AC 2010-1089: WHAT DO PRIOR EXPERIENCE AND STUDENT ATTITUDES SAY ABOUT ECE LAB ABILITY?

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Abstract

One hundred nine students over three semesters took a Prior Experience Questionnaire and the Pittsburgh Freshman Engineering Survey as part of their initial Electrical and Computer Engineering lab. Twelve weeks later, each student was given a lab practical as part of this sophomore lab. The lab practical, given to the students the last week of the course, is used as the measure of ECE lab skills. The practical has the students perform basic measurements with a multimeter and an oscilloscope on a simple circuit that also requires the use of a power supply and a function generator. These skills were used throughout the semester long lab in various experiments. This practical is done individually and each result is observed by the Teaching Assistant.

Correlations were then calculated between the survey results and the lab practical in an effort to determine what factors contribute to better lab practical scores and thus, hands on ability.

The results show that most correlations are small. The highest correlations were Lab Grade and GPA, 0.65 and 0.45 respectively. When the partial correlations are taken correcting for GPA, the number of significant factors decreased by 30% and ACT scores became strongly correlated to the lab practical score.

When females (approximately 10% of the sample population) were removed, there were no significant changes in the correlation results.

Introduction

What makes students successful in an Electrical and Computer Engineering introductory laboratory? If a set of prior experiences can be determined, or a set of attitudes, then these could be used to help improve student performance. This paper will explain the progress of determining the prior experiences and attitudes of students taking an Electrical and Computer Engineering laboratory and discuss the correlations between their performance in the laboratory and their responses to surveys about their past experiences and attitudes toward engineering.

Background

The ECE sophomore laboratory is the first experience with instructional introduction to the function and use of electrical test equipment used in the ECE department. The instruments include multimeters, oscilloscopes, function generators, DC power supplies, breadboards, resistors, simple logic chips, circuit simulation software, and simple logic programming. The course has a common lecture one hour each week, and individual lab sections meet in the lab for a two-hour period each week. The lecture covers basic skills that will be needed in that week's lab. In our curriculum, this lab precedes the basic

circuits class. The lecture is used to explain basic concepts such as series and parallel circuits, demonstrate the use of instruments, and teach programming skills.

Lab sections contain approximately 16 students working independently, each at their own lab station. There is typically one Teaching Assistant and a helper in each lab (usually a senior undergraduate student). Many of the labs build on previous lab exercises. For instance, students learn voltage and current measurements in the first lab, and these skills are used in virtually all future labs. Oscilloscope measurements are also used in the majority of labs for voltage measurements of AC signals. Most of the labs require the students to demonstrate a particular skill for the Teaching Assistant, such as performing a particular measurement reading.

Procedure:

During the spring, summer, and fall of 2009 approximately 109 students participated in this study that used a series of surveys to determine what kind of background might improve their performance in the ECE sophomore introductory laboratory. These surveys were given the second and third weeks of class (after the second lab period).

Two surveys and an aptitude test were given electronically to each student. The first survey was a Prior Experience Questionnaire (PEQ) consisting of 148 questions. The questions asked about the prior experience of the student in preschool, middle school, high school, and post-high school. These questions included both academic and non-academic experiences. The answer options range 1-4 for each question to indicate the amount of exposure with that particular experience. The questions for the PEQ were developed in [2] as an instrument help predict spatial ability test scores. It was derived from a much larger series of questions about spatial experiences (approximately 480) that through a series of pilot studies, was pared down to approximately 312 questions about formal academic subjects, non-academic activities, and sports [2]. These 312 questions were reduced to the 148 that were used in this study. The results of [2] showed that the correlations between the survey and a Mental Rotations Test indicate men who did better on the test, were more likely to have participated in non-academic activities in high school, followed by junior high/middle school non-academic experiences. The study also separated out men and women in their analysis, finding that the combined scores did not yield significant relationship between the composite survey scores and the test scores. It should be noted, that the questions were about the frequency of the experience and did not delve into what they thought of the experience (if they liked it or wanted to do it).

The second survey was about attitudes. The Pittsburgh Freshman Engineering Survey (PFE) was used to determine what students thought about academic subjects, their confidence in different subjects, and their thoughts about engineering as a profession [1]. The survey consists of 50 questions; each question had a 1-4 answer range. The PFE was developed in [1] in order to determine the impact that attitudes have on students leaving engineering. This was done by administering the survey at the beginning of a student's engineering education and then again at the end of the first year. The differences were then compared to the attrition of select groups of students based on

academic success (based on course performance). In the study [1] it was found that students that left engineering due to poor academic performance had more positive attitudes than those who had good academic performance. This was especially true when looking at questions about their general attitudes towards engineering. Based on these and other conclusions, the study was able to develop a model to help predict a freshman engineering student's first-term "quality point average" and whether a student leaves the engineering program in good or in poor standing. Based on this model, steps could then be taken to proactively help students that are more susceptible to leaving engineering [2].

This paper uses the PFE and PEQ to see if students' attitudes and confidences or their prior experiences are related to their ability to work in the lab. The students' lab ability is measured by a single laboratory exercise- the lab practical.

Lab Practical:
The lab practical is the "final exam" for the laboratory. Each student must demonstrate the basic skills of measuring voltage, current, resistance, and the proper use of an oscilloscope for capturing a voltage signal. No calculations are done in this practical- it only demonstrates the students' ability to use the equipment to make measurements. The TA or helper goes around and checks each student's setup and final result. The practical takes approximately 30 minutes for a student to complete.

Along with the laboratory grades and the lab practical score, additional student data was used including GPA, ACT scores, and earned credit hours.

Correlations between the survey answers and the lab practical score and lab grade were run using MatLab's corrcoef function. These were then sorted by significance.

Results

Correlations were calculated for all variables with respect to the lab practical score. Only those correlations which are significant ($p < 0.05$) will be discussed. All correlations are less than 0.64 with the majority of them below 0.4. Not surprisingly, the highest correlation, 0.623, was with the final grade for the lab. Part of this is because the lab practical is about 8% of the course grade. Most of it can be attributed to the fact that the ability to use electronic equipment is central to completing the lab exercises.

While many of the results are intuitive (a negative correlation with arts and crafts, dance, a preference for liberal arts courses), some of the correlations, at first glance, seem counter intuitive for engineers. "Formal academic experience in automotive technology" has a correlation of -0.298 and the correlation for "Repaired Automobiles" is -0.207. Perhaps this is a reflection of the differences between electrical engineers and, say, mechanical engineers. One that is more difficult to explain is the negative correlation with "Formal Computer Programming" (-0.263). The complete list of results is shown in Appendix 1.

The variable with the second highest correlation is the students' GPA at 0.451. This

supports the conventional wisdom that good students are generally good across the board. In order to determine if this GPA effect was masking other factors, partial correlations were calculated while controlling for the GPA. There were notably fewer variables that had a significant p value (13 factors as compared with 18). The p values of all the variables have increased, with seven of the original factors no longer having significance. There are three additional variables whose correlation with the Lab Practical is now significant. The one that is most surprising is the negative correlation (-0.222) between the grade on the lab practical and attending day care as a pre-schooler. A table of results is shown in Appendix 2.

The study has 11 females and 98 males. When looking at the correlations of the variables to the Lab Practical for only the male students, the significance value (p) decreases for most of the results (see Appendix 3). This can be expected, as there is a slightly smaller population. In general, the magnitudes of the correlations are higher for this population. This would seem to indicate that the total population has more variability than the population containing just the male students. There are also 4 variables for which the correlations are significant which were not significant in the whole population. As with the case when controlling for GPA, the variable "attended day care center" has a negative correlation (-0.227).

Looking at the correlations of the female population is hampered by the small sample size (n=11). This is also the reason there is not a large change in the correlations between the total population and the male only population. When the females are removed from the correlation calculation, it decreases the sample size only by about 10%. Conversely, when the males are removed, the sample size is reduced by about 90%. For the population of females, there are only 4 variables for which the correlations with the Lab Practical are significant, with 2 of these being "GPA" and "Lab Grade". It is notable that the correlations for this population are higher than for the others. The correlation of the variable "Arranged furniture" is positive (0.863) for the female population. It is negative (-0.231) for the male population.

Some of the interesting results were the factors whose correlations were not significant. Students were asked if they had academic experiences in Electronics in middle school and in high school. For both of these, the correlation had a magnitude that was less than 0.05 and a p value that was greater than 0.75. Questions on non-academic experiences in constructing or repairing radios or stereos, doing hands-on electrical circuitry, and repairing or upgrading computer hardware also did not have correlations that were statistically significant.

Conclusions

The results do not give a clear indication that particular prior experiences correlate with better lab skills of students. This confusing picture could be due to the specific nature of some questions, so that only a small number of students participated in any one activity. The analysis does show that the higher their academic skills and self-confidence level, the better their performance in the lab.

That being said, it does not necessarily mean that having specific attitudes (or not having specific attitudes) will affect the lab score. It just means that those with a higher lab score did (or did not) have these specific attitudes.

Future Work

The next steps in this project are to try to develop principle factors for the two surveys. It is hoped that this will give higher magnitude correlations. Then regressions can be calculated to model performance to past experience and attitude to determine if it can predict lab performance.

References

1. Besterfield-Sacre, Mary; Atman, Cynthia J.; Shuman, Larry J. "Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering". *Journal of Engineering Education*, April 1997 PP. 139-149

2. Deno, John A.; "The Relationship of Pre-College Experiences to Spatial Visualization Ability of Beginning Engineering Graphics College Students", Ph.D. Dissertation, The Ohio State University, Ohio, USA,1994

Appendix 1:

With "Lab Practical Score" as reference	Survey	Corr	Sig
Lab Practical Score		1.000	0
Lab Grade		0.623	0.000
GPA		0.451	0.000
Middle and High School Years Non-Academic Experiences: Arts and crafts	PEQ	-0.307	0.003
Middle and High School Years Non-Academic Experiences: Martial arts	PEQ	-0.305	0.003
Middle or Junior High School Years Formal Academic Experiences: Automotive technology	PEQ	-0.289	0.005
Elementary School Years Activities: Dance	PEQ	-0.288	0.005
Formal Post High School Education: Mechanical drawing or drafting	PEQ	0.284	0.006
Middle and High School Years Non-Academic Experiences Sports: Skateboarding	PEQ	-0.273	0.008
Skill Confidence: Engineering	PFE	0.264	0.009
High School Years Formal Academic Experiences: Computer programming	PEQ	-0.263	0.011
I have strong problem solving skills.	PFE	0.256	0.011
I enjoy taking liberal arts courses more than math and science courses.	PFE	-0.254	0.012
Middle and High School Years Non-Academic Experiences: Scouting (Boy Scouts, Girl Scouts, 4-H, Awana…)	PEQ	-0.226	0.028
Pre-School Years Activities: Instrumental music	PEQ	-0.225	0.029
I am confident about my current study habits or routine.	PFE	0.224	0.027
Middle and High School Years Non-Academic Experiences: Repaired automobiles	PEQ	-0.207	0.045
Elementary School Years Activities: Arts and crafts	PEQ	-0.206	0.047
Middle and High School Years Non-Academic Experiences: Theater and drama	PEQ	-0.204	0.049

Appendix 2

With "Lab Practical Score" as reference, controlling for GPA	Survey	Corr	Sig
Lab Practical Score		1.000	0
Lab Grade		0.493	0.000
GPA			
Middle and High School Years Non-Academic Experiences: Arts and crafts	PEQ	-0.239	0.028
Middle and High School Years Non-Academic Experiences: Martial arts	PEQ	-0.276	0.011
Middle or Junior High School Years Formal Academic Experiences: Automotive technology	PEQ	-0.222	0.042
Elementary School Years Activities: Dance	PEQ	-0.243	0.025
Formal Post High School Education: Mechanical drawing or drafting	PEQ	0.247	0.023
Middle and High School Years Non-Academic Experiences Sports: Skateboarding	PEQ	-0.282	0.009
Skill Confidence: Engineering	PFE	0.274	0.011
High School Years Formal Academic Experiences: Computer programming	PEQ	-0.270	0.013
I have strong problem solving skills.	PFE	0.232	0.032
I enjoy taking liberal arts courses more than math and science courses.	PFE	-0.185	0.090*
Middle and High School Years Non-Academic Experiences: Scouting (Boy Scouts, Girl Scouts, 4-H, Awana…)	PEQ	-0.142	0.194*
Pre-School Years Activities: Instrumental music	PEQ	-0.155	0.157*
I am confident about my current study habits or routine.	PFE	0.101	0.357*
Middle and High School Years Non-Academic Experiences: Repaired automobiles	PEQ	-0.115	0.293*
Elementary School Years Activities: Arts and crafts	PEQ	-0.089	0.416*
Middle and High School Years Non-Academic Experiences: Theater and drama	PEQ	-0.146	0.181*
Elementary School Years Activities: Worked puzzles	PEQ	-0.252	0.020
Pre-School Years Activities: Attended day care center	PEQ	-0.222	0.042
Formal Post High School Education: Plastics technology	PEQ	-0.217	0.040

* correlation is not significant ($p > 0.05$)

Appendix 3

With "Lab Practical Score" as reference, Males only	Survey	Corr	Sig
Lab Practical Score		1.000	0
Lab Grade		0.616	0.00
GPA		0.423	0.00
Middle and High School Years Non-Academic Experiences: Arts and crafts	PEQ	-0.330	0.002
Middle and High School Years Non-Academic Experiences: Martial arts	PEQ	-0.324	0.003
Middle or Junior High School Years Formal Academic Experiences: Automotive technology	PEQ	-0.291	0.007
Elementary School Years Activities: Dance	PEQ	-0.322	0.003
Formal Post High School Education: Mechanical drawing or drafting	PEQ	0.292	0.007
Middle and High School Years Non-Academic Experiences Sports: Skateboarding	PEQ	-0.300	0.005
Skill Confidence: Engineering	PFE	0.264	0.013
High School Years Formal Academic Experiences: Computer programming	PEQ	-0.283	0.009
I have strong problem solving skills.	PFE	0.281	0.008
I enjoy taking liberal arts courses more than math and science courses.	PFE	-0.270	0.011
Middle and High School Years Non-Academic Experiences: Scouting (Boy Scouts, 4-H, Awana…)	PEQ	-0.251	0.021
Pre-School Years Activities: Instrumental music	PEQ	-0.278	0.010
I am confident about my current study habits or routine.	PFE	0.101	0.357*
Middle and High School Years Non-Academic Experiences: Repaired automobiles	PEQ	-0.115	0.293*
Elementary School Years Activities: Arts and crafts	PEQ	-0.234	0.031
Middle and High School Years Non-Academic Experiences: Theater and drama	PEQ	-0.217	0.046
Middle and High School Years Non-Academic Experiences: Arranged furniture	PEQ	-0.231	0.034
Pre-School Years Activities: Attended day care center	PEQ	-0.227	0.037
Pre-School Years Activities: watched educational TV	PEQ	0.225	0.039
I am studying engineering because I enjoy figuring out how things work.	PFE	0.219	0.040

* correlation is not significant ($p > 0.05$)

Appendix 4

With "Lab Practical Score" as reference, Females only	Survey	Corr	Sig
Lab Practical Score		1.000	0
Lab Grade		0.616	0.000
GPA		0.885	0.004
Middle and High School Years Non-Academic Experiences: Arranged Furniture	PEQ	0.863	0.003
In the past, I have not enjoyed working in assigned groups.	PFE	-0.691	0.040