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

Hatice Ozturk, North Carolina State University

Hatice O. Ozturk is Teaching Associate Professor of Electrical and Computer Engineering, Biomedical Engineering at North Carolina State University. She is also coordinator of assessment for both programs.

Joni Spurlin, North Carolina State University

Joni E. Spurlin is University Director of Assessment and Associate Director, University Planning and Analysis at North Carolina State University.

Assessing the connectivity of an Electrical and Computer Engineering Curriculum

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. with essential core and intermediate electives marked to show the sampling done across the curriculum.

	CORE 1					CORE 2					INTERMEDIATE					SPECIALIZATION																	
	ECE 200	ECE 206	ECE 211	ECE 212	ECE 220	ECE 301	ECE 302	ECE 303	ECE 305	ECE 306	ECE 402	ECE 403	ECE 404	ECE 406	ECE 407	ECE 420	ECE 421	ECE 422	ECE 435	ECE 436	ECE 437	ECE 442	ECE 451	ECE 453	ECE 455	ECE 456	ECE 460	ECE 463	ECE 464	ECE 465	ECE 466	ECE 480/81	Totals
A	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	94
B	3		2	3	1		3	1	3	3		2					3			1	2	3	3	1	1	3		3	1		3	2	47
C	2	3	2	3	1	1	3		2	3	3	1	3	3	1	3	2	3	2	3	3	3	3	2	2	3	3	3	3	3	3	3	78
D			2			1			1	1					1						2	3	3	0	3	2	3	2	2	2	2	3	33
E	1	3	2	1	3	3	3	3	3	3	3		2	2	3	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	84
F	1		1		1	1	1	1	2		1			1		1		2			1		2	2	3				1			1	23
G	3		1	1		1	3		2	3	2		2	2		2		2			3	3	2	1	2	1		3	2	3	2	3	49
H	1		1		1	1	2	1	1	1			2		1								2	1	1			1	1		1	1	20
I	1	1	1		1	1		1	1	1	1				1	2	1	1			2		3	3	2			1	1		1	2	29
J								1	1					1	1								2	1	1							1	9
K	3	1	2	1	3	3	3	1	3	3	3	3		3	1	3	2		3	3	3	3	3	3	1	3	3	3	3	3	3	3	78

Figure 1: ECE curriculum with core, intermediate and specialization electives and their contributions of program outcomes at 3: Major, 2: Intermediate and 1: Basic levels. (For A-K program outcomes look at www.abet.org). The courses used in the experiments are framed with bold lines.

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[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[5,6,7,8].

Other educators have begun to use these methods in astronomy, economics, biology, chemistry, computer science, economics, and engineering[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.

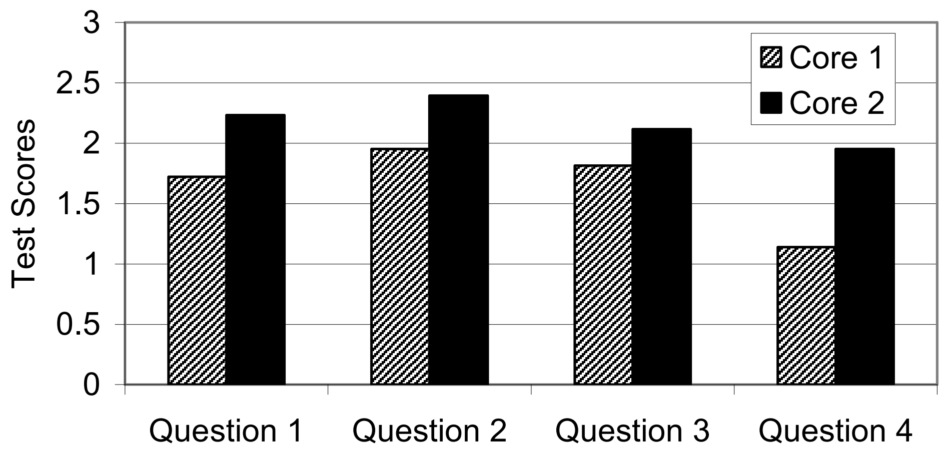

Figure 2. Average scores of students on the four questions which are picked from the prerequisite knowledge as they finish Core 1 (ECE220) vs. as they exit Core 2 (ECE301). Maximum score per question is 3.

Normalized gain as defined in [7] was calculated using the numbers given in Figure 2.

$$\langle g \rangle = \frac{Posttest(Avg.) - \Pr etest(Avg.)}{100 - \Pr etest(Avg.)} = .38$$

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

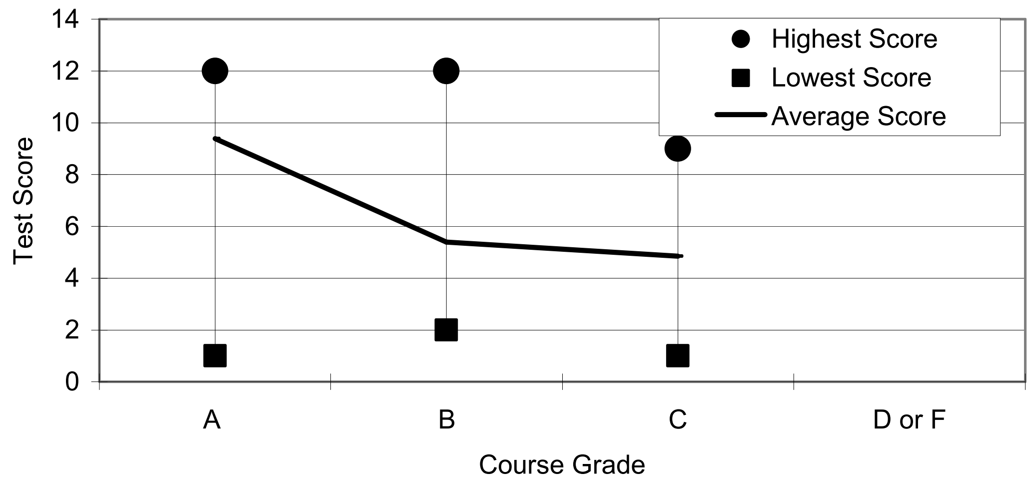

Figure 3. Distribution of Core1 (ECE220) course grades and Core2 (ECE301) pretest results. N=43, Maximum score: 12, Mean: 6.63, Std. Dev.: 3.57, Corr.:0.56.

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.

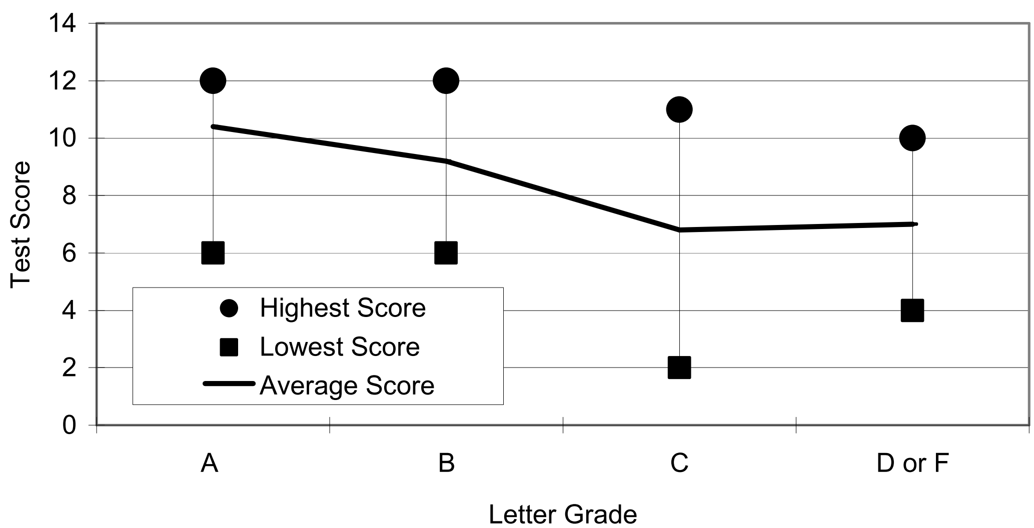

Figure 4. Distribution of Core2 (ECE301) course grades and Core2 (ECE301) posttest results. N=43, Maximum score: 12, Mean: 8.69, Std. Dev.: 2.78, Corr.:0.61.

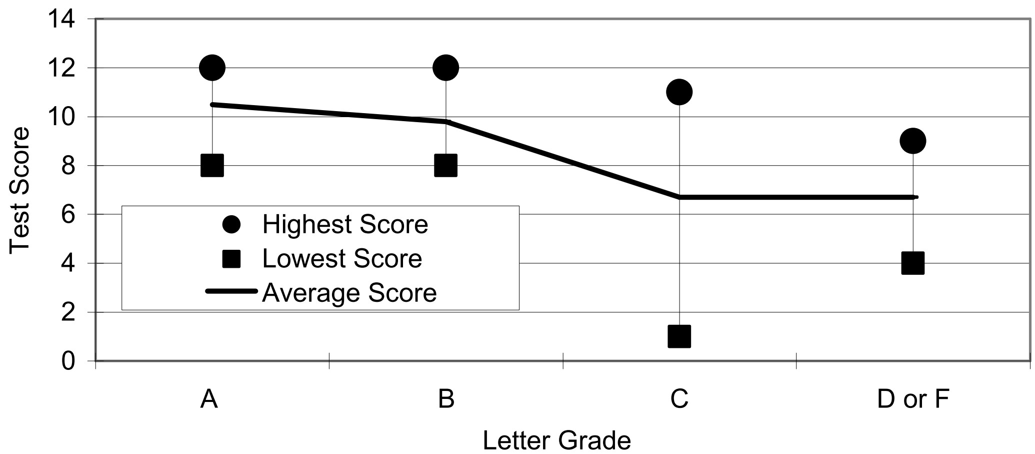

Figure 5. Distribution of Core2 (ECE301) course grades and Intermediate elective follow-up test results. N=43, Maximum score: 12, Mean: 8.88, Std. Dev.: 2.67, Corr.:0.64.

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 Core2. 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.

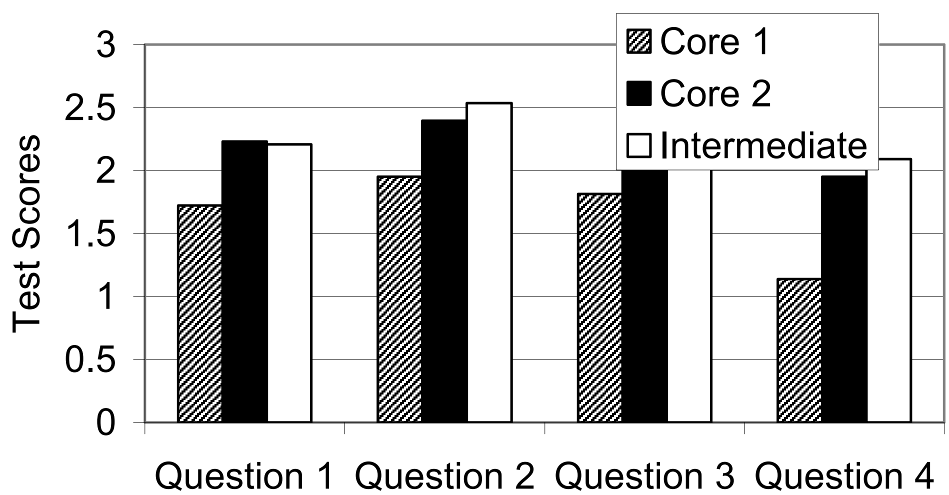

Figure 6. Average scores of the four test questions in the three courses.

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.

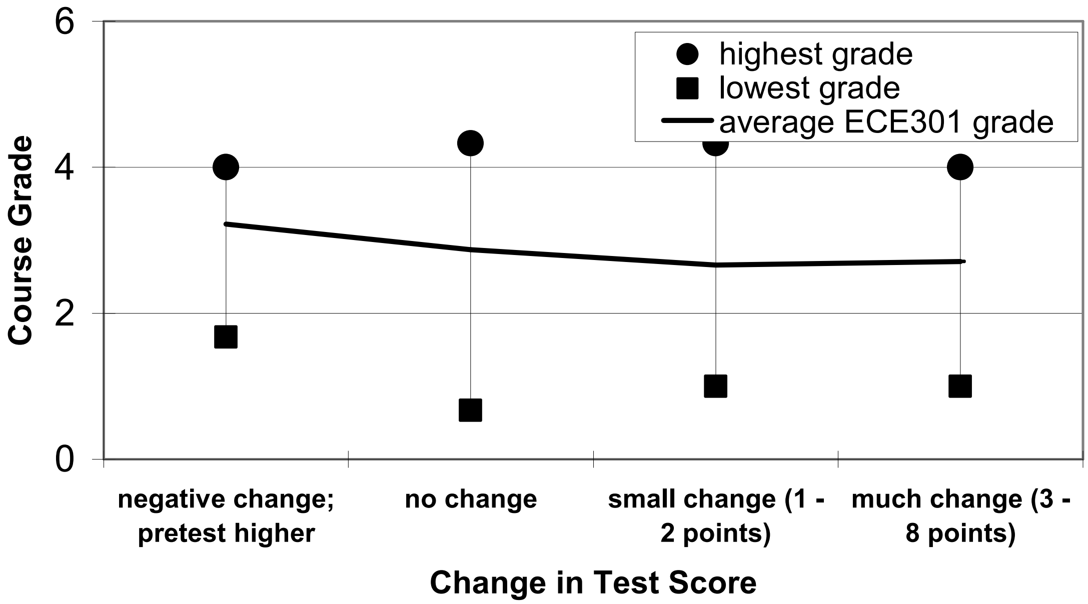

Figure 7. Relationship of knowledge gained and course grades

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

1. Ozturk, H., Spurlin, J.E. "Assessing Connectivity of a Program's Curriculum" Invited Presentation at North Carolina State University Undergraduate Assessment Symposium, Raleigh, NC,April 2005.

2. Spurlin, J.E. "How to use Course-based data for Academic Program Review." Invited presentation at North Carolina Independent Colleges and Schools' Assessment Symposium, May 2005.

3. Spurlin, J.E. Course based assessment: Developing methods to understand what students are learning within a course. Interactive session presented at *American Association of Higher Education Assessment Conference*, June 2003.

4. Spurlin, J.E., Balik, M., Ozturk, H. Course-based assessment that lead to program assessment. Invited Presentation at North Carolina State University Assessment Symposium, Raleigh NC, April 2003.

5. R.R. Hake, "The Physics Education Reform Effort: A Possible Model for Higher Education?" 10 February 2006 [NTLF42.pdf] (100 kB). This is a slightly edited version of the article that was: (a) published in the December 2005 issue of the National Teaching and Learning Forum, online at http://www.ntlf.com/, and (b) disseminated by the Tomorrow's Professor list as Msg. 698 on 14 Feb 2006.

6. **Hake, R. R.** 1999 *a.* Analyzing change/gain scores. Unpublished. [online] URL: http://www.physics.indiana.edu/~sdi/AnalyzingChange-Gain.pdf.

7. Hake, R. R. 2002. "Assessment of Physics Teaching Methods," Proceedings of the UNESCO-ASPEN Workshop on Active Learning in Physics, Univ. of Peradeniya, Sri Lanka, December 2002.

8. R.R. Hake, "Interactive engagement versus traditional methods: a six thousand student survey of mechanics test for introductory physics courses", American Journal of Physics, Vol. 66, pp. 64-74, (1998)

9. Zeilik, M., C. Schau, N. Mattern. Conceptual astronomy. II. Replicating conceptual gains, probing attitude changes across three semesters. Am. J. Phys. 67(10): 923-927, 1999.

10. Zeilik, M. 2002 "Birth of the Astronomy Diagnostic Test: Prototest Evolution," Astronomy Education Review 1(2); online at <http://aer.noao.edu/AERArticle.php?issue=2&section=2&article=5>.

11. Allgood, S. & W.B. Walstad. 1999. "The longitudinal effects of economic education on teachers and their students." Journal of Economic Education 30(2):99-111

12. Roy, H. 2001. "Use of Web-based Testing of Students as Method for Evaluating Courses." Bioscene 27(3): 3-7

13. Belcher, J.W. 2003. "Improving Student Understanding with TEAL" [TEAL Technology Enhanced Active Learning], Vol. XVI No. 2 October/November 2003 The MIT Faculty Newsletter: <http://web.mit.edu/jbelcher/www/fnlEditedLinks.pdf>.

14. Krause, S., Birk, J.P., Bauer, R.C., Jenkins, B., and Pavelich, M.J. (2004). "Development, Testing, and Application of a Chemistry Concept Inventory," *Proceedings, Frontiers in Education Conference*, Savannah, GA, USA