Balancing pedagogy and technology in designing assessment: A case study in Engineering education

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The assessment case study at the core of this paper is embedded in an Engineering unit where the concepts of signal processing are taught and there is also a requirement to use the industry standard, MATLAB, to perform signal processing operations. The learning design for the case study is a multimode, three-part assessment process that addresses the diverse backgrounds and learning styles in the student cohort; it also, aligns assessment with learning and teaching outputs and equips students with skills they will require for professional practice.

Keywords: engineering education, assessment, small group teaching

Introduction

Natasha McCarthy said that "... engineering can be seen as delivering knowledge by a much more direct route than by aiding science. There is a useful distinction in philosophy between 'knowing that' and 'knowing how' ..." [Natasha McCarthy, 2006]. Teachers appreciate access to innovative assessment case studies embedded within particular disciplines and associated with professional practice frameworks. That is the thinking that underpins funding by the Carrick Institute for four major assessment projects to enhance assessment practices in a range of disciplines in to enhance the assessment of learning in Australian higher education, including a 2006 Carrick Competitive Grant for Teaching and Assessing Meta-Attributes in Engineering. [The Carrick Institute for Learning and Teaching in Higher Education (2006)]. This paper presents an assessment case study embedded in Engineering education where there are constant pressures to incorporate curriculum content that reflects rapid technological advances, which fosters our Engineering students not only "know what" but also "knowing how". It is important to note that this kind of "knowing how" represents knowledge relating to some of the most fundamental features of nature. A new generation of wireless devices, for example, combines aspects of cellular phones, personal digital assistants and digital cameras; it enables new modes of mobile communication such as short text messaging, event notification, e-mail and web browsing. These wireless services depart from traditional telephony to new modes of IP-based multimedia communications. Inevitably the signalling system that enables all of the functionality of the cellular and telephone network will be replaced by more versatile signalling based on Internet protocols. Clearly there is a significant momentum to update curriculum content and it is often in the design of assessment that staff need to strike a balance between competing pressures.

The Engineering assessment context

Engineering education at the University of Canberra involves aspects of mathematics, physics and electronics, computer programming and hardware; but it also incorporates management fundamentals, teamwork project management and communication skills. In the first author's experience of teaching Engineering at more than five universities, commonly encountered problems include:

i. Diversity of student learning/backgrounds
ii. The need to keep Engineering students conversant with professional industry tools and standards
iii. The challenge to promote deep learning
iv. Aligning assessment with other learning and teaching aspects in the unit

Ramsden's (2003) observation that we can no longer rely on students having detailed pre-requisite knowledge is applicable to Engineering students, especially in mathematics and science. There is a particular requirement to be aware of the first year student experience. One in five students in the United Kingdom, and one in three in Australia, will be amongst attrition statistics (Biggs 2003). In terms of teaching approaches, it is possible to conduct very good small group engineering education (Huang and Woolsey 2000 and 2001) but assessment is a critical intersection point. Brown and Knight (1994) argue that the best way to change student learning is to change assessment methods and that suggestion is taken up in this paper. In Beetham's (2005) view peer assessment and the use of technologies offer opportunities to deepen the learning process for formative assessment and reflection.

Assessment requires one to strike the optimum balance between inputs, such as teachers' activities and marking time, and the resultant quality of student learning. The 2005 ASCILITEAssessment theme extends beyond traditional areas of educational technology to incorporate a 'whole of life' context and this has particular relevance because it invites consideration of the attributes that we would want to see in our Engineering graduates. Traditional Engineering graduate values remain valid, such as an uncompromising commitment to excellence and precision in design in real world projects. In fact, these graduate attributes standards need to be imbued in our students graduates so that the security, safety and design excellence in engineering installations is assured. Associated with this is the requirement for students to become expert users of industry tools such as MATLAB, a powerful environment for conducting high-level data analysis, simulations and numerical computation with matrices and vectors. It is vital that engineers apply principles learnt in a university environment to real life problems.

Assessment innovation adopted

Normally, to the teacher, assessment is at the end of the teaching-learning sequence of events, but to the student it is at the beginning. There are many good reasons why we should assess students, but two are outstandingly important, namely (a) Formative assessment, the results of which are used for feedback. Students and teachers both need to know how learning is proceeding. (b) Summative assessment, the results of which are used to grade students at the end of a unit, or to accredit at the end of a programme. The assessment context is a second year engineering unit, *Signals and Systems* in the degree of Network Engineering at the University of Canberra. The assessment item is conducted in a laboratory setting with an envisaged time-span of 150 minutes. The assessment guidelines and criteria are clearly explained in the unit outline which the students receive in print and electronic form in the first week of semester. For the students the assessment is a summative assessment but for the teaching and learning processing the designed assessment plays both roles.

The value of the assessment item in Table 2 is 100% but this constitutes only 20% of the weighting of marks for the total assessment in the unit. Unit assessment normally consists of nine assignment marks, with the top eight marks averaged to produce the final grade.

Table 1: Teaching context

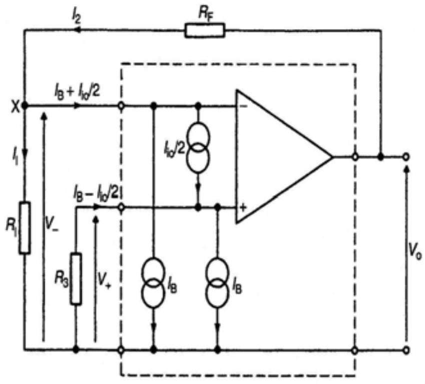
Discipline	Bachelor of Network Engineering
Subject	*Signals and Systems*. This subject introduces the concepts of signal processing including transformations between continuous and discrete signals and between the time and frequency domains, and the use of MATLAB to aid the numerical solution of problems in these areas. It also further develops the electronics of digital and analogue systems commenced in "Introduction to Computer Engineering" and "Introduction to Telecommunications Engineering."
Learning outcomes	After completing this subject students should be able: • to analyse linear networks and determine the frequency spectra of signals, • use MATLAB to perform signal processing operations, • design a variety of electronic circuits based on operational amplifiers, • analyse and design combinational, and sequential digital systems and data acquisition systems using the most appropriate technology for a given application.
Students	First semester/ second year of course. Diversity of backgrounds, levels of experience
Mode of delivery	On-campus delivery. Class contact: three hours of lectures and up to four hours of laboratory/tutorial work

As Table 2 indicates, the assessment innovation is a multimodal form of assessment, consisting of three inter-related parts.

Table 2: Overview of the assessment innovation

	1: Watching and Answering	*2. Reading and Answering*	*3. Thinking and Answering*
Description of each part	Students view multimedia material in laboratory tutorial class that introduces the simulation software called Pspice and Protel, widely used in industry.	Short questions with some simple calculations. Calculations to be checked by the software simulations.	Consist of two more advanced conceptual questions, which also involve some problem-solving skills explored in tutorials

Aim	To provide opportunities for students to experience the "feel" of the software To ensure that students become familiar with the general range of options within this software and learn how to design digital and analog circuits. To review and reinforce the design principles learnt in the classes	To verify Part 1 learning results To assess learning from tutorials/lectures To ensure students have understood the basic concepts related to the designs of digital and analog circuits To assess application skills for the calculations for the digital and analogue circuits, in particular for the timing managements via calculated values	To ascertain how students combine learning and the problem-solving skills To promote a deep approach to learning To demonstrate how "problem-solving" is very important in real designs, in particular for their future career.
Mix of group and individual assessment	Students work in pairs and discuss answers	Individual submission of answers	Individual submission of answers
Sample questions	How to interpret what you are watching the MATLAB image in Figure 1? How to choose a parameter you are going to measured in the software Pspice? What is the maximum time?	Construct the state table for the machine described by the state-transition diagram:	Obtain the condition of zero output offset due to input current by the circuit shown (See Figure 1 and Figure 2) The answer: the students should obtain the equation Vout = IB (RF-R3(1+RF/R1))+f(IIO), then get the IB term to be zero and obtain: R3 = R1//RF. (See Figure 1)
Time	40 minutes	50 minutes	60 minutes
Weighting	20%	50%	30%



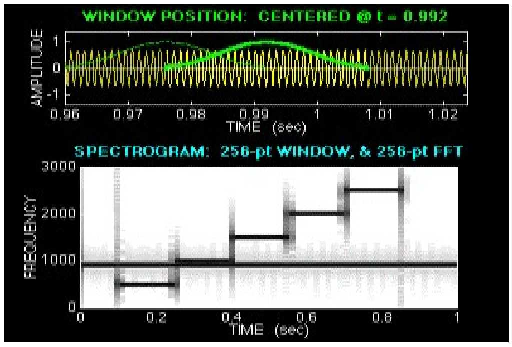


Figure 1: Circuit

Figure 2: A MATLAB picture

5. Discussion and analysis

This innovation incorporates multimode assessment, distinguishing it from traditional assessment. In the second year of the course, there in an increased emphasis on designing assessment that encourages a transition from surface learning to deeper learning approaches. The adoption of small group teaching in first year engineering units means that the lecturer already has a close knowledge of student performance and so, for example, a student who encountered difficulties in first year Physics , would also be likely to be challenged again in second year. There is a recognition then that such students, who are in a minority, need to be encouraged to make significant advances in their learning; furthermore, there is a deliberate strategy to challenge the majority of students at the intermediate level, and those at advanced levels, to adopt deeper learning approaches.

The discussion of questions in Part 1, for instance, departs from traditional Engineering assessment practice, and provides opportunities for students to feel more confident with what they have learnt. The examination will show students learning skills and knowledge at a reasonable level. In terms of teaching, we can obtain some information that is hard to obtain from traditional methods, such as how the learning skills apply for our students and how they treat the case of difficulties of a semi-real problem; furthermore, we can review the kind of teaching methods adopted and how may need to be modified.

As background to Part 3, there are some skills to solve the circuit-design problems that were demonstrated in the tutorial classes using various examples eg. negative feedback that can make the output stable. Limitations of electronic components such as frequency factors were also discussed and if students failed to make these connections, they will be unable to produce correct calculations in the time available. The problems in Part 3 are more authentic professional practice problems because students are required not only to solve equations but to check charts and tables, a common occurrence in real industry designs.

In Part 3, we believe the most capable students will have the chance to obtain marks > 25% of the total marks in this part (which means we are accepting the highest mark will be 95% of the total examination). Less capable students still have chance to obtain 5% of the total marks in this part (eg they indicate the solving direction by inserting some signals such as equation, words description, or diagrams), applying some of the concepts presented in the earlier tutorial classes. In other words, it is hard fail (less than 50% of the total marks); it is also hard to obtain higher marks as well (say the marks > 85% of the total examination marks). Most students will be in the range from 65% to 75% of the total marks, a reasonable distribution in an examination of engineering subjects.

6. Conclusion

The Engineering assessment case study presented in this paper is a multimode assessment, designed to address diverse student backgrounds and learning styles; it is aligned with learning and teaching in the unit and assesses skills required in professional practice. It is a model that is transferable to other Engineering courses and could easily be included in a national portfolio of assessment examples.

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