The old and the new: student perceived efficacy of electronics laboratory equipment

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Structured abstract

BACKGROUND
Undergraduate engineering students require exposure to an appropriate level of practical activities to complement the theory delivered in their course. This not only serves the purpose of catering to students' different learning styles but in contributing to developing practical skills important to achieving an adequate level of job-readiness. The mode by which practical activities are implemented can vary widely across different units of study and different institutions. Electronics practicals within the School of Engineering at Deakin University have traditionally involved the construction and analysis of bread board circuits. Recently however, the practicals have changed to utilise modern computer-integrated Lab Volt FACET board equipment.

PURPOSE
This paper discusses electronics practicals using two very different types of laboratory equipment and reports on student perceived efficacy. The aim of the study is to gain an understanding of student perceptions so as to be able to refine the practicals to increase student engagement.

DESIGN/METHOD
This paper discusses two very different types of laboratory equipment employed in electronics practicals within the School of Engineering at Deakin University. This study focuses on students in electronics-related engineering disciplines and their perceived efficacy of the different equipment with the aim of providing valuable insight regarding student engagement. Survey data was collected from first and second year students who had completed successive classes using the different types of laboratory equipment.

RESULTS
When compared with the electronics practicals and equipment previously used at Deakin University, the Lab Volt FACET boards provide a well-structured and resource efficient method for conducting practicals. The preliminary survey results indicate that there are mixed preferences for which type of laboratory equipment students perceive to be the better learning tool. The results also indicate that these perceptions appear to align with students in specific disciplines. These observations suggest that discipline specific characteristics of students are an important consideration in achieving improved student engagement and a positive learning experience.

CONCLUSIONS
The outcomes of the preliminary study suggest that there are discipline specific characteristics which affect students' perceptions of the efficacy of laboratory equipment. These outcomes will assist Deakin's School of Engineering to refine the use of the Lab Volt FACET board laboratory equipment to achieve improved student engagement. Future research will build upon these findings to investigate expectations of students in different disciplines and whether there is a difference in preferred learning and any correlation to student perceptions.

KEYWORDS
Electronics practicals, engineering practicals, Lab Volt FACET board

Background and framework

Undergraduate engineering students require exposure to an appropriate level of practical activities to complement the theory delivered in their course. This not only serves the purpose of contributing to practical skills important to achieving an adequate level of job-readiness, but also in catering to students' different learning styles.

It has been widely accepted that learning styles play an important role in student learning. Felder (1996) discusses four models of learning styles that have been used for engineering education: the Myers-Briggs Type Indicator (McCaulley 1990), Kolb's Learning Style Model (Harb et. al. 1993), Hermann Brain Dominance Instrument (Lumsdaine and Lumsdaine 1995), and the Felder-Silverman Learning Style Model. The Felder and Silverman (1988) model has been widely used for engineering education and emphasises the importance of appropriately catering for the different learning styles of engineering students. The original model has been refined to have four dimensions including redefinition of the visual-verbal dimension (Felder and Spurlin 2005). Students' learning styles can be determined using the Index of Learning Styles (ILS) instrument which indicates preference along each of the four dimensions; *sensing* or *intuitive*, *visual* or *verbal*, *active* or *reflective*, and *sequential* or *global*.

The mode by which practical activities are implemented can vary widely across different units of study and different institutions. In the School of Engineering at Deakin University, electronics practicals have traditionally involved the construction and analysis of bread board circuits. Recently however, the School of Engineering has transitioned to Lab-Volt Fault-Assisted Circuits for Electronics Training (FACET) board equipment (Lab-Volt Systems 2013) which employs Computer Assisted Instruction (CAI). In terms of the Felder-Silverman learning styles, it is suggested that compared to lectures, either type of practical activity caters more for *active* and *visual* learners than for *reflective* and *verbal* learners. This is based on experience in delivering the practicals to hundreds of students as well as interpretation of Felder and Spurlin's (2005) following definitions of the two dimensions.

> *"visual (prefer visual representations of presented material, such as pictures, diagrams and flow charts) or verbal (prefer written and spoken explanations);*
>
> *active (learn by trying things out, enjoy working in groups) or reflective (learn by thinking things through, prefer working alone or with a single familiar partner)"* (p.106)

In this paper, the student perceived efficacy of the two different types of practicals is investigated. The results of a preliminary student survey suggest a discipline-specific preference for a particular type of practical. The different types of practicals are detailed in the following section, and although both target similar learning outcomes, they do have distinct differences which may align with different learning styles. For example, the Lab-Volt FACET board equipment presents students with graphical displays on a computer screen as well as having circuit interfaces well labelled in plain English and with graphical descriptors. In contrast, the bread board circuits require students to identify electrical components by their physical appearance and component markings. It is hypothesised that any discipline-specific preference may relate to learning style preferences, particularly on the *active*-*reflective* and *visual*-*verbal* dimensions of the Felder-Silverman model.

There is a large body of work which suggests that, in general, engineering students have a strong preference for visual learning (Rosati 1999, Dee et al 2002, Felder and Spurlin 2005). This knowledge is often utilised to enhance student learning through visualisation such as in the work by McGrath and Brown (2005).

This paper begins by introducing the old and new electronics practicals. To promote ease of reading, throughout this paper, the construction and analysis of bread board circuits is simply referred to as *bread boards*, and the Lab-Volt FACET board equipment as *FACET boards*. A survey is then presented as completed by students who had undertaken an electronics fundamentals class in the second half of 2012 (employing bread boards), followed by a digital electronics class in the first half of 2013 (using the FACET boards). This allowed comparison of the two different types of practicals by the same group of students. The difference in subject matter of the two classes is acknowledged and to address possible bias in survey responses, students were asked to disregard the actual content covered and to focus on the type of practical. The results of the preliminary survey are then presented and observations discussed. Suggestions for future work are then made, particularly with respects to further investigation of relationship between student learning styles in different disciplines and discipline-specific preferences for the different types of practicals.

Methodology

The FACET board laboratory equipment employing CAI represents a significant departure from the bread boards traditionally used for electronics practicals within the School of Engineering at Deakin University. Both types of practicals require use of other standard electronic laboratory equipment such as power supplies, multimeters, oscilloscopes and function generators. The two types of practicals are discussed in the following subsections.

Bread board practicals

Aside from the standard electronic laboratory equipment mentioned above, the bread board practical equipment comprises a bread board, single core jumper cables, a component kit, and common identification and conversion charts. This equipment is shown in Figure 1. The experiments covered in the first year class using the bread boards are listed in Table 1.

Table 1: Experiments conducted in the first year class using the bread boards

An Introduction to DC Electronics
An Introduction to AC Electronics
Inductors and Resonant Frequencies
Series and Parallel Circuits
Introduction to Transistors
Introduction to Operational Amplifiers

Figure 1: Bread board laboratory equipment

Lab Volt FACET board practicals

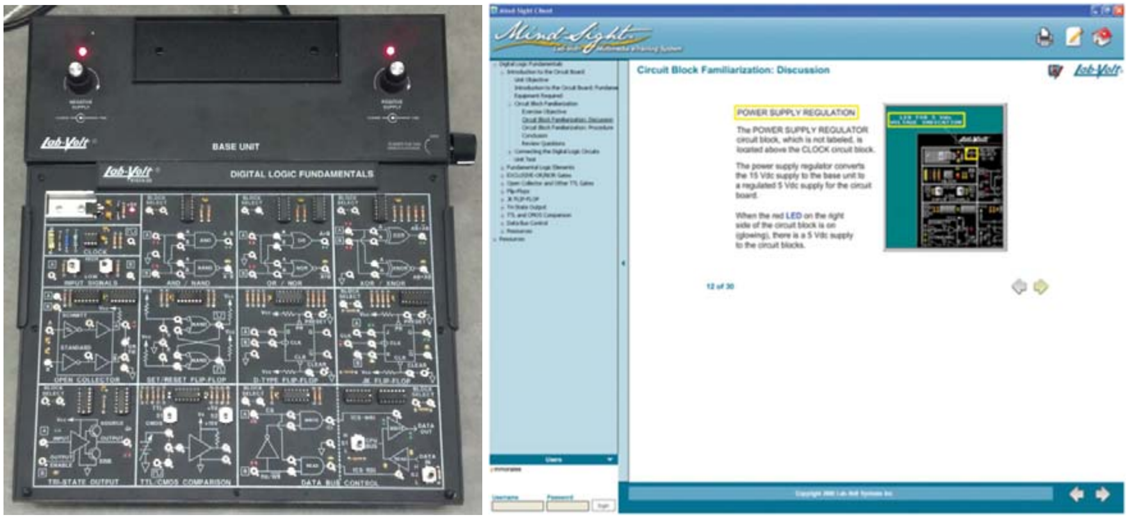
The Lab Volt FACET board equipment is significantly more complex than the bread boards it has replaced. The FACET boards are PC integrated and students are required to follow CAI to complete the practicals. The FACET board setup including the required PC and standard electronic test equipment is shown in Figure 2. The experiments completed in the second year class are listed in Table 2.

Table 2: Experiments conducted in the second year class using the FACET boards

Logic Gates and Boolean Algebra
D-Type Flip-Flops and Clocked Circuits
AND/NAND and OR/NOR Gates
Exclusive OR/NOR Gates
7-Segment Display/Driver
Flip-Flops
TTL & CMOS Comparison
Tristate Outputs
JK Flip-Flops
4 Bit Shift Register

Figure 2: Lab Volt FACET board laboratory equipment

Figure 3 (a) shows the Digital Logic Fundamentals FACET board used in the practicals of the second year class. As can be observed the electronic components and ICs are clearly visible and visually augmented by relevant logic symbols and labelling. Additionally, different topics are separated into regions on the FACET board. To undertake the practicals, students follow steps such as making electrical connections using jumper leads, as instructed by the MindSight software. Figure 3 (b) shows a screen shot of the MindSight software providing familiarisation with relevant components of the FACET board (Lab-Volt Systems 2013). MindSight provides students with detailed CAI on how to complete the practicals as well as requesting measured and calculated quantities such as voltage and frequency to be entered which are then stored in the MindSight database against students' individual accounts.



(a) (b)

Figure 3: Lab Volt FACET board and accompanying MindSight software (a) Digital Logic Fundamentals FACET board as used in the second year class, and (b) MindSight software interface (Lab-Volt Systems 2013)

Preliminary Survey Results

A survey was undertaken to provide preliminary indications of student perceived efficacy of the two different types of practicals. The study was approved by Deakin University's Ethics committee and was completed using the Survey Monkey data collection instrument.

To achieve quality data, responses were filtered to only include students who completed the two classes in succession, i.e. the first year class covering electronics fundamentals and using bread boards, followed directly by the second year class covering digital electronics and using FACET boards, and also to students who were able to recall sufficient detail regarding both types of practicals.

After filtering, the data sample size was eight student responses (N=8). All students were in an electronics-related discipline, with 50% Mechatronics/Robotics and 50% Electrical/Electronics students. Despite the small sample size, the results are valuable in that they represent the same group of students who undertook both types of practicals in succession. It is intended that the results provide good preliminary indicators of students' perceptions surrounding the different types of practicals.

Given that students were exposed to the different types of practicals in different classes and at different levels of study, i.e. bread boards in first year fundamentals class and the FACET boards in a second year digital electronics class, student bias for particular content needed to be considered. To address this, where applicable, survey questions began with the statement, *Disregarding the actual content covered…..*

To begin with, students were asked which type of practical they prefer where 75% (N=6) specified the bread board as utilised in the first year class. When asked which practicals they felt were the most effective as a tool for providing practical skills in Electronics 86% (N=7) of respondents specified bread boards.

When asked which of the two types of practicals students felt were most effective as a tool for understanding electronics concepts and theories, there was an equal preference for both types. In terms of disciplines, 75% (N=3) of Mechatronics/Robotics students specified the FACET boards and 75% (N=3) of Electrical/Electronics students specified bread boards.

When asked which practicals the student felt contributed most to their competency as an engineer in their field, 37.5% (N=3) choose bread board circuits and 62.5% (N=5) selected the FACET boards. In terms of frustration, 75% (N=3) of Mechatronics/Robotics students found the bread board more likely to leave them frustrated, and 75% (N=3) of Electrical/Electronics students specified the FACET boards.

A similar discipline-specific preference was observed when asked in which practical the students felt they were likely to disengage and stop focusing on the required tasks. Mechatronics/Robotics students exclusively specified (N=4) bread boards whereas Electrical/Electronics students all (N=4) specified FACET boards.

Students were posed with the hypothetical scenario where they were a new Lecturer and needed to choose one of the two types of practicals for a third year class they would be teaching. 75% (N=6) of respondents specified that they would use bread boards. Electrical/Electronics students exclusively selected bread boards, whereas Mechatronics students were evenly split between the two types of practicals.

The results of this preliminary survey suggests that Electrical/Electronics students are less frustrated, less likely to be disengaged by bread boards, and would prefer them over FACET boards if they were to teach their own third year class. The results are more mixed for Mechatronics/Robotics students, however it does appear that those who responded are more likely to disengage and lose focus when using bread boards.

Students were asked to rate the enjoyability of using the FACET boards, where 1 is comparable to the least enjoyable practical experience ever undertaken and 10 is the most enjoyable. The responses are plotted in Figure 4. Is it interesting to observe that enjoyability ratings fell at either end of the range being either between 1 and 2, or 6 and 9. The absence of mid-range scores of 3, 4 or 5 suggests that overall the respondents felt that the FACET boards rated either low or high in enjoyability.

In terms of disciplines, Mechatronics/Robotics students all (N=4) rated the FACET boards as reasonably enjoyable, ranging from 6 to 9, whereas 3 of the 4 Electrical/Electronics students rated the practicals between 1 and 2, suggesting low enjoyability. This aligns well with the earlier observation that Electrical/Electronics students as a group appear less frustrated and are less likely to be disengaged when using bread boards, and would prefer them over FACET boards if they were to design their own third year course.

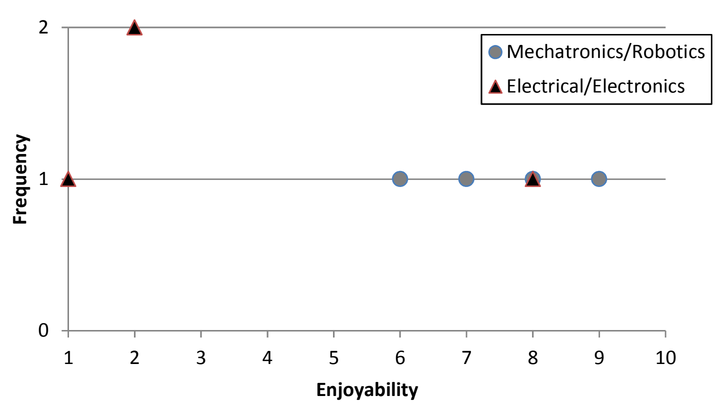


Figure 4: Enjoyability rating for the practicals employing computer-integrated Lab Volt FACET boards

All students undertook a common first year and the survey was completed midway through their second year of study. As such, it is likely that all students have had similar exposure to study involving practicals by which to compare the enjoyability of the FACET boards.

The results of this preliminary study suggest that there may be a preference by Mechatronics/Robotics students for the FACET boards, and for bread boards by Electrical/Electronics students. This would suggest that discipline specific characteristics of students are important to achieving improved engagement and a positive learning experience. It is hypothesised that any discipline specific preference may relate to learning styles, particularly to the *active-reflective* and *visual-verbal* styles of the Felder-Silverman model.

There is a body of work suggesting that Engineering students are *visual* learners. In this paper it is suggested that both types of practicals cater more for *active* and *visual* learners than they do for *reflective* and *verbal* learners. As discussed, the preliminary survey results indicate a preference by Electrical/Electronics students for bread board practicals. A reason for this could be that some of the *visual* information provided by the FACET boards (Figure 3) may be perceived as unnecessary and a deviation from the core electronics underlying the practical. For a Mechatronics/Robotics student on the other hand, the highly *visual* integrated systems (FACET board, PC, test equipment etc) may be seen as more relevant to their undertaking of the same practical. In such a scenario, if students from different disciplines have a similar preference for *visual* learning, but different perceptions of the relevance of *visual* content, then the amount *visual* learning and the perceived efficacy of the type of practical may vary. In terms of *active* learning, a similar situation is possible where perceptions by different disciplines as to what is considered relevant *active* content may be different and affect the *active* learning achieved. To investigate this, future work will use the ILS to compare the learning styles of a larger number of students in both disciplines as well as a more detailed survey of the perceived efficacy of both types of practicals.

Conclusions

The outcomes of the preliminary study suggest that there are discipline specific characteristics which affect students' perceptions of laboratory equipment's efficacy. These outcomes will assist Deakin's School of Engineering to refine the use of the Lab Volt FACET board laboratory equipment to achieve improved levels of student engagement. Future research will include a more detailed analysis of students in different disciplines and consider whether a difference in preferred learning styles exists and any relation to student perceptions.

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