs, alpha was very high, 0.85 and above. Eliminating any one item would have had essentially no effect on the alpha value.

What's Next?

The current plan is to implement the QQI on a broader scale within the department. To do so, we plan to transfer it to an online instrument that will provide statistical feedback to the instructor of the course. In the interim, we plan to adapt it to a scantron sheet. Idealistically, we envision a highly automated process where mid-semester, the QQI for that course is created online. The professor receives notice that the survey is ready, provides his class any necessary access information, and in a week or so, when the students have all completed the survey, the professor receives a data file with the results including descriptive statistics which he can then use towards modifications to his class.

Bibliography

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Appendix A

Student Evaluation of Outcomes/Objectives

This survey measures your perceptions of how much this course (not the entire curriculum) has helped you to meet the course student learning outcomes and objectives. This survey measures your experiences with this course by looking at the quantity and quality of the learning activities provided by the course as well as your perceived improvement.

- **Quantity refers to the amount of time you have spent in this course on activities, including homework, projects and classroom discussion or lecture, to help you meet the student learning outcomes and objectives.**

- **Quality refers to how appropriately the activities in this course were designed to support your development of skills and acquisition of knowledge to meet the student learning outcomes and objectives.**

- **Improvement refers to your own perceived personal improvement in knowledge and skills to meet the student learning outcomes and objectives.**

Instructions:

For each outcome listed in the first column, indicate your response for quantity, quality and improvement by circling the appropriate numerical value based upon the scale provided at the top of the column. Circle NA if you find the student learning outcome/objective to be not applicable for this course.

Student Id Number_____

Learning Outcomes	Quantity The amount of time in this course spent on activities to support this learning outcome has been 1 way too little 2 too little 3 just right 4 too much 5 way too much	Quality The quality of the activities in this course to support this learning outcome has been 1 very poor 2 poor 3 satisfactory 4 very satisfactory 5 exceptional	Improvement As a result of this course, I have improved my skills to support this learning outcome. 1 strongly disagree 2 disagree 3 neither agree nor disagree 4 agree 5 strongly agree
1a. Ability to apply engineering fundamentals to real problems.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
1b. Ability to apply the principles of thermodynamics to real-world problems.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
1c. Ability to apply the principles of fluid dynamics to real-world problems.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
1d. Ability to apply the principles of heat and mass transfer to real-world problems.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
2a. Ability to analyze open-ended problems.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
2b. Ability to solve open-ended problems.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
3. Ability to perform engineering design (components, systems, and processes).	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
4a. Ability to use modern computer tools in mechanical engineering.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
4b. Ability to apply specialized software application such as MATLAB in the analysis of engineering problems.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
5a. Ability to effectively communicate the results of an engineering analysis in writing.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
5b. Ability to communicate effectively in routine oral conversation with teammates	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
5c. Ability to use graphics to effectively communicate the results of engineering analysis.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
6a. Ability to work productively in teams.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
6b. Ability to apply interpersonal skills in engineering contexts.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA

You're not done yet - CONTINUED ON BACK >>>>>>>>>>>>>>

Learning Outcomes and Objectives	Quantity The amount of time in this course spent on activities to support this learning outcome has been 1 way too little, 2 too little, 3 just right, 4 too much, 5 way too much	Quality The quality of the activities in this course to support this learning outcome has been 1 very poor, 2 poor, 3 satisfactory, 4 very satisfactory, 5 exceptional	Improvement As a result of this course, I have improved my skills to support this learning outcome. 1 strongly disagree, 2 disagree, 3 neither agree nor disagree, 4 agree, 5 strongly agree
7. Awareness of professional issues in engineering practice.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
8. Awareness of contemporary issues in engineering practice.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
9. Ability to define the steps necessary for addressing a project.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
10. Ability to determine the necessary resources for addressing a project	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
11. Ability to ask the right questions for addressing a project.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
12a. Ability to create schedules necessary for completing a project.	1 2 3 4 5 NA	1 [illegible] 3 4 5 NA	1 2 3 4 5 NA
12b. Ability to maintain schedules necessary for completing a project.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA
13. Ability to successfully find the information necessary for completing a project.	1 2 3 4 5 NA	1 2 3 4 5 NA	1 2 3 4 5 NA

END OF SURVEY

Please contact Theresa Jones, tljones@mail.utexas.edu, for permission to use this survey.