First Year Electronics Not Only for First Year Electronics Students - How to Ensure Engagement Through Innovation

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Structured Abstract

BACKGROUND

Undertaking a broad range of fundamental introductory courses is an important part of Undergraduate Engineering education. These courses are also often part of a first year curriculum common to students of different Engineering disciplines. This paper investigates the use of robotics as a tool to improve engagement in the practical component of an introductory first year Electronics course. The robots were utilised to provide physical demonstration of the purpose of simple electronic circuits. The use of the robots aligns with features of the Design Based Learning (DBL) pedagogy.

PURPOSE

The implemented robot practicals were specifically designed to increase student engagement and motivation in electronics practicals while maintaining the same learning outcomes. Design based learning is self-directed where students initiate learning by designing innovative and creative solutions to fulfil both industry and academic requirements. The use of the robot practicals aligns with features of the DBL educational model.

DESIGN/METHOD

The robot practicals were designed to simultaneously increase student engagement and to improve the learning experience for students studying both Electronics related and non-Electronics related disciplines (such as Mechanical and Civil Engineering). An evaluation study was performed to determine the student perceived effectiveness of the approach in improving student engagement.

RESULTS

An evaluation survey was undertaken and this paper presents results demonstrating that the robot practicals had a positive impact on the students' interest in learning the relevant concepts during the practicals. Lessons learnt from this experience can be applied to future practicals.

CONCLUSIONS

The implementation of the robot practicals aligns with keys elements of the DBL model such as active learning, hands-on work, and engaging real-world and multidisciplinary tasks. The survey results demonstrate a positive response to the robot practicals which is a particularly valuable outcome considering that the majority of the cohort and survey respondents were pursuing degrees in unrelated disciplines, i.e. Mechanical and Civil Engineering.

KEYWORDS

Robotics, common first year, electronics, design based learning, engineering education.

Background

Fundamental introductory courses are an important part of an Undergraduate Engineering degree. These courses provide students with a base level of knowledge before they specialise in their chosen Engineering discipline. Students from various disciplines often undertake the same range of foundation studies which may be part of a common first year curriculum. This paper investigates the use of robotics as a tool to improve student engagement within the practical component of a first year introductory Electronics course.

Learning is an active process involving investigation and creation based on a learner's experience, interest, and curiosity which should result in expanded skills and knowledge. Learning can occur in many different ways such as discovery learning, which is student driven and based on activities of interest. In terms of retention, according to Vere (2009), when students are taught how to design a system or to solve a problem, they typically remember around 10% of what was read, 20% of what was heard, 30% of what was seen, 50% of what they saw and heard, 70% of what they wrote and said, and 90% of what they actually did (de Vere, 2009). Table 1 lists three learning modes, methods by which learning occurs and how much students remember using each method. Vere (2009) discusses the best way to achieve effective learning is to employ all three learning modes.

Table 1: Learning modes (de Vere, 2009)

Learning Mode	How Do we Learn?	How Much Do We Remember
Action Learning	Participating in the activity	100%
	Simulating the activity	90%
	Teaching the activity	70%
Visual Learning	Watching demonstration	50%
	Watching moving pictures	40%
	Viewing pictures	30%
Verbal Learning	Hearing words	20%
	Reading	10%

There are different approaches to learning which encompass the three learning modes discussed above. As emphasised by Vere (2009), the highest learning retention occurs when students actually undertake the activity. This mode of learning, i.e. Action Learning, often occurs in Engineering courses through practicals and other similar activities. Herein an introductory Electronics course undertaken as part of a common first year curriculum is considered. Traditionally the course involved a mandatory and assessed practical component where students were required to follow procedures to build, test and troubleshoot Electronic circuits. This paper discusses the introduction of robots as a tool to increase student engagement in these practicals.

Aziz (2008) discusses the University of South Australia's introduction of an Engineering common first year to provide their students with common multidisciplinary foundation Engineering knowledge (Aziz, 2008). The author discusses the ability of the common first year to enable professional practice to occur from first year as well as allowing high achieving students to accelerate their degree and finish within three years. O'Steen et al. discusses the introduction of "Engineering 101" at the University of Canterbury (O'Steen, Fee, & Jordan, 2008). Their first-year course is designed to engage students by "problem-solving through solution design," and the results demonstrate that they were successful in increasing student engagement.

In their work, Carlson et al. (1997) introduced a hands-on first year elective Electronics lab course aimed at increasing student motivation and retention by building confidence, stimulating curiosity and demonstrating the relevance of Engineering (Carlson, Schoch, Kalsher, & Racicot, 1997). Evaluations demonstrated that they were successful in achieving their aims. Bradbeer (2001) introduced “Studio Teaching” for an introductory Electronics course undertaken by first year Mechatronics Engineering students (Bradbeer, 2001). Traditional delivery methods were replaced by a combination of mini-lectures, demonstrations, discussions, and problem-solving and computerised activities. Preliminary results demonstrate that students achieved a deeper understanding and improved grade performance. Recent work by Caldwell & Jones (2011), discusses an interesting approach which used robots to captivate and engage computer science students (Caldwell & Jones, 2011).

The first year Electronics course considered herein provides students with a broad introduction to Electronics. The course is introductory and students are not required to possess any prerequisite electronics or electrical knowledge. The course is common to the whole first year Engineering cohort which comprised students from Electronics, Mechatronics/Robotics, Mechanical and Civil Engineering disciplines. The course was completed by 104 students studying ON-campus and 21 students studying in OFF-campus mode. The introductory course introduces students to electronics fundamentals such as Ohm’s law, Kirchhoff’s Voltage and Current Laws, Semiconductors and Digital Logic. The course was delivered over a single semester through Lectures, Tutorials and Practical sessions. In order to complete the Practical component of the course students were required to complete a set of six practicals (three hours duration each) throughout the semester.

To increase student engagement and motivation robots were introduced as a tool to augment students’ practical sessions. The aim was to continue to satisfy the same learning objectives, while adding to the experience by allowing students to observe physical behaviour as a result of the outputs of the electronic circuits. The implementation of the robots to the practicals, as opposed to the previous practicals, aligns with features of the design based learning (DBL) pedagogy.

DBL is a self-directed approach where students initiate learning by designing innovative, practical and creative solutions which fulfil academic and industry expectations. DBL can be an effective vehicle for learning and is centred around a design problem solving structure and is derived from a combination of problem and project based learning. Design projects have been used to motivate and teach science in elementary, middle, and high school classrooms and can help to open doors to possible engineering careers. Doppelt and Wijnen argue that DBL was implemented more than a decade ago but requires further development (Doppelt, 2009; Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008; Doppelt & Schunn, 2008; Wijnen, 1999).

DBL is an active learning process which makes students practise and recognise different learning styles and team based activities which support learning and sharing through cooperative methods (Doppelt, et al., 2008; Reynolds, Mehalik, Lovell, & Schunn, 2009). Doppelt (2008) states that DBL is one type of project-based learning which involves students engaging in the process of developing, building, and evaluating a product they have designed. The robot practicals discussed herein invoke more active learning by students than the previous electronics practicals.

In engineering science classrooms, DBL provides new possibilities for learning science (Doppelt, et al., 2008). Working on and completing design based activities can contribute to students being proud of their achievements, as well as building their confidence as thinkers and designers. Doppelt and Schunn argue that DBL encourages students’ active participation and construction of knowledge rather than passively learning about engineering science from textbooks and lectures (Doppelt & Schunn, 2008).

The robot practicals contextualise the electronic circuits covered to real-world applications where the electronic circuitry acts as a control circuit for a real-world multidisciplinary physical system, i.e. the robot. The robot practicals also require a higher level of hands-on activity. When compared with the previous practicals, these characteristics of the robot practicals better align with features of the DBL pedagogy such as active learning, hands-on work, and engaging real-world and multidisciplinary tasks.

Design/Method

This paper focuses on the practical component of a first year Electronics course within the School of Engineering at Deakin University. The course was delivered through Lectures, Tutorials and twelve Practicals completed over six sessions. The practicals focused on parts of the course content deemed suitable for practical sessions. Table 2 outlines the practicals undertaken in the course prior to the introduction of the robot practicals.

Table 2: Previous Practicals

No.	Detail
1	The breadboard and the transistor
2	Logic gates
3	NAND and NOR gates universality
4	Equivalence of Boolean expressions
5	Combinational circuits and the logic probe
6	Flip-flop circuits
7	The voltage divider and the digital multimeter
8	Introduction to the oscilloscope
9	Diodes and applications
10	Introduction to transistors
11	Operational amplifier: open loop operation
12	Operational amplifier: closed loop operation

The SumoBot from Parallax was utilised as the robotic platform facilitating the robot practicals (Parallax, 2014). The SumoBot provides continuous rotation servo motors for locomotion, different sensors for detecting physical quantities, a microcontroller which can be programmed for controlling the robot and a breadboard for integrating custom electronics. The provision of the breadboard allows students to implement electronic circuits in a similar manner to that previously achieved using the breadboard included in the Home Electronics Laboratory Pack (HELP) (Long, De Vries, Hall, & Kouzani, 2008). As discussed by Long et al. (2012) the practicals needed to cater for both and ON and OFF-campus students, so the SumoBot was added to a revised HELP (Long, Horan, & Hall, 2012). To enable students to undertake the necessary practicals, the SumoBot's onboard microcontroller was pre-programmed to execute simple movements in response to the outputs of the student's electronics circuits.

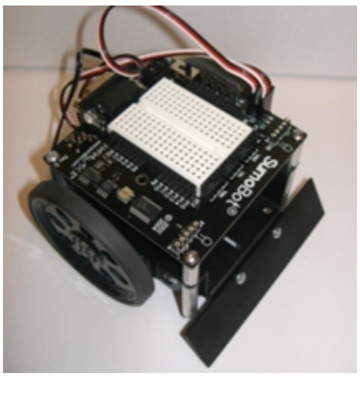

Figure 1: SumoBot robot from Parallax (Parallax, 2014)

The original experiments in the Electronics course were designed to cover a subset of the course's content. The choice of particular content covered in the practicals was based on considerations such as appropriate depth of content for practicals, equipment availability and completion time. Given the implemented robotic platforms, in order to fully realise the effects of the approach, the practicals were redesigned according to the same criteria. The revised practicals are outlined below in Table 3.

As can be observed from Tables 2 and 3, the original and revised practicals cover similar content however the revised practicals were chosen based on being more suitable for achieving engaging outcomes using the robotic platform.

Table 3: Revised Practicals

No.	Detail
1	The SumoBot platform and LEDs
2	Logic Gates
3	Universality of NAND and NOR Gates
4	Combinational Logic and the Logic Probe
5	Flip-flops and Latches
6	Introduction to the Oscilloscope
7	Clocked Circuits and Object Detection
8	SumoBot Obstacle Avoidance
9	The Transistor
10	The LED and Phototransistor
11	Operational Amplifier: Amplification
12	Operational Amplifier: The Comparator

Results

As a common first year course there were students from a diverse range of backgrounds and the course was undertaken by a total of 125 students. An evaluation study was performed using the SurveyMonkey data collection instrument and the study was approved by Deakin University's Ethics Committee.

The robots were introduced to increase student engagement and to improve the learning experience for students studying Electronics-related disciplines as well as those from Mechanical and Civil disciplines. 45 students participated in the evaluation and the non-Electronics related disciplines (Civil and Mechanical) represented more than 75% of respondents. The student cohort was predominantly male (84.44%) and studying in an ON-campus mode and more than 82% of the respondents were aged between 18 and 26.

The extent to which the introduced robot practicals had a positive effect on students' experience and learning was evaluated through questions relating to the use of the robots in the course. Herein we focus on the questions directly related to engagement.

To gauge students' general interest in robotics, the following survey item was included:

In general, I find the idea of robots….

The response, shown in Figure 2, demonstrates that approximately thirds of the respondents found robots in general *Highly Exciting* (33%), *Exciting* (36%) and *Slightly Exciting* (29%). Only 1 respondent indicated that they found robots of no general interest. This result suggests that the use of the robots is at minimum effective in catching students' attention.

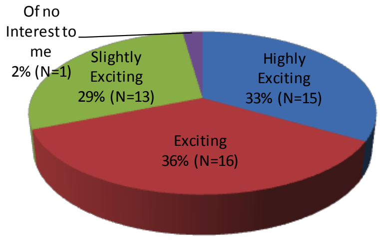

Figure 2: Students' general interest in robots

To determine the level students felt that the robot practicals contributed to their engagement in the practicals, students were asked to choose one of three endings which they felt best completed the following statement.

If the robots were not included, my interest in learning the concepts covered experiments/practicals would have been

[More without the robots, Less without the robots, or The Same]

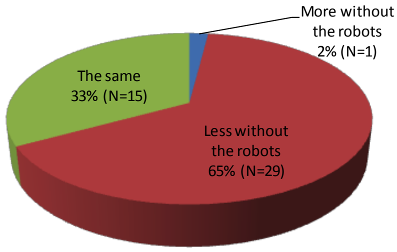

Figure 3: Students' interest in learning due to the introduction of the robots

The responses to this question are depicted by Figure 3. As shown, only 2.22% (N=1) of students responded that their interest in the learning the concepts covered in the practicals would have been higher without the robots. 33.33% (N=15) of students responded that their level of interest would have been the same without the robots. 64.44% (N=29) of students responded that their interest in learning the concepts would be less if no robots were included. Given that non-Electronics related disciplines (Civil and Mechanical) represented more than 75% of survey respondents this is an especially valuable result.

This demonstrates that robots can have a positive impact on student perceived engagement in Electronics concepts covered in practicals. Considering the results presented in Figure 2, where almost all of the respondents found robots in general exciting to some degree, it would seem that the exciting nature of the robots could be a major contributor to this result. The authors also believe that contextualising the electronic practicals to a real-world application can make the practicals more interesting to students.

Conclusions

This paper discusses the introduction of robots as a tool to increase student engagement in an introductory Electronics course undertaken as part of a common first year Engineering curriculum. There are characteristics of the implemented practicals which align with the Design Based Learning (DBL) pedagogy. Results indicate that students' interest in learning the content underlying the practicals would be less had the robots not been included. Given that Civil and Mechanical Engineering students comprised more than 75% of the respondents this is an especially valuable result. The results also demonstrate that robotics is an exciting topic as indicated by most respondents and this finding could be valuable to others considering the use robotics as a tool for improving engagement in other Engineering courses.

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