Electronic Instrumentation Background of Freshmen Computer Engineering Students

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Abstract

The level of hands-on engineering experience tends to vary widely among beginning engineering students. Whereas certain basic elements of academic preparation are guaranteed by program admission criteria, they typically are not concerned with specific elements of a particular engineering discipline; rather, these criteria establish general aptitude and/or proficiency in math and science. This paper analyzes a survey of the electronic instrumentation background of 2006 computer engineering freshmen at RIT, of which 19% indicated no prior electronics instrumentation knowledge, and 65% lacked hands-on experience with oscilloscopes.

Introduction

Within the context of engineering study, ability with electronic instrumentation is a necessary component of education, but it is not a primary goal. Although such facility is certainly required in educational exercises to observe and reinforce learned principles as well as to evaluate designs, it is merely a means to various ends—requisite "tools" in the engineering student's toolbox. On the other hand, unlike the tangible parts students are required to have in their lab kits, these "tools" of skill must be acquired through instruction and experience. Since curricula are full of topics to satisfy more pressing required learning objectives, electronic instrumentation instruction is often relegated to a very brief discussion and demonstration in the very lab session where some quite extensive use is required.

Thus, a student's prior experience level with electronic instrumentation can affect many facets of his or her laboratory coursework. Beyond obvious characteristics and implications of ability with such equipment, attitude is a paramount determiner of laboratory performance. In particular, a student with no prior equipment experience who is neither confident nor proficient following a three-minute just-in-time overview in a laboratory session, will likely be somewhat intimidated by the laboratory expectation, at the very least. Depending on his or her personality and drive, the student may engage fully in the activity and press forward, or the student may disengage and struggle through the laboratory exercise—and perhaps through subsequent, dependent exercises.

One way to approach individual disparities is to incorporate use of electronic instrumentation in a required course before any courses that need the equipment. Over the past decade, most engineering curricula have incorporated some sort of hands-on freshman engineering course, and this type of course seems ideal for introducing or reacquainting students with electronic instrumentation. In seeking to do so, however, there is a need to assess prior knowledge of these incoming students, so that familiar aspects are not overemphasized. For this reason, a survey was conducted among last year's freshman students consisting of all computer and some undeclared engineering students at RIT.

Background

All freshmen in the computer engineering program at RIT take Freshman Seminar. The seminar serves as a laboratory introduction to computer engineering where students gain hands-on experience with real-world computer engineering applications and observe practical, necessary interactions with other disciplines.[1] They also develop laboratory skills and experience with laboratory equipment required in subsequent courses. In addition, they are exposed to technical writing aspects of professional communication at a point in their academic career where they are consciously developing classical writing skills.

In terms of curriculum placement, the seminar complements a prerequisite lecture course as an experiential introduction to computer engineering. The seminar aspect of the laboratory class is ideal for this purpose in that it allows for presentation and discussion of underlying concepts only to the extent students require for a particular hands-on laboratory exercise. Accordingly, exercises are designed so that students do not have to understand theoretical concepts to any great extent before working with their applications.

Since computers intrinsically involve electronics, the first laboratory exercises investigate electronics principles. These exercises serve as experiential validation of basic direct-current (DC) circuit theory introduced in the prerequisite course. Furthermore, they familiarize students with electronics test equipment (e.g., multimeters and oscilloscopes) and components (e.g., resistors, breadboards, power supplies, and function generators). This electronic instrumentation experience is the focus of this paper—in particular, an attempt to assess the students' experience levels before taking the class.

Survey

During their last class of winter quarter 2006-2007, Freshman Seminar students took a survey regarding their awareness and experience with course concepts prior to taking the course. These students consisted of all computer engineering freshmen along with some undeclared engineering freshmen considering computer engineering. A total of 122 students submitted the survey.

The survey asked students to indicate their experience level, prior to taking the course, with various aspects/topics covered in Freshman Seminar. For each survey item, students circled one of five possible prior experience levels: none, aware, introductory, moderate, and advanced. The first two levels indicate no personal experience, and the last three levels correspond to hands-on experience. These distinctions were indicated by grouping and headings on the survey form.

With regard to electronic instrumentation, the survey asked students to rate their prior experience with multimeters, analog oscilloscopes, digital oscilloscopes, and function generators. In addition, circuit experience was addressed with resistors, DC circuits, and breadboards. for each of these items, students circled the level of experience that best matched their prior experience.

The surveys were tabulated by assigning a numeric value to each of the five specified experience levels: 0 for none, 1 for aware, 2 for introductory, 3 for moderate, and 4 for advanced. Each student's survey responses for each item were then entered into a spreadsheet. Subsequently, the spreadsheet was used to calculate percentages of respondents for each item and experience level.

Results

122 students completed and submitted surveys regarding their prior electronic instrumentation and component experience. For each item on the survey, all submitted surveys indicated one of the specified experience levels. Table 1 gives the percentage of students responding with each experience level. Figure 1 shows the prior experience distribution for each electronic component and instrument.

Table 1. Prior Electronic Instrumentation Experience

Electronic Instrument or Component	**Percentage of Students with Prior Experience Level**				
	None	**Aware**	**Introductory**	**Moderate**	**Advanced**
Multimeter	13.9	12.3	21.3	33.6	18.9
Oscilloscope (Analog)	30.3	27.9	23.0	14.8	4.1
Oscilloscope (Digital)	30.3	34.4	18.9	13.1	3.3
Function Generator	46.7	24.6	13.1	9.0	6.6
Resistors (Physical)	4.9	13.9	26.2	37.7	17.2
DC Circuits (Building)	8.2	13.9	27.0	35.2	15.6
Breadboard	18.0	23.0	21.3	17.2	20.5

Analysis

The results indicate that most of these freshmen had some prior knowledge of electronics. In particular, they were most familiar with resistors, DC circuits, and multimeters. This prior experience is expected because of physics and physical science courses in high school curricula. On the other hand, their previous exposure to more expensive and specialized equipment was limited. Nearly one third were unaware of oscilloscopes, and nearly half had no knowledge of function generators. Thus, prior knowledge and experience decreased as the complexity of electrical components and instruments increased. In Figure 1, this trend is graphically observed as a stair effect rising from left to right.

Given the primary focus of providing hands-on experience in Freshman Seminar, a binary taxonomy of hands-on experience may be more meaningful. Thus based on whether students had any prior hands-on experience, Table 2 summarizes the responses from Table 1. Responses of none and aware are counted as no prior hands-on experience, whereas responses of introductory, moderate, and advanced are counted as having prior hands-on experience. As mentioned earlier, students were advised of this experiential dichotomy by the grouping and headings on the survey form, so this interpretation is within the context of the survey responses. Figure 2 depicts the hands-on experience trends across electrical components and instruments.

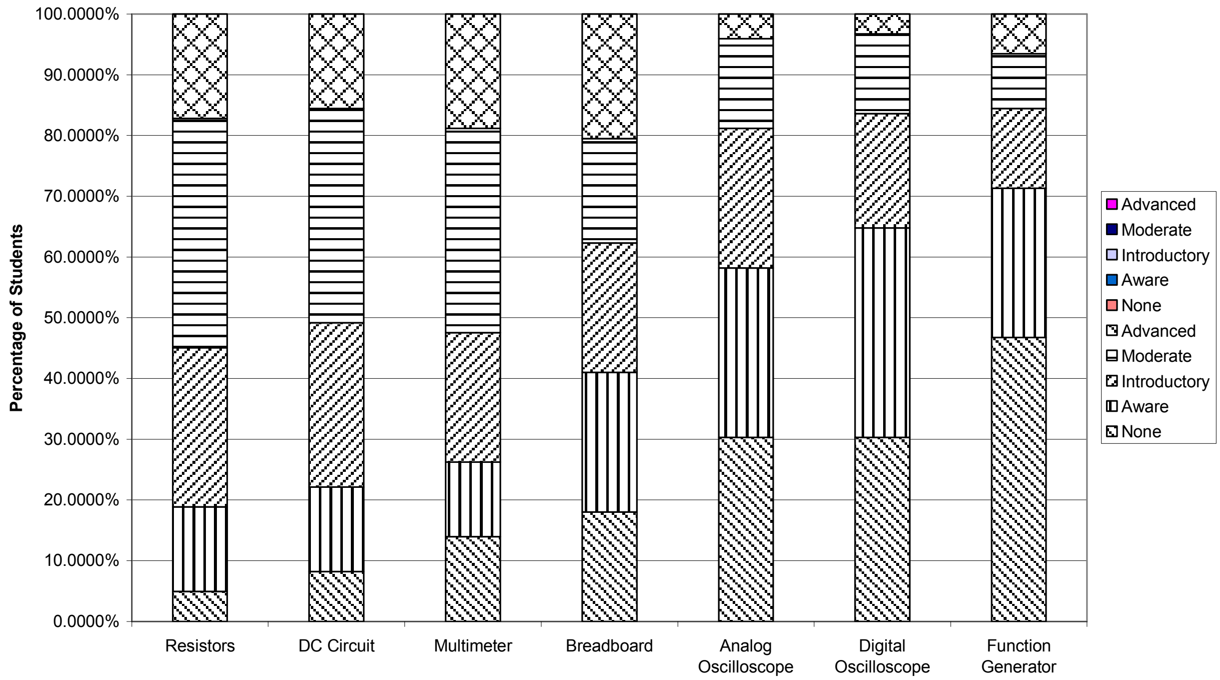

Figure 1. Prior Experience with Electronic Components and Instrumentation

Table 2. Prior Hands-On Electronic Instrumentation Experience

Electronic Instrument or Component	**Prior Experience Level (Percentage of Students)**	
	Hands-On	**Not Hands-On**
Multimeter	73.8	26.2
Oscilloscope (Analog)	41.8	58.2
Oscilloscope (Digital)	35.2	64.8
Function Generator	28.7	71.3
Resistors (Physical)	81.1	18.9
DC Circuits (Building)	77.9	22.1
Breadboard	59.0	41.0

With regard to prior hands-on experience, Table 2 indicates the same trends that were observed earlier from Table 1 with regard to prior knowledge. Only around 20-25% of students had not worked with resistors, DC circuits, and multimeters, whereas roughly 60-70% of students had not worked with oscilloscopes and function generators. Summarizing all the categories, 19% of these freshmen computer engineering students had no active personal experience with electronic instrumentation. As with the raw survey data in Figure 1, Figure 2 from these hands-on categorized results indicates decreasing prior hands-on experience with increasing electronic complexity.

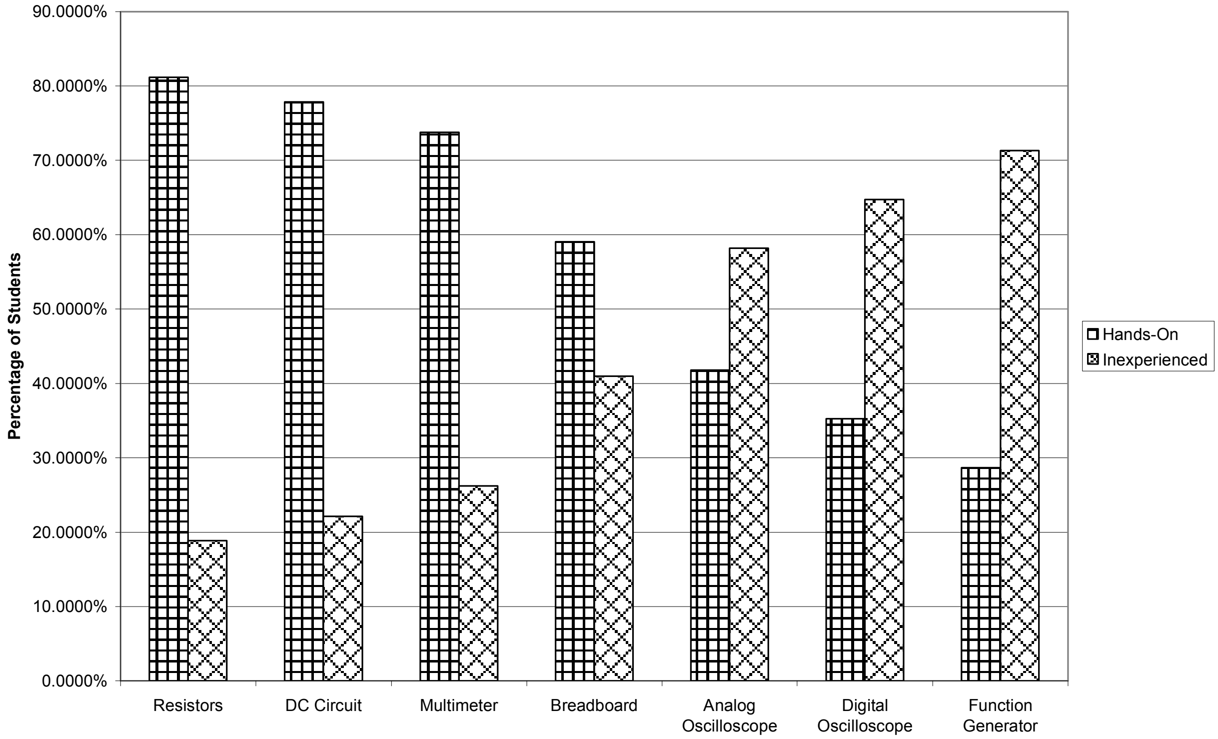

Figure 2. Prior Hands-On Experience with Electronic Components and Instrumentation

Conclusions

The number of students who have no prior knowledge or hands-on experience with electronic instrumentation is not negligible: a minimum of five percent for the former and 19% for the latter. Furthermore, when considering the full range of electronic instrumentation commonly used in the curriculum, nearly three fourths of students are lacking hands-on experience. More specifically, 60-65% of students have had no tactile experience with oscilloscopes.

With regard to the integrity of the survey data, individual variations of personality and self-assessment are problematic for strict interpretation of the allowed levels of hands-on experience: introductory, moderate, and advanced. For example, the percentage of respondents indicating advanced hands-on experience with oscilloscopes does not correspond with observed classroom experience in Freshman Seminar. From these responses, it seems that students were less likely to underestimate their experience level; however, no metrics were established to assess or avoid such skew. To avoid effects of personal response variations, the analysis presented here has been limited to responses indicating no prior knowledge or no prior hands-on experience. Thus, variations of hands-on experience levels are not required, because prior hands-on experience is considered as one category in the analysis.

Since a significant number of students have no prior exposure to electronic instrumentation, it seems reasonable to provide introductory experiences with electronic components and test equipment. Following the trends observed in the survey results, students are somewhat more familiar with resistors, DC circuits, and multimeters, whereas they require significantly more introduction to oscilloscopes. On the other hand, it seems that none of the surveyed aspects are universally familiar among students, so some introduction is required to bring the class as a whole to a common level of proficiency and understanding.

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