2006-966: ASSESSING THE CONNECTIVITY OF AN ELECTRICAL AND COMPUTER ENGINEERING CURRICULUM

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Abstract

Program level assessment is done by combining the contributions from several units within the program at designated time intervals. Course level assessment is one of those units and is usually done within a course using tests, homework, projects, presentations etc. without looking at the connected courses and their learning outcomes. Although course level assessment uses most of the resources under assessment and is considered an essential feedback path in making the curricular changes, very little effort has been devoted to reliable measures of student learning as they go through a sequence of connected courses. This study focuses on assessment across the Electrical and Computer Engineering curriculum in the signals and systems area and looks into what has been retained from the core knowledge.

Introduction:

Faculty members who serve on course and curriculum committees are quite familiar with the complaints of the instructors who teach lower level undergraduate courses. The most common one being: “students don’t have the prerequisite knowledge!” given after the proper acknowledgement of the instructor who taught the prerequisite course. This feedback usually lacks any quantitative measure but spreads like wildfire and soon enough finds its way to the agenda of the course and curriculum committee. At that point, coordinator of assessment makes a simple request that evidence is needed before any actions are taken about the problem.

Engineering programs have gone through transformations after EC2000, designed processes which would facilitate the continuous improvements of their programs and placed the curriculum at the center of their operations. Electrical and Computer Engineering department at North Carolina State University was one of the leaders of this movement and adopted a two tier curriculum after a year of intense work involving all of its constituents. The contributions of courses in the ECE department to the ABET program outcomes are shown in Figure 1.
essential core and intermediate electives marked to show the sampling done across the curriculum.

We looked at the three courses marked on Figure 1.

1. ECE 220 Analytical Foundations of Electrical and Computer Engineering (Sophomore Level)
2. ECE 301 Linear Systems (Junior Level and ECE 220 is the prerequisite)
3. ECE 402 Communications Engineering (Senior Level and ECE 301 is the prerequisite)

From 2004 to 2006, we followed a group of students through these courses and obtained core knowledge test results in all three of the courses. We asked four questions:

1) Do students come in with prerequisite knowledge?
2) Are course grades and retention of knowledge correlated?
3) Do students continue to learn the basics of a curriculum, even if not specifically taught in a course?
4) Who learns the most?

The two-tier curriculum design allows us to repeat this experiment in two more areas; digital systems and electronics. Sampling across the curriculum in three major areas has the potential to give us valuable data in assessing the effectiveness of the curriculum in place.
Methods of course assessment and how to develop assessment of learning across the curriculum have been developed by the authors over the past few years\textsuperscript{1,2,3,4}. This paper explains the use of assessment to answer the four questions outlined.

**Experiment**

On the first day of ECE 301 class, students were presented with a quiz which had four questions. These four problems were chosen from the core knowledge of signals and systems area and all four of them were chosen from areas which were covered in the prerequisite course ECE 220 but not with equal emphasis.

Question 1: Sinusoidal signals (Functional graphing skills)

Question 2: Time shifting and scaling of basic signals (Operations on independent variable)

Question 3: Euler’s identity (Complex numbers)

Question 4: Laplace transform of a decaying exponential (Integrals of complex functions)

It was expected that the average of the fourth problem would be much less than the first problem. The quiz sheets were numbered and students were asked to put their number next to their name on the class roll. The instructor put the class roll with code numbers in an envelope, sealed it and signed it across the seal to assure the students that their responses will remain anonymous. They were asked to give their best effort and the importance of this experiment was communicated to them. The tests were not returned, however, the results were shared with the class to give them an idea as to where their baseline is. The prerequisite material was not taught again during the semester but it was referenced frequently. At the end of the semester, students were given a test on the same topics with slightly different questions and they were asked to put their code numbers once again on their tests.

In the following two semesters, students were tested again, this time in an elective course, ECE402 which used ECE301 as the prerequisite course. When all the testing was finished, students who were present in all three of these tests were identified and there were 43 of them.

The tests described above were labeled as follows:

Test given on the first day of ECE 301: **Pre-test** (Prerequisite course: ECE 220)

Test given during the last week of ECE 301: **Post-test**

Test given during the first month of ECE 402: **Follow-up** (Prerequisite course: ECE 301)

Hake, a renowned physics education expert, has published widely about the use of pre/post testing as a direct assessment measure of student’s domain-specific learning in physics education\textsuperscript{5,6,7,8}.

Other educators have begun to use these methods in astronomy, economics, biology, chemistry, computer science, economics, and engineering\textsuperscript{9,10,11,12,13,14}. 
Results

In this section, we would like to present the results in the same order as the questions given above.

1. **Do students come in with prerequisite knowledge?**

  Instructors who teach lower level classes in engineering know it all too well that having a passing grade in the prerequisite class is not always equal to possessing the prerequisite knowledge. The best way to find out what they know is to give them a test on the perquisite material on the first day of class. Their pretest performance not only shows us where their weaknesses are but also allows us to measure knowledge gained at end of the semester by providing us a baseline.

  If we put an arbitrary threshold of 70% on their pretest performance as “possessing the prerequisite knowledge”, only 30% of the students were above the threshold in this experiment. It is possible to translate this low percentage as lack of prerequisite knowledge and take an action on the prerequisite course. However, when these students were tested again at the end of the semester, on the same knowledge, 60% of them scored above the set threshold.

  When we look at the posttest scores, we see significant positive change in all categories. The big jump on Question 4 from Core1 to Core 2 is an expected result since the subject material (Laplace / Fourier Transforms) is rather difficult to learn and retain at the sophomore level. The material was introduced in the Core1 course during the last three weeks of the semester with the side note that it will be covered in depth in the Core 2 course.
Normalized gain as defined in [7] was calculated using the numbers given in Figure 2.

\[
\langle g \rangle = \frac{\text{Posttest(Avg.)} - \text{Pretest(Avg.)}}{100 - \text{Pretest(Avg.)}} = .38
\]

A six-thousand student survey of mechanics test data for introductory physics courses classifies a course with average gain greater than 0.3 in the “interactive-engagement zone”\(^8\).

2. Are course grades and retention of knowledge correlated?

Figure 3 shows us the relationship between letter grades in Core1 (ECE220) course and pretest results. Core 1 (ECE220) is a sophomore level C-wall course and therefore there are no D/F grades. There is a strong correlation between the course grades and retention of knowledge. Students with higher course grades have higher test scores. When we look at their pretest scores, students perform in a wide range in all grades but from the averages we can see that they are not uniformly distributed within those ranges. Students who got A’s in Core1 have an average of 78% followed by students who got B’s with 45% and students who got C’s with 40%.

Figure 4 shows us how much learning has taken place during the semester on the prerequisite material even though they were not taught the material again. The ranges of scores for students who received A’s and B’s are narrower than Figure 3 and the correlation between the posttest scores and course grades is higher.

Figure 5. Data is different than the previous two figures because the follow up course is an elective course and naturally students who liked the material in Core 2 and did well would be more inclined to choose this elective. The ranges of scores for students who received A’s and B’s
in the prerequisite course shrink even more and the correlation between the follow-up test results and the Core2 course grades is highest among the three sets of data.

Figure 3. Distribution of Core1 (ECE220) course grades and Core2 (ECE301) pretest results. N=43, Maximum score: 12, Mean: 6.63, Std. Dev.: 3.57, Corr.:0.56.

Figure 4. Distribution of Core2 (ECE301) course grades and Core2 (ECE301) posttest results. N=43, Maximum score: 12, Mean: 8.69, Std. Dev.: 2.78, Corr.:0.61.
3. Do students continue to learn the basics of a curriculum, even if not specifically taught in a course?

If we look at the averages of the individual problems on all three tests, we can see that not only students continue to learn the prerequisite material in the Core 2 course; they also retain what they learned. The follow-up test was given on the 6th week of the semester without an announcement and resulted in a higher overall average than the posttest given at the end of Core 2. It is also important to mention that some of these students were taking the follow-up course one or two semesters after they took the Core 2 course.

![Figure 6. Average scores of the four test questions in the three courses.](image-url)
4) Who learns the most?

We also looked at the relationship between knowledge gained and course grades and did not see a correlation between the two. Course grade averages were comparable for groups with different amounts of change between their pretest and posttest performances. We have to look at other attributes of the students such as their learning styles to be able to answer this question.

![Figure 7. Relationship of knowledge gained and course grades](Image)

Conclusions

Course level assessment is difficult to normalize due to many variables involved in the process. Pre and post testing the students in a given course is an efficient way of measuring student learning. Assessment of fundamentals across the curriculum gives us valuable information about student learning and retaining what is being learned. Commitment to deliver the prerequisite material to the next level course is important in achieving the connectivity designed into the curriculum.
References


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