AC 2012-3101: EVALUATION OF DIRECT ASSESSMENT TOOLS IN ELECTRONICS ENGINEERING TECHNOLOGY

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Evaluation of Direct Assessment Tools in Electronics Engineering Technology

Abstract

The Electronics Engineering Technology (EET) program at Pittsburg State University (PSU) was a pilot program for an electronics engineering technology nationally-normed assessment exam in 2009. The exam, developed by a cooperative effort between IEEE, the Society of Manufacturing Engineers (SME) and the Electrical and Computer Engineering Technology Department Heads Association, was designed as a direct assessment tool. PSU has used this exam now for three consecutive years. Results of this exam are discussed. How the results of the exam have been utilized in program improvement as well as how the exam has assisted in relation to preparation for an ABET visit is also discussed.

In addition to the nationally-normed exam, the EET Program at PSU has used a novel, direct assessment tool over the past ten years. The usage of the two assessment tools at PSU have for the past three years been congruent. The two tools also overlap in much of the content. However, application of the two tools diverges in a few significant manners. This paper reviews both exams, their results and how the EET program at PSU has interpreted the results. Also the changes to the EET program that the assessment tool has triggered are also discussed.

Introduction

A program's long term success depends on the program's ability to produce productive graduates. Measuring the ability of a program to produce productive graduates in the short term can be challenging. Through assessment of student's abilities over time, a reasonable short term measure of the efficacy of a program can be ascertained. However, the method and tools used for assessment can have a serious effect on the usefulness of the assessment.

During the past decade, ABET has adopted assessment as a key element of program outcomes-based accreditation. In that period, the Institute for Electrical and Electronic Engineers (IEEE) responded to an initiative by the Electrical and Computer Engineering Technology Department Heads Association (ECETDHA) addressing the absence of a nationally-normed Electronics Engineering Technology relevant assessment tool by sponsoring the development of an assessment instrument. Pittsburg State was an early adopter of this tool and this allows us the opportunity to consider the types of information the new assessment tool is providing. This paper reviews the use of three separate quantitative assessment tools used at Pittsburg State University (PSU) in the Electronics Engineering Technology (EET) program. The three assessment tools include the traditional (but recognized as incomplete) grade point average, the new IEEE-sponsored and Society of Manufacturing Engineers (SME) administered standardized assessment exam, and a PSU EET-developed assessment tool. The IEEE-SME normative test is a relatively new tool available to EET programs. The outcome of this test over the past three years, as well as PSU-EET general experience with the test will be covered. These comparisons are being made to determine relative merits of assessment efforts and some sense of the weight of grades being awarded[1,2].

EET Program at Pittsburg State University

Pittsburg State University is a regional four-year university located in the rural southeast corner of Kansas. The institution has approximately 7,000 students, the majority of which are fulltime undergraduate students. The Electronics Engineering Technology undergraduate program is a small program consisting of four full time faculty, two adjuncts and approximately 70 enrolled students.

Students in the EET program are required to take three semesters of core curriculum studies in electronics engineering technology. The curriculum includes basic concepts relating to AC and DC theory, circuitry and measurement, digital logic concepts and an introduction to semiconductor devices and applications. After the completion of the core curriculum, students are required to take a set of comprehensive assessment exams. The content of the exams cover the student outcomes for each of the core courses. The exam is set up as a one credit- hour required course. After the completion of the core exam course, students then take a selection of required upper-division courses within the EET program. Students also can select a specialization which includes, Aerospace Electronics, Control Systems, Embedded Systems, Communication Electronics, or a customized emphasis. During the senior year, students are required to take a two-semester capstone design course sequence. The first semester consists of proposing, and designing a ‘senior project’. The second semester has the students build a prototype of that project.

A major point of emphasis in the PSU-EET program is the hands-on application of principles. Because of this emphasis, the vast majority of courses in the PSU-EET program include a lab component. Besides giving some distinction to the PSU-EET program, labs give an opportunity for students to exercise written and oral communication as well as teamwork skills.

EET Assessment Objectives at Pittsburg State

The main objective of assessment in the PSU-EET program is to ascertain deficiencies, weaknesses, or points of concern within the curriculum. The information established by the assessment is used to make corrections in the curriculum. This closed-loop system allows for corrections on specific topics or aspects of the program. A secondary goal is to assess the state of the program as a whole, that is, an aerial view. Review of assessment data presents an opportunity to review topics covered throughout the curriculum and provides an opportunity to view the current and future directions of the program.

Two major direct assessment activities are performed throughout the undergraduate curriculum. Direct assessment is used in an attempt to provide objective measures that program objectives are being met[3,4]. The first assessment point is performed during the students 4^{th} semester (spring semester of the sophomore year). The second assessment point is performed during the students 8^{th} and final semester (spring semester of the senior year).

An additional goal is to make the assessment process without a heavy faculty load increase. A heavy increase in faculty load due to assessment can have a detrimental effect on teaching and research, which is detrimental to the program. Though nearly all programs would benefit from limiting assessment loading onto faculty, limited loading is particularly important for programs with a small faculty, such as Pittsburg State's EET program.

Describing the Assessment Tools

This section describes the tools compared in this paper. While there are significant differences between the exams, there are also significant similarities including range of topics, range of difficulties and, at our university, a group of about forty people who have now experienced both assessment tools.

PSU-EET Core Exam

The first assessment tool is a series of direct assessment exams. The exams were developed internal to the PSU-EET program[5,6]. The exams were developed to assess students specifically on topics taught within the program during the first three semesters. These topics include the core topics taught in what is considered our core courses. Topics include basic electricity/electronics, AC and DC principles, digital logic circuits and theory, and semiconductor devices theory and applications. The series of exams are taken as a one credit hour course during the 4^{th} semester. Exams are scored by faculty in a 0-3 range using a rubric judging degree of competence in the answers. The exams have been assessed primarily by the same faculty member every year. The bulk of the exams are short answer definitions, calculations or problems to solve. Some items must be answered from memory with more complicated problems allowing reference support. There is no review or preparation beyond publication of the range of topics covered. There is no external incentive to score well other than supporting assessment mandates associated with accreditation.

The advantage of this type of assessment tool is its ability to evaluate how much of the foundational materials have been "internalized" and innate abilities to manipulate fundamental formulae and concepts. The disadvantage is the lack of incentives for maximizing effort and a potential delay time of up to two years between discovering weaknesses and potential remediation.

IEEE-SME Electronics Assessment Exam

The IEEE-SME Electronics Assessment Exam is a collection of approximately 120 multiple choice questions spanning a range of topics considered to be common to most baccalaureate Electronics Engineering Technology programs[6]. The assessment exam questions seem to be crafted to cover a broad range of capabilities. EET programs across the country were polled as to subject matter and a body of knowledge committee created a set of questions reflective of the topics gathered. Yet another committee vetted the questions and their answers to formulate the exam. Students being assessed may be administered the assessment either on paper or on-line. The IEEE-SME Electronics Assessment Exam at Pittsburg State is taken by senior capstone students at the end of their second and final semester of the capstone. Figure1 lists a few sample questions from the IEEE-SME website as well as questions from the PSU-EET core exam.

IEEE Assessment Exam Sample Questions extracted from The Society of Manufacturing Engineers (SME) web site. Correct choice is indicated in ***Bold Italic*** type.	Similar Electronics Engineering Technology **Core Exam** questions extracted from Pittsburg State University test bank. Correct answers follow question in ***Bold Italic*** type.
The unit of force in the International System of units (the SI system) is the: ***a. Newton***. b. Kilogram. c. Joule. d. Slug.	How are units of “Amps” and “Volts” defined in terms of fundamental units? (e.g., Watt = Joule / Second) ***Amp = Coulomb / Second*** ***Volt = Joule / Coulomb***
Two sinusoidal voltages of the same frequency have peak values of 8 V and 6 V, respectively. They have a phase difference of 90°. Determine the peak value of the sum of the two voltages. a. 2 b. 14 ***c. 10*** d. 48	Write an expression of voltage as a function of time for the AC voltage available from a 50 Hz power outlet. Assume an amplitude of 150 Volts. ***v(t) = 150 sin(2*π*50*t)*** ***OR*** ***v(t) = 150 cos(2*π*50*t)***
The gray code 11101000_G is equivalent to the binary number: a. 11101001_2 b. 00010111_2 ***c.*** $\boldsymbol{10110000_2}$ d. 10011100_2	Express “-5” as an eight bit two’s complement binary number. ***1111 1011***

Figure 1 – Sample questions from two assessment tools

PSU-EET Assessment Database

Both exams were broken up into major topic areas. In the IEEE-SME exam, each of those major topic areas is broken down into sub-categories. The IEEE-SME exam is directed at a broader audience, and therefore has a wider range of topics. Not all IEEE-SME topics are covered in the core exam. Likewise, the core exam covers a few topics that are not addressed in the IEEE-SME exam. In order to make a more direct comparison of the two exams, this analysis will only look at topics that are covered in both exams. Within this analysis there are 29 individual topics covered. Each has scores from one or more question/subtopic from each exam. A breakdown of the topic coverage in each exam is shown in the table in Figure 2. The "core" column data represents the specific question identifier from the PSU-EET test bank. The IEEE-SME categories represent subfields as listed in the Sample Report document from IEEE-SME that matches most closely the PSU-EET assessment tool[7,8]. This table allows interested readers to map correlations graphs later in the paper back to the specific topics being compared.

	PSU - CORE Questions	IEEE-SME Categories
TOPIC 1	PROLOG 1	1.9;12.5
TOPIC 2	PROLOG 2	1.4
TOPIC 3	PROLOG 3	1.5
TOPIC 4	PROLOG 4	1.2
TOPIC 5	PROLOG 5	12.1
TOPIC 6	PROLOG 6	1.3
TOPIC 7	DC 1; 2	3.4
TOPIC 8	DC 3; 2:1	3.7
TOPIC 9	DC 6	3.3
TOPIC 10	AC 5	1.7;2.3
TOPIC 11	AC 7	1.6
TOPIC 12	AC 8	2.8
TOPIC 13	AC 9	2.1; 2.9
TOPIC 14	AC 11	2.5
TOPIC 15	AC 12	2.9
TOPIC 16	AC 13	2.6
TOPIC 17	AC 14	2.12
TOPIC 18	AC 3, 1	2.6; 2.9
TOPIC 19	AC 3, 2	2.11
TOPIC 20	LOGICS 8	5.3
TOPIC 21	LOGICS 9	5.2
TOPIC 22	LOGICS 10; 2:2	5.4
TOPIC 23	LOGICS 11, 12	5.1
TOPIC 24	LOGICS 13	5.5
TOPIC 25	LOGICS 14	5.5; 5.7
TOPIC 26	DEV & CKT 1	6.1
TOPIC 27	DEV & CKT 2	6.2
TOPIC 28	DEV & CKT 5; 6; 3:1a; 3:1b; 3:1c; 3:1e;	6.6
TOPIC 29	Lab Report / O-Scope	2.1

Figure 2 – Breakdown of topic coverage in each assessment tool

The PSU core exam has been used for over ten years in the EET program. The IEEE-SME assessment exam has only been used at PSU for the last 4 years. All scores used in this analysis are from 39 students who have taken both the core exam and the IEEE-SME exam. One major caveat in the comparison of the two exams is the point in the curriculum in which the exams are taken. The core exam is at the end of the sophomore year, while the IEEE-SME exam is in the senior year. Due to differences in scoring techniques, scores had to be scaled in order to make a more direct comparison.

Methodology for Evaluation of Assessment Tools

Student Performance per Topics

Within the PSU-EET program, assessments are used to determine the areas, topics and skills that improvement efforts most need to be focused on. This is the main objective of assessment in the PSU-EET program. Overall major topic areas will be examined, as well as individual topics from each major area will be examined. Questions to be answered are what topics in each area need the most improvement, and which topics are/are not being retained? A major benefit of having two evaluation points allows for evaluation of idea retention. This evaluation of performance demonstrates the method in which assessment is used with the PSU-EET program in the closed-loop improvement cycle.

The IEEE-SME exam was administered from 2009 to 2011 at PSU. Students who took the IEEE-SME exam had taken the core exam during a period ranging from 2007 to 2010. Yearly analysis is based off of the point in time in which students took the core exam. Evaluation of each topic will be done on a four year and a single year basis. The four year method is done to show trends that may be developing over time and the single year basis is to help in the response time when a problem is detected.

Evaluation of Assessment Tools

Having used two different type assessment exams over four years gives PSU-EET the ability to make a comparative analysis of the two exams, their benefits and weaknesses. To compare the two exams, an evaluation of topics will be done. Performance on topical scores has to be analyzed cautiously as the assessments occur at two different points in the curriculum and a direct comparison may lead to inaccurate conclusions.

Correlation of GPA and Assessment

GPA is not a direct indicator of a student's comprehension of the material taught. Other items factor into a student's GPA such as one's work ethic. In fact the need of assessment directly relates to the deficiency of GPA in assessing student knowledge. In the PSU-EET assessment database used in this paper, GPA for each of the student in the database was pulled. A statistical correlation number between the two exams and between each assessment was found.

Evaluation Results & Analysis

Evaluation of Student Performance per Topics

An overview of the five major topics show that AC Principles and Logic Circuits in both exams scored low. This can be seen in the graph in Figure 3. In general these two areas are perhaps in the most need of curriculum or teaching enhancement. The second item to note is the difference in scores between tests. This is particularly notable in DC Principles and Circuit Device areas. The difference may indicate a lack of retention of content over the intervening two year period between assessments.

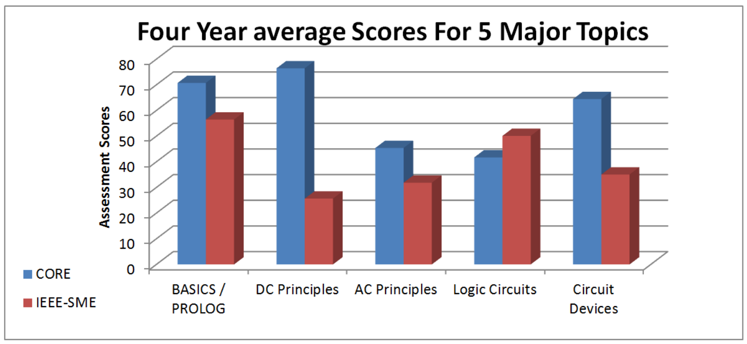

Figure 3 – Four year scores for 5 major areas

The table in Figure 4 shows the lowest ten scoring topics from each exam. Four of the ten topics are found in both the core exam and the IEEE-SME exam. Three of the four are from AC Principles. This analysis also shows that the logics scores where some of the lowest in the core exam, but no logics topic made the lowest 10 scores of the IEEE-SME exam.

Lowest Topic Scores

	CORE		SME	
	TOPIC #	MAJOR AREA	TOPIC #	MAJOR AREA
1	TOPIC 24	LOGICS	TOPIC 16	AC PRINCIPLES
2	TOPIC 25	LOGICS	TOPIC 18	AC PRINCIPLES
3	**TOPIC 13**	**AC PRINCIPLES**	**TOPIC 28**	**DEVICES**
4	**TOPIC 15**	**AC PRINCIPLES**	TOPIC 7	DC PRINCIPLES
5	TOPIC 17	AC PRINCIPLES	**TOPIC 15**	**AC PRINCIPLES**
6	**TOPIC 19**	**AC PRINCIPLES**	TOPIC 9	DC PRINCIPLES
7	TOPIC 22	LOGICS	TOPIC 8	DC PRINCIPLES
8	TOPIC 14	AC PRINCIPLES	**TOPIC 19**	**AC PRINCIPLES**
9	**TOPIC 28**	**DEVICES**	**TOPIC 13**	**AC PRINCIPLES**
10	TOPIC 10	AC PRINCIPLES	TOPIC 11	AC PRINCIPLES

Figure 4 – A comparison of the lowest performance areas for each assessment tool

Topics 15, 19, 13, 28 all are top priorities for future improvements in our courses. In all 16 different topics made the "lowest scores" list. Overall the AC principles and the digital logic courses are most in need of attention. These topics are those in which future improvements will be most focused on.

Trending each course on a per-year basis, illustrates that scores from both exams in prolog and logic is declining while DC Principles is on an uptick over the last couple of years (see Figure 5). The logic course on the IEEE-SME exam is also declining. In the PSU-EET exam the logic course is flat. In both courses the AC Principles was consistently low.

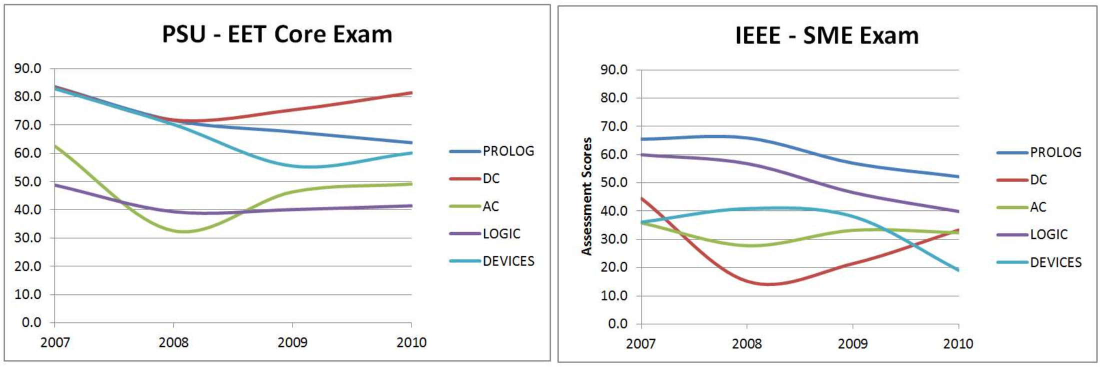

Figure 5 – Per year assessment scores of five major areas
(The years in both graphs indicate the year in which the student took the IEEE-SME exam)

Evaluation of Assessment Tools

One major aspect of this paper was to perform an evaluation of the two assessment exams. Though the two have differing slightly differing applications, the line graph in Figure 6 shows the scores per topic of each of the 29 topics. Figure 7 is the same graph as seen in Figure 6 with additional graphical analysis added.

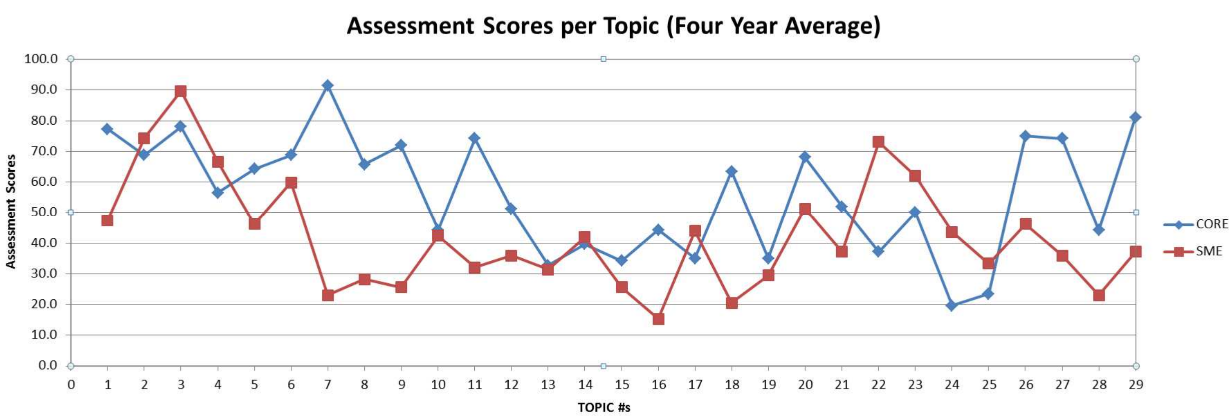

Figure 6 – Average Student Scores per Topic

The boxes in Figure 7 highlight scores that are for all intents and purposes, equal. This comprises 10 different topics, or 1/3 of the assessment topics. The asterisk (*) highlights the 4 scores where the IEEE-SME score was higher than the Core exam score. That means that 15 (52%) of the scores were higher in the core exam. The scoring difference could potentially be attributed to the lack of idea retention or may be a function of the difference between the exams and their applications.

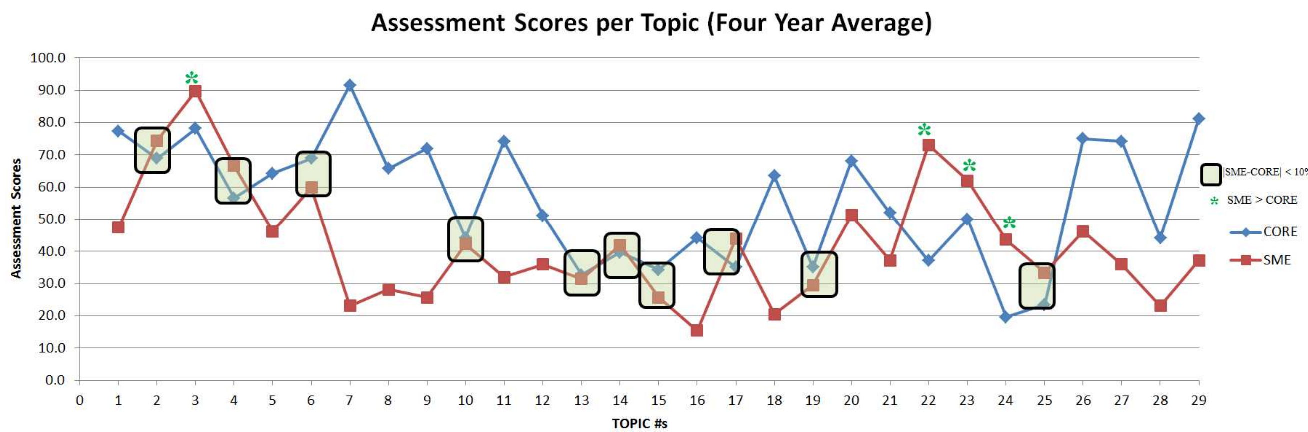

Figure 7 – Topics Identified as Substantially Equivalent

When looking at the assessment tools on a per-year basis, the two tools have a high level of correlation. This is demonstrated in the six graphs in Figures 8 and the table in Figure 9. AC and DC Principles correlation are both above 0.97. The two tools assert to perform essentially the same task, to measure the level of knowledge of students. Such a high level of correlation between the two similarly oriented tools indicates that the tools are producing reliable results.

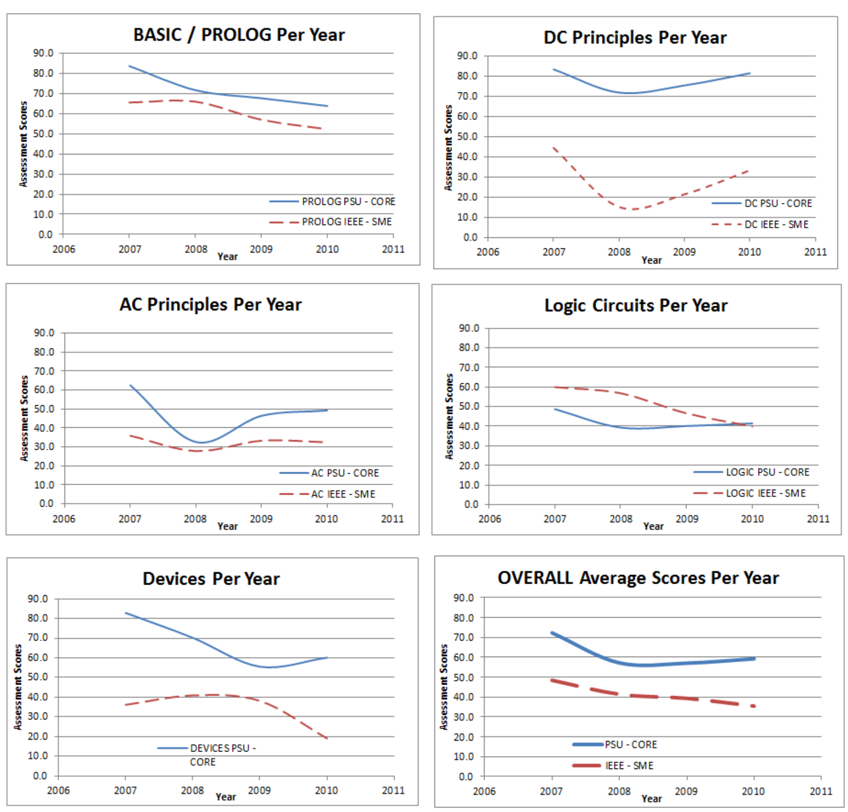

Figure 8 – Per year scores of 5 major topic areas and of overall assessment scores

Correlation Between SME and Core Exam Yearly Averages Per Topic

PROLOG	DC	AC	LOGIC	DEVICES	**AVERAGE CORRELATION**
0.805	**0.976**	**0.968**	**0.499**	**0.312**	**0.826**

Figure 9 – The correlation between IEEE-SME scores and PSU-EET scores per-year over a four year period.

In addition to this, GPA was correlated to the IEEE-SME exam by a factor of 0.42 on the per year basis and by a factor of 0.48 in the four year average scores for students. The core exam displayed no significant correlation in the four year average or on a per-year basis.

Discussion

The fact that the two exams are highly correlated, at least in 3/5 of the exam provides significant evidence as to the validity of both direct assessment tools. In addition to the high correlation of per-year data, in the four year average scores 10 of 29 topics are within 10%. The logics course had a 0.5 correlation with general trends in the same direction. With only four data points (four years), this may be considered inconclusive of how well the two exams align. Further, in all but 4 of 29 topics, the IEEE-SME scores are lower than the core exam. It is felt that the consistently lower IEEE-SME scores are due to idea retention over the two year lapse between courses. By interpreting the data in this manner, one corrective action would be to add into the curriculum reinforcement activities in upper division courses. The IEEE-SME exam had a better correlation to GPA than did the core exam by a factor of four. The IEEE-SME correlated relatively well with both the core exam and with student GPA.

One major issue with both exams is response time in implementing corrective actions. An assessment at the end of a student's undergraduate career or as in the case presented in this paper, in the middle and at the end of a colligate career, means that corrections to a course may take two years or even longer. Reduction of the feedback latency can be accomplished by implementation of a per-course assessment process where an assessment is made at the end of or during the course itself. One drawback to the per-course assessment process is the inability to assess retention of ideas over a period of time.

Conclusions

The assessment exams identified topics that could benefit from improvement in pedagogy. Topics from the two exams which are in need of improvement only partially align with one another. The cause of this may be a difference in the exam itself or in the application. In either case the results have highlighted specific topics where continuous improvement efforts may be most beneficial.

Both the PSU-EET core exam and the IEEE-SME exam are valid assessment tools adding benefit to the PSU-EET program. The PSU-EET Core exam and the IEEE-SME exam had a high level of correlation in three of the five major topic areas and significant correlation in one more topic area. The fifth category, the lack of correlation may be due to instability in the professorship of that particular course throughout the years measured. The lack of correlation could also be attributed to variations in the exam itself.

The IEEE-SME exam demonstrated some level of correlation to GPA. Though GPA is not a strong assessment tool, the significant correlation between GPA and the IEEE-SME exam, relative to the core exam, indicates that the IEEE-SME exam is a valid and beneficial assessment tool. The correlation of the core exam was poor relative to both GPA and the IEEE-SME exam. This indicates that the application of the tool or the exam itself is not as beneficial as the IEEE-SME assessment.

Changes to assessment methodologies are being implemented in response to this study. Assessment now will be done on a course by course basis. The reason for the change to course based assessment is to reduce latency assessment and remediation. Each instructor will assess the course at an appropriate time during that course. The current plan is to continue to use the IEEE-SME exam to ensure a consistency in the quality of assessment and to measure student idea retention. The IEEE-SME exam will also be used as a tool in the future to evaluate the new course based assessment.

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