A Comparison of Learning Styles in an Introductory Electrical Systems Course

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Abstract

The introductory electrical systems course is one of the first opportunities that engineering students have to apply fundamental knowledge of math and physics to practical problem solving and circuit analysis. Since few students have practical experience with electrical circuits the material can prove difficult to apply. Typically, electrical systems are diagramed as circuit models, and basic physics concepts are translated to visually applied circuit analysis techniques (e.g., mesh current method, and current divider methods). Given this methodology, our supposition is that visual learners would have an advantage. Our long term goal is to design the course and its associated laboratory exercises to be optimally geared towards students' learning style in order to improve success.

In this study, we will test the hypothesis that there is a relationship between students' learning style and course performance. The measure of student learning style will be the Felder Index of Learning Styles which is an instrument developed by Richard Felder, Linda K. Silverman and Barbara A. Solomon that identifies a student's learning preferences over four dimensions (sequential/global, visual/verbal, intuitive/sensing, active/reflective). We will examine relationships between students' index of learning styles with their exam, assignments, laboratory, and overall grades. We will also explore the impact of factors such as, gender, GPA, and major on these relationships. Data will be collected from students enrolled in seven sections of an introductory electrical systems course, where the practice was to apply common homework, laboratory exercises, and exams. This course presents basic circuit analysis techniques for DC and AC circuits including operational amplifiers. The results of this study will guide future modifications to this course, instructor teaching style, assignments and/or lab content.

Background on learning styles

There has been much published work on the Index of Learning Styles (ILS) since it's inception in 1988 and some of these results are relevant to this study[1 – 8]. The ILS groups students' learning into four dimensions (sequential/global, visual/verbal, intuitive/sensing, active/reflective). Similar to the ILS, the Myers-Briggs Type Indicator (MBTI)[8], Kolb's Learning Style Model, and Herrmann Brain Dominance Instrument (HBDI)[5] can also be used to identify an engineering student's personality type, thinking preference, or learning style. These tools have been shown to be effective for academic advisement to aid a student in developing effective test preparation skills and study techniques[2]. Studies of students' learning preference, measured with the ILS, have reported that most engineering students are visual, active, and sensing and possibly global[1]. However, typically the teaching style employed in engineering courses is not well matched to this style[1]. It has been demonstrated that if course curriculum or teaching style is modified to better match student learning style then student performance can be improved[2-4]. Traditional lecture style instruction focusing on theoretical development is not optimal for the visual, active learner. A possible exception that is commonly found in undergraduate education is laboratory instruction. Felder[7] suggests that although laboratory courses are inherently sensory, visual and active, if in practice they are highly mechanical in nature then they do not encourage active learning.

Since women are under represented in engineering, researchers have also investigated the gender differences in engineering students' learning preferences. Using the ILS tool, Rosati[9] found that female students were more reflective (opposed to active), more verbal (opposed to visual) and more sequential (opposed to global) than their male counterparts. In another study, Litzginger & Felder[10] reported similar results, however they found no significant difference in active/reflective preferences of female students compared to male students and more female students are sensing. Although these studies indicate that there may indeed be gender differences in the preferred learning style among engineering students, more studies are needed before any conclusions can be generalized.

The motivation for this work was to identify factors that affect student performance in order to improve the course, content delivery and/or teaching style to improve student learning and success. It is well accepted that, in order for an engineer to be successful in any career, it is necessary for the individual to develop skills characteristic of a diversity of learning styles. This conclusion implies that a lecture must include elements from all of the dimensions so that students can learn to adapt to delivery of content in a variety forms. It should also be noted that how a student performs in a course is based on several factors including their motivation, physical and emotional condition, self-confidence, available time, rapport with instructor and classmates as well as the learning and teaching style[8].

Course description

The goal of this study was to evaluate student performance in a sophomore-level electrical systems course based upon learning styles and demographics. The electrical system course is taught at a small, private engineering institution in the Midwest and the overwhelming demographic of the student population is white male. The course extends basic DC circuits concepts taught in the freshmen year Physics course. Topics taught include KVL, KCL, nodal and mesh analysis, Thevenin's theorem, superposition, source transformations, AC power, maximum power transfer and operational amplifiers. This course is multi-disciplinary and includes 3 hours of lecture and 3 hours of lab per week, a lab practical, 2 midterms and a final. Student majors include: electrical, computer, mechanical, biomedical, and optical engineering, economics, math, and physics.

Study Cohort Description

There were 187 students enrolled in the electrical system course in Fall 2006; 146 students consented to participation in this study (78%). In this group, there were 128 (88%) sophomores and 18 (12%) juniors, 119 (82%) men and 27 women (18%). The distribution of majors and ethnicity of the participants is shown in Figure 1.

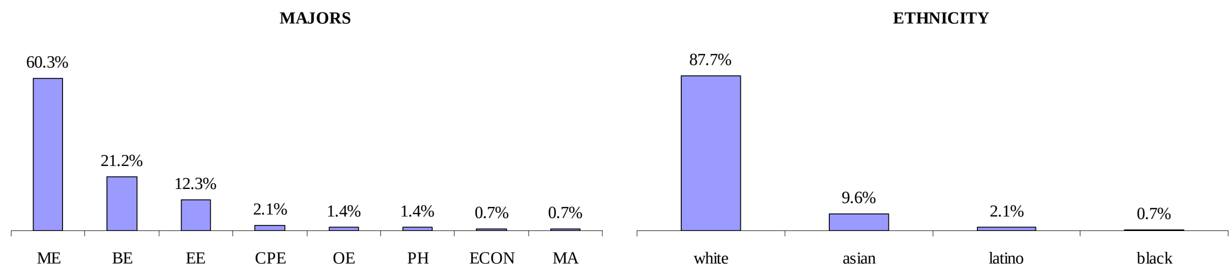

Figure 1: Course Major and Ethnicity Distribution

Many of the incoming freshmen to the university complete the online Index of Learning Styles Instrument in the summer or during freshman orientation. The distribution of learning styles for the participants is illustrated in Figure 2. The preferences were rated as slight (1, 3), moderate (5, 7), or strong (9, 11) for each of the categories: sequential/global, visual/verbal, sensing/intuitive, active/reflective. The learning style of the students in the study cohort were consistent with other published studies[6]. The key fact observed is students in the study cohort are more likely to be visual learners.

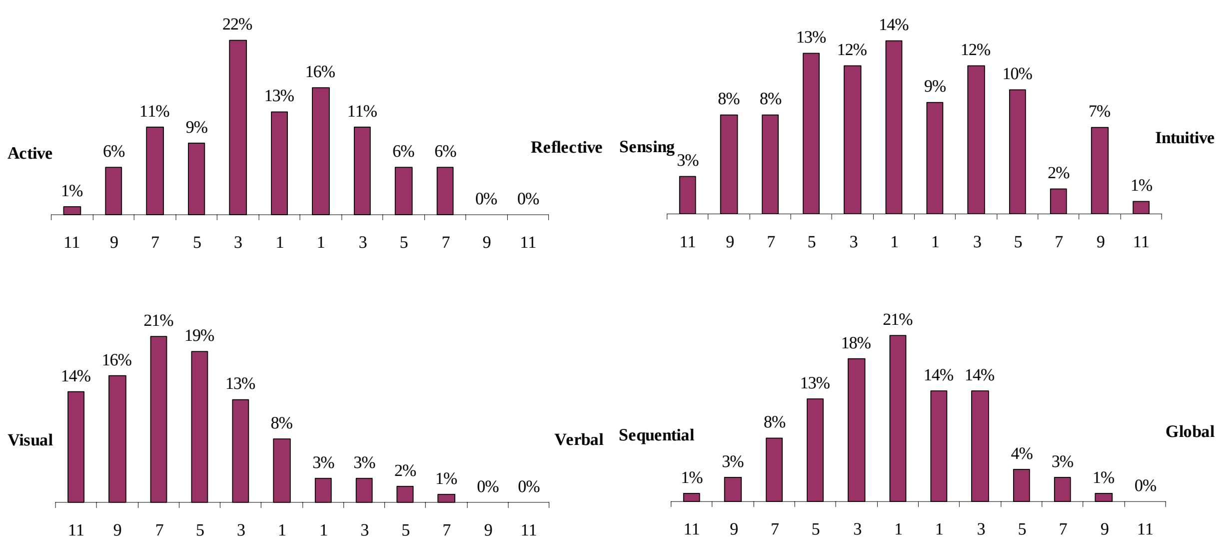

Figure 2: Course Index of Learning Styles

Study methodology

The methodology used to compare the learning styles of the students in the introductory electrical systems course based upon course performance and demographics involved the consent process, and acquisition and analysis of data. This study was approved by the Institutional Review Board and consent was obtained in advance from the 7 instructors for the 8 sections of the course. Informed consent was obtained from all student participants by one of the two principal investigators during the last 2 weeks of the Fall 2006 course. For all participants, the learning style, demographics and course grades (labs, lab practical, exams, homework, course grade) were examined for relationships using SPSS ANOVA and t-tests. Initially, correlation tests were executed to determine if there were any positive and negative correlations among the data. All significant correlations were evaluated further using hypothesis testing. The results of this study are presented in the subsequent section.

Statistical Results

As expected, correlations indicated that all course grades were positively correlated and significantly related to each other. Additionally, students who did well on the SAT and had a higher GPA performed better in the course at a level of 5% significance. It was also determined that there was no significant difference in course performance based upon major. Many other demographic categories were too small of a sample set to perform a statistical analysis or were insignificant, since 80% of the respondents were White and all other ethnicities were represented by less than 1%.

The only significant difference at a level of 5% with respect to the learning styles was for the active and reflective learners. The analysis indicated that reflective learners performed better on the homework ($t(140) = 2.23$, $p = .028$), labs ($t(140) = 3$, $p = .003$), exams ($t(140) = 2.98$, $p = .003$), and overall course grade ($t(140) = 3.23$, $p = .002$). The lab practical, graded for reflective learners, was also higher but not significant at a level of 5%. It should be noted from Figure 2 that an overall majority of the students had a preference for visual and sequential learning which may indicate why there is no statistical difference between the two groups. However, further analysis would be necessary to determine the reason for no statistical difference between the sensing and intuitive students.

Women and men appeared to perform equally as well on all course grades except for the lab practical. For the lab practical exam, men performed an average of 10 points higher than their female counterparts ($t(144) = -3.1$, $p = .002$). This gender difference was not found in the laboratory grade. The laboratory exercises are performed in self-selected teams of two, but the lab practical exam is performed individually.

Conclusions and Future Studies

The null hypothesis for this study was there would be no correlation between learning styles and course performance. However, the results of our correlation study showed that there is a relationship between a student's preferred learning style and performance in the class. Although, we expected the visual learners would perform better in the course, we did not evidence of this. However two other interesting results merit more study. First, we did find that reflective students performed on average better than active learners. It seems that reflective learners are able to master the material and use that contextual knowledge to excel in all course measures. One explanation is that even though the material is visual in nature, the presentation may be passive. Furthermore, the laboratory exercises are active in nature, but possibly too rigid and sequential. To understand this effect, one might categorize activities in the lab based upon the dimensions of the learning style to determine how much of the lab actually is geared towards active, visual, and sensing learners.

Second, our data suggests that there is a gender difference in how female students perform in the lab that is only apparent when they are tested individually. Anecdotally, we observed several behaviors that could attribute to this phenomenon. Cross-gender teams are likely because of the small percentage of women. It has been observed that sometimes males with more hands on experience take control of the experimental side and the women fall into the role of recorder. It could just be that the women feel less confident when working on their own, which could lead to mistakes and lower their score on the individual test. Since the sample size of women in this study (27) is small, additional studies should be conducted with larger sample sizes to see if this result can be reproduced. Future studies would examine cross-gender versus same gender teams to see if this effect persists. By categorizing the prior hands-on experience of the females, we could determine if experience affects the intimidation. Statistical studies can be augmented with interviews and follow-up surveys to collect qualitative data about the female experience in lab.

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