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Innovation in Engineering Education at the University of South Australia

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This paper summarises a range of educational issues and actions from within the School of Electrical and Information Engineering at the University of South Australia. Philosophical considerations focus on learning styles, the case for experiential learning, and drivers for intensive learning approaches. Methods are reported for enriching students' experiences, so improving their academic performance and sense of satisfaction. These are peer assisted learning, the use of virtual instrumentation as a didactic tool, and the implementation of novel final year projects. Initiatives in Web-based presentation include a uniform preparation tool, the use of Web-based delivery and interaction for large classes, a novel multi-media browser for information on magnetism applications and a Web-based project logbook.

INSTITUTIONAL BACKGROUND

This year sees the 10th Anniversary of the University of South Australia (UniSA), formed in 1991 by the amalgamation of two institutions: the South Australian Institute of Technology (SAIT) and the South Australian College of Advanced Education (SACAE). The SAIT had a tradition of vocational and professional preparation for business, science and engineering. The SACAE had emerged from the successive integration of colleges mainly focused on teacher education, but with significant diversification including art and design, business plus other humanities-based vocations.

Through the late 1970s and the 1980s, there was a strong requirement from directorate level within the SAIT, and hence in the engineering schools, for outcome-oriented curricula and assessment, descriptive programme and course documentation derived from clearly enunciated rationales, and teaching and learning practices that were informed and shaped by these. It is only fair to say that there were also strong conservative forces within the engineering and contributing science and business schools that favoured traditional teaching methods and resisted innovation. The accreditation processes of The Institution of Engineers, Australia (IEAust) have also tended to inhibit radical rethinking and change.

Amalgamation with an institution that had a strong educational mission might have been expected to accelerate the move to educational reform. In fact, there was a rather lengthy gestation period following the union, but since the mid-1990s, a lusty and very vocal reform agenda has dominated the intellectual life of the new University. The process begins with a group of desired qualities of UniSA graduates, which are:

- Body of knowledge: operates effectively with and upon a body of knowledge of sufficient depth to begin professional practice.
- Life-long learning: is prepared for life-long learning in pursuit of personal development and excellence in professional practice.
- Effective problem solver: is an active problem solver capable of applying logical, critical and creative thinking to a range of problems.
- Work alone and in teams: can work both autonomously and collaboratively as a professional.
- Ethical action: is committed to ethical action and social responsibility as professional and citizen.
- Communicate effectively: communicates effectively in professional practice and as a member of the community.
- International perspective: demonstrates international perspective as a professional and as a citizen.

These traits are rather similar to those concurrently being espoused by the engineering professional bodies, and articulating with increasing detail into every aspect of curriculum development and teaching and learning practice and management, outcome orientation has been incorporated throughout the University's programmes. This has been reinforced by a comprehensive quality assurance system. The resulting climate favours reflection on educational rationales and methods, though micro-reform and innovation is easier to achieve than large-scale reform. This is despite, or perhaps because of, frequent major programme reviews and revisions.

EDUCATIONAL REFORM WITHIN THE ELECTRICAL ENGINEERING DISCIPLINE

The electrical engineering discipline, understood in its widest possible meaning, has been reorganised several times since the formation of UniSA [1]. Currently, it is focused in the School of Electrical and Information Engineering (EIE) within the Division of Information Technology, Engineering and the Environment (ITEE).

Within the discipline, a group of engineering academics has persisted with pedagogical experiments in the pursuit of excellence in teaching and learning. Colleagues from support agencies within the University have ably assisted them in this quest. The theoretical strength and capacity for reflection of the team has been reinforced by recourse to relevant pedagogical theory. One artefact of this has been an articulation and adoption of conscious cycles of experimentation and reflection, both as regards educational research and teaching and learning experiences.

Outcomes of these experiments and considerations have been widely reported at a number of platforms, including annual conferences conducted by the UNESCO International Centre for Engineering Education (UICEE) [2-10]. One focus has been on *philosophical considerations*, embracing the study and implementation of relevant theories of education to provide benchmarks for pedagogical experimentation and practice.

Identifying and assessing non-traditional means of expanding technical comprehension and the generic skill base of students has led to *expanded visions* of engineering education. The impact on education of technological developments, such as Web-based teaching and learning, has prompted the authors to adopt advances in this area to better cater for variation in learning styles and to improve accessibility, thereby *adjusting to the changing landscape*.

PHILOSOPHICAL CONSIDERATIONS

The increasing diversity of students in tertiary education has led to greater interest in how students learn, and how their learning is influenced by their social and cultural backgrounds. This area of research is often viewed as an aspect of the inclusive curriculum – a curriculum that attempts to include the interests, values and experiences of all students, whatever their backgrounds. The term *learning styles* is used to describe the ways individuals or cultural groups prefer to receive, process and present information and ideas.

The literature on learning styles divides into two groups: one group sees differences in learning styles as deriving from differences in personality, life experiences and purpose of the learning. The second interpretation finds that students shape their learning methods to their teachers' expectations (or at least to their understanding of their teachers' expectations). If teachers expect rote learning, students will learn by rote. If teachers expect analytical and critical thought, students will respond accordingly, as long as they receive effective academic guidance on how to develop these skills.

Four basic learning styles can be identified:

- *Convergent*: good at problem solving, decision making and the practical application of ideas.
- *Divergent*: good imaginative ability and awareness of meaning and values.
- *Assimilation*: good at inductive reasoning and creating theoretical models.
- *Accommodative*: efficient in carrying out plans and like getting involved in new experiences.

Engineers usually have a convergent learning style. Engineering education, with its heavy emphasis on problem solving and engineering science, relies principally on convergent and assimilative learning styles. The authors have attempted to change patterns of teaching and learning in the programmes and courses under their control to force students to adopt a range of learning styles [11]. In doing so, they have attempted to embrace relevant theories of education and provide benchmarks for pedagogical experimentation and practice. Some pertinent theories and related experiments are related in this section.

CONSIDERATIONS ON EXPERIENCE-BASED LEARNING

Within our culture, academic learning is valued because of its power, and experiential learning is sublimated, devalued or neglected. In contemporary universities, with their emphases on accountability, economies of delivery and promotion by research, experiential learning is generally under threat. However, there are some things, which can only be learned by experience. The case for experiential learning can be argued from theoretical considerations [2]. Those considered here are the physiological, psychological, epistemological and pragmatic.

Effects of Experience

Experiential learning affects us at a *physiological* level. If mind is pattern, rather than organic parts, which are continually replaced, experiential learning will always alter our minds. The process will be pervasive and often unpredictable and exponential. *Psychology* has always emphasised experience as the basis of emotions and instinctive behaviour.

Opinions differ as to the physiological mechanisms of emotion, but collective experience demonstrates that emotions kick in more quickly than rational thought, colouring our responses to stimuli, and dictating our behaviour. This profoundly affects the effectiveness of people engaged in the intellectual professions, both individually and in groups. The *epistemological* models of Piaget [12], Kolb and McIntyre [13], and Honey and Mumford [14] all demonstrate the possible polarising of learning into alternating modes of action and reflection. This duality underlies the *pragmatic* approach of Revans, which also features meta-learning episodes in which groups (*sets*) reflect on their motivations for decision making [15].

Issues for Experiential Learning

In many settings, the nature of the experience is unpredictable. This creates tensions for schools and teachers of engineering. What objectives are to be realised through student experience? What experiences are appropriate to achieving those objectives? How can educators promote the likelihood that students will in fact receive those experiences? If they don’t, is that important? If so, what can be done about it? How are outcomes to be assessed, given that many are non-theoretical, and that the outcomes must be non-deterministic? Is it ethically defensible to seek to modify students’ intuitive or emotional behaviour?

The Achievement of Experience

Having identified, at least in broad terms, those qualities it is desired that learners should acquire through experience, and having refined the course structure to reflect where that experience is to be incorporated, it is then possible to devise an experience scheme at the course level. Where a decision has been taken to minimise mediation, what Andresen et al call *buttresses* must be in place to prevent catastrophe [16]. These will frequently take the form of alternative experiences, or timely intervention. Experience must not be permitted to degenerate into learning of negative attitudes or time serving through lack of preparation or inattention by educators.

The most appropriate way to detect whether the desired objectives are being achieved or negated is to have scheduled opportunities for reflection. These range upward from the daily report or diary to formal meetings for – ideally – peer review and re-initiation. To incorporate such meetings is consistent with the successful Revans approach and the epistemological justification for it [15]. By incorporating methods for raising self and group awareness, these meetings can also contribute to the achievement of the desired objectives.

The use of self-evaluative instruments will assist considerably in determining whether non-academic objectives have been met. It is entirely appropriate that the self-evaluation should cover the entire range of possible behavioural, attitudinal and emotional developments that have occurred. Learners should be encouraged to identify and record these. Whether educators should be privy to the records is a matter of culture and the degree of mentoring that occurs within institutions.

The authors have experimented with many means of incorporating experiential learning into their programmes and courses and have progressively adopted the Revans model as a paradigm for such developments [17].

IMPLEMENTATION OF INTENSIVE TEACHING AND LEARNING MODES

Academics commonly teach intensive courses to an external clientele. Participants in these courses are normally strongly motivated, generally familiar with the potential application of the material and success-oriented. Incentives to attend such short courses have been considerably increased by the requirement of engineering professional bodies in many countries to count the course attendance towards continuing professional development quotas or as part of the admission process to professional engineer status. There is a strong economic justification for offering intensive courses in undergraduate and coursework postgraduate programmes and making these available to external participants [3].

There are many valid alternatives to the intensive mode of delivery. These include the more mechanistic modes of teaching and learning using computer-based instruction packages and self-paced learning materials. However, the authors value face-to-face teaching because of its potential for role modelling of generic skills; for example, interactive face-to-face teaching obligates students to frame and articulate an intelligent oral contribution.

Higher learning educators, employers and the profession favour deep learning approaches. The work of Selmes on secondary school students [18] has been shown to be equally valid for higher education, eg by Ramsden [19]. Deep approaches are notoriously difficult to achieve in mechanistic modes of delivery – almost tautologically so – but may be achieved through pre-planned and spontaneous activities in face-to-face teaching. Heywood et al. concluded that computer-based teaching and learning programmes are frequently misaligned to clients' learning needs, even though on the surface they are carefully tuned to specified learning needs [20].

A number of courses within the programmes in the School of Electrical and Information Engineering at the UniSA are offered in a variety of intensive modes. Instructive examples include:

- Postgraduate courses in Test and Evaluation.
- Engineering innovation and practice.
- Electromagnetic compatibility.
- Power and energy systems.
- Offshore delivery.

Postgraduate Courses in Test and Evaluation

In formulating a portfolio of postgraduate courses in Test and Evaluation, programme designers proposed flexible delivery modes. The actual choices lay between intensive short courses and traditional teaching spread over a semester. Although unarticulated, there was a strong belief that short courses were most suitable for practitioners in employment and for international students visiting Australia expressly to study these topics. This belief seemed to be vindicated by strong demand in the short term, and in fact only short courses were offered. This decision was driven by economic considerations.

A sharp fall in demand prompted a re-evaluation of the programme. It was concluded that the claimed flexible delivery was not being delivered and that there was merit in offering the programme in a variety of ways consistent with variation in the preferred learning styles of individuals.

On the face of it, this experience raises concerns about the efficacy of intensive short course modes. However, there are questions that can be legitimately asked concerning the short-lived demand for the test and evaluation programme in the intensive mode. Was there ever going to be a continuing demand for this topic, both locally and overseas? Were effective marketing strategies employed to win a follow-on cohort of students? Were those who attended satisfied with their experience? If not, did they have any influence on potential participants? Was there something wrong with the way in which the intensive courses were offered? It may be that the experience is not inimical to intensive mode teaching and learning at all, but it is certainly true that there are lessons to be learned and applied.

Engineering Innovation and Practice

A three-day workshop is conducted early in the 2nd year course of Engineering Innovation and Practice. This intensive workshop is designed to bring students up to a basic skill level in a number of areas related to electrical and information engineering, prior to their engaging in small projects that reinforce the lessons learned. Topics include constructional techniques, the use of laboratory instruments, circuit simulation, an introduction to functional analysis and system modelling techniques, and considerations of manufacturability and maintainability.

One advantage of an intensive session is that students are able to concentrate on acquiring a disparate skill without distraction. Eliminating repeated set-ups for extended practical work promotes efficiency. This method of inculcating necessary, but easily neglected, skills seems so natural that it is hard to conceive of an alternative method of doing it.

Electromagnetic Compatibility

The course on Electromagnetic Compatibility (EMC) was initially developed during one of the authors' sabbatical leave in 1998 and delivered to 30 Masters students in the Electrical Engineering Department at Doshisha University in Kyoto, Japan. After modifications and academic approvals, the course was subsequently delivered in a short-course format during four days of a mid-semester break in April 2000 at the University of South Australia as an elective course for undergraduate and postgraduate students in electrical engineering disciplines. It attracted a sizeable audience of 24 undergraduates, three postgraduates and 13 industrialists, mainly from defence industry and government sectors.

The course fills a gap in electrical engineering programmes at the University of South Australia, emphasising the importance of EMC considerations in the design and use of computers, telecommunications, control, instrumentation, industrial and consumer electronics, military equipment, home electrical appliances and electrical power systems. Use of mathematics was reduced to a minimum in the course, which placed it on an introductory level. Understanding, interpretation and application of EMC standards made up an important part of the course.

Delivery methods included lectures, tutorials, a laboratory session (Electromagnetic Interference Resistant Measurements), demonstrations of EMC modelling techniques and of EMC measurements in a reverberating chamber as well as in a screened room. There was no examination component in the assessment, with three reports worth 50% and a major assignment counting towards the remaining 50%. Full lecture notes (112 pages) were made available to the participants.

The assignment was an open-ended task designed to expose the students to the design, prototyping and testing issues related to EMC practices, standards and measurements required for information technology products. The course administration was quite complex and needs to be reviewed for the next offering in 2001.

Course participants were surveyed to determine their impressions of relevance of material and depth of coverage. Responses indicated general satisfaction. Different treatment of undergraduates and fee-paying participants in providing transport for a field excursion was highlighted by some undergraduates as a significant course satisfaction issue, illustrating that getting the setting right is important. The most significant differences were in the ratings for relevance and depth. Table 1 shows differences in perceptions between undergraduates, postgraduates and industry participants.

Table 1: Relative perceptions of relevance and depth.

Population	Mean Satisfaction Level %	
	Relevance	Depth
Undergraduates	87	70
Postgraduates	66	33
Industry Participants	62	69

Providing joint sessions for non-homogeneous groups will always require careful attention to the issues of relevance and depth. In this case, the relative dissatisfaction of postgraduates and industry participants was explicable because the limited background of undergraduates restricted the coverage, which could be attempted. It was concluded that this problem could be addressed in future by providing a two-day intensive introduction for undergraduates prior to the main body of material.

Power and Energy Systems

The initial decision to offer the course in Power and Energy Systems at the University's geographically remote Whyalla Campus in intensive mode was based on lecturer availability more than anything else. The course was offered over two one-week sessions, seven hours a day, in which lectures/tutorials intermingled indistinguishably. The sessions took place during scheduled semester and mid-semester breaks. Most sessions were conducted with students sitting in front of a computer, enabling them to put new knowledge into practice straight away; this was facilitated using third party software that enabled realistic problems to be simulated and solved very early in the course. PowerPoint presentations and a plant visit provided wider perspectives. Assessment was done by way of assignments at the end of each week.

The effectiveness of the teaching/learning methodology was measured through the descriptive responses under the following headings:

- Integration of subject matter.
- Retention.
- Ease of learning/understanding.
- Teaching standard.

Respondents consistently ranked the course as good to excellent in all respects.

Students were invited to give their perception of the relative merits of this method of presenting the course compared with possible alternatives. The options were:

- Two continuous weeks of intensive learning.
- Two intensive weeks separated by several weeks.
- A series of full-day intensive sessions.
- Conventional lecture-tutorial format.

Overall, students have strongly favoured two separate weeks intensive format over the other options. Their reasons for this were:

- One week at a time of continuous study was near the limit for the absorption of knowledge; two full-time weeks would be too much.
- Two one-week sessions allowed concentration on the topic to the exclusion of all else, retention and timely re-application of material from previous day(s), ability to see material in context, accessibility of lecturer, ability to clear up problems with the whole class benefiting, the necessity for lecturers attempting this format to be truly knowledgeable, and the usefulness of assignments set after sessions in consolidating knowledge.

- A series of one-day intensive sessions would eliminate the tendency for learning fatigue but would lack many advantages of the two one-week sessions.
- Conventional, non-intensive teaching would be least exhausting, but reduces concentration, makes recall difficult, defers consideration of context and thus diminishes relevance. It also allows lecturers to evade answering questions immediately. This approach did have its supporters, though.

Factors that students identified as important to the successful use of the intensive two-week format, and conversely, factors that could seriously undermine its effectiveness were:

- Most important to the success of the intensive teaching mode is to have a knowledgeable, well-prepared lecturer. Students believed that most of their teachers would not succeed using the intensive format!
- The availability and use of software, which made lengthy, reiterative calculation transparent, was a strong factor in enabling students to concentrate on principles and practical effects of circuit and parameter variation.
- Students welcomed the frequent variation between chalk-and-talk, personal simulation exercises, electronic displays, anecdotes, *what-if* questioning, etc, which kept them stimulated, and was perceived as offering alternative explanations always progressing towards identifiable goals for each day and overall. Plainly, a monotonous or diffusive technique would be counter-productive.
- Lengthy assignments involving choice and synthesis, often with open-ended answers, were seen as reflections of real life activity of engineers and served well in consolidating concepts. Students welcomed the absence of examinations, and felt the assignments were an authentic and fair method of assessing their ability. Having to attempt vastly simplified problems in limited time would not measure achievement against the course objectives.

In post evaluation interviews with the students, the question was posed: *How has your life changed as a result of taking this course?* Many responses were technical but 50% reported improvements in generic skills and positive developments in attitudes towards their studies, their career, and their role in the community.

Offshore Delivery

The University of South Australia and the School of Electrical and Information Engineering have been active in establishing joint agreements for offshore delivery of University programmes in countries within the region. Delivery of courses has often been via two-week intensive face-to-face sessions in the host country. Factors influencing this choice have been:

- Students' comfort in their own environment.
- Cultural preferences for face-to-face teaching.
- Economics of the operation.
- Students' obligations to their employers who sponsor their studies.

In this context, it must be noted that intensive teaching poses extraordinary demands on the delivering course coordinator. The hardships are manifest in the form of exhaustive hours of preparation prior to teaching, intensive teaching in an unfamiliar environment in terms of organisational support as well as physical and cultural settings. These are compensated for by motivational factors including educational and financial rewards coupled with opportunities for exposure to advanced technological practices of multinational companies, often present at target destinations. Proof of success for this mode of delivery is provided by the increasing numbers of enrolment in many of the offshore programmes offered by the University.

Inferences of the Experiments in the Intensive Mode of Teaching and Learning

Intensive teaching and learning strategies offer a number of advantages and are particularly suitable for mixed groups of learners comprising undergraduates, postgraduates and practising professionals. However, it is necessary to be aware that participants may often have different backgrounds and expectations.

EXPANDED VISIONS

The object of the next group of educational initiatives has been to expand the vision of students by having them work in richer contexts, enabling them to gain enhanced technical insights and/or generic skills essential for the effective exercise of their profession. These arose from the following observations:

- Engineering educators have been most anxious to attract good quality students into engineering programmes and to retain them. Unfortunately, students of engineering find it difficult to cope with the rigours of engineering study.
- Students of engineering find it difficult to grasp abstract concepts. This is particularly true in electrical engineering where the underlying phenomena

are invisible, necessitating the use of complex mathematics that may further obscure physical understanding.
- There is a lack of purpose in artificially contrived final year projects. Students often seem to go through them in a perfunctory fashion, without really developing technical proficiency or generic attributes.

Specific responses by the team included a *peer mentoring scheme* to increase educational opportunities, the use of *virtual instrumentation* as an educational device, and *novel final year projects*.

Peer Mentoring Scheme

Peer mentoring is recognised as a significant and successful strategy to assist new students in making the transition from school to university. Learning from peers is a valid factor in students' cognitive development at university, but it is also an important component of life-long learning. Benefits for commencing students not only include being successful in their studies, but also developing teamwork skills and collaboration in problem solving.

Mentors can assist students in learning courses, by helping them develop study and time management skills, facilitating study groups, providing social support and being role models. They can also give useful feedback on specific learning problems to course lecturers. Mentors also benefit from these programmes as they improve their own knowledge base in courses, as well as developing communication and teamwork skills and self-confidence. Successful peer mentoring programmes have well-developed training and support schemes as fostering cooperative learning needs to be taught.

Past experiences and educational research indicate that some students are more *at risk* than others. Although there are notable exceptions, students with relatively low Tertiary Entrance Ranking (TER) results (ie less than 70 or so) and those who have already failed in the past are in particular danger. Females and overseas students often face cultural isolation, even though they may be very good students; this also presents an unwelcome risk. These factors were taken into account when targeting students to participate in the scheme [21].

The mentors were selected from those students of years two, three and four who mailed in their expressions of interest with details of why and how they hoped to conduct the mentoring. They were motivated, had good interpersonal skills and good knowledge and a grasp of first year courses. Mentors reported weekly by e-mail to the School Secretary on the work they did and progress achieved individually with all group members. Fortnightly debriefing sessions were attended by all mentors and members of the supervision team (Head of School, the first year programme director and a study adviser from the Flexible Learning Centre). Course coordinators were also invited to attend. The meetings played a very important role as a feedback mechanism for the whole programme. The mentor group constituted the School's Student Reference Team.

A total of 77 students (58 males and 19 females) were assigned to mentors. They were grouped purposely in such a way that there were at least two females and an overseas student in most of the groups. There was also a mixture of students with moderate or low TER and with high TER. We hoped that the latter ones would be able to increase the chances of academic success of the whole team. Of these 77 students, 49 (41 males, 8 females) either took no part in the programme or attended only a single meeting with the mentor. These people are referred to in the following as *non-participants*. The remaining 28 students (17 males, 11 females) attended at least two mentoring sessions, the average number being 5.2. These people constituted the group of *participants*. Data on academic achievement in the first semester of 1999 were obtained from university records for these people and the achievements of the participants compared with that of non-participants.

An interesting initial finding was that a significantly higher proportion of the females than of the males actually participated. This may reflect a stronger preference in women than in men for learning in small, socially interacting groups. In the case of academic achievement, data were available for 68 students.

Taking into account academic results in other courses, it is possible to speak of, at the very least, a clear tendency for the participants to surpass the non-participants as far as academic achievement was concerned. It was observed that both groups' average grades were very low. Even though the participants obtained better marks than the non-participants, their overall average was still in the lowest category of pass. The non-participants had an average below 50% in every course considered here, as well as overall. This suggests that, by and large, the students in this study had correctly been identified as needing mentoring.

The major single problem faced by both the old and the new schemes was the low motivation to participate of a large percentage of the student population of the first year (this problem did not exist with second year students). This could be addressed by linking attendance to assessment in targeted courses. Other approaches include a promotional campaign about the scheme and development of teamwork habits and collaborative learning approaches in first year students, both early in the academic year.

Virtual Instrumentation

Virtual Instrumentation provides a powerful tool for visualisation of invisible phenomena underlying studies in electrical engineering. The modular programming approach permits simulation at many layers of complexity, but the simple, intuitive user interface enables students to concentrate on the outcomes rather than the underlying complexity of the computing task. This has proved advantageous in enabling students to visualise and comprehend phenomena under increasing reality constraints.

One particular case is that of the study of electrical machines. For instance, beginning students of electrical machines have considerable difficulty in understanding how a rotating field can be created by passing electrical currents through a specially arranged set of stationary coils housed within the machine. The authors exploited the visualisation features of LabVIEW to create an animation tool that allows students to explore and comprehend this phenomenon at their own pace [6]. Figure 1 illustrates a Virtual Instrument (VI) used for this purpose.

Three coils are displaced in space by 120°: The VI allows the current in each coil to be specified by the user. The student is thus able to interact with the animation to investigate the effect of varying the amplitude, frequency or the phase angle of the coil currents with immediate effect. Individual coil currents, the corresponding magnetomotive forces and the resultant magnetomotive force are all displayed dynamically. When students eventually manage to set the required conditions for the coil currents, they are rewarded by the dynamic depiction of a perfectly balanced rotating field.

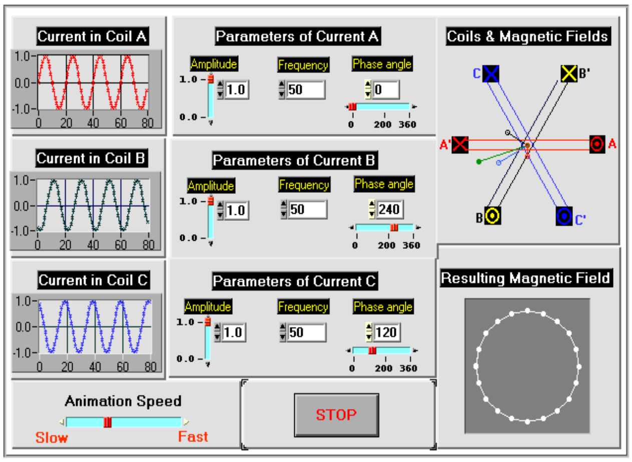

Figure 1: Virtual Instrument for depiction of a rotating magnetic field.

A further example is that of a variable speed drive. The emphasis is on the *macroscopic* system aspects rather than on intricate component details. Students are given the task of investigating the behaviour of the system, comprising a specified supply, a motor and a load. Figure 2 depicts a typical drive system simulation. The model is based on a mathematical formulation describing the electromechanical relationships governing the behaviour of the system. Guidance is given as to how to obtain such a mathematical model, culminating in a set of simultaneous differential equations. The simulator is based on equations formulated in space-phasor format in an arbitrary reference frame, rotating at ω_a.

$$\vec{u}_s^{\,a} = \vec{i}_s^{\,a} R_s + \frac{d\vec{\lambda}_s^a}{dt} + j\omega^a \vec{\lambda}_s^a$$

$$\vec{u}_r^{\,a} = \vec{i}_r^{\,a} R_r + \frac{d\vec{\lambda}_r^a}{dt} + j\left(\omega^a - \omega_r\right)\vec{\lambda}_r^a$$

$$\frac{2}{3}\Im\left[\vec{\lambda}_s^a \vec{i}_s^{\,a\,*}\right] = J\frac{d\omega_r}{dt} + D\omega_r + T_{load}$$

The simulator constitutes a powerful didactic tool allowing the student to acquire an understanding of a complex course matter much more readily than is possible by being instructed in conventional ways. The front panel of the VI allows the machine model parameters to be varied so that the sensitivity to parameter variations can be gauged. The operating

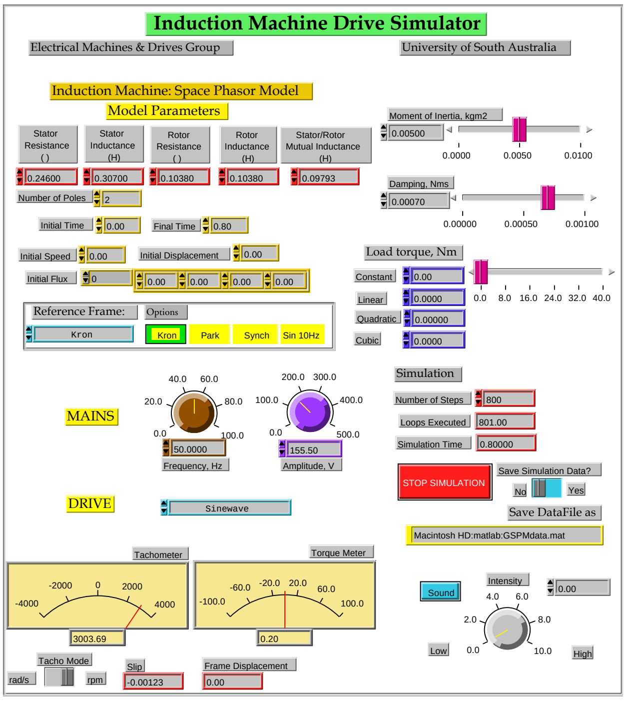

Figure 2: Virtual Instrument for the simulation of a variable speed drive.

parameters, including load characteristics and the type of supply can be changed readily. For instance, it is possible to select a supply from a range that varies from a sinusoidal mains supply to a six-step inverter. Furthermore, the VI offers alternative choices for the selection of a reference frame. Visualisation of reference frames has long been a difficulty for students but the simulator presents the results dynamically, visually and immediately.

Novel Final Year Projects

Final year engineering design project typically aims at providing students with experience and appreciation of the process of performing engineering projects in one of the streams of engineering associated with electrical and information engineering, including the specification, design and development, customer interaction and reporting processes. Students work together in teams under the guidance of an experienced supervisor and learn about the processes of teamwork [5].

There are two kinds of objectives in the course specification: technical as well as the development and exhibition of generic skills. The need to develop technical competence is obvious and all practising engineers will need skill in teamwork and effective communication [21]. However, by adroit choice of projects and innovation in the way they are managed, many other important objectives can be realised. These include, but are not limited to:

- Presentation skills;
- Time management;
- Adherence to budget;
- Commercial awareness;
- Entrepreneurial skills;
- Lessons in team dynamics.

One of the most effective means of extending student ambition and achievement is by engaging them on a project of industrial relevance. This may take the form of a project executed for an industrial client and utilising their resources, or at another extreme, a project performed at the university but with sponsorship from an industrial partner [22]. Such projects may be interdisciplinary in nature [23]. The experience of the authors is that interdisciplinary final year projects with industrial sponsorship attract ambitious and high-achieving students who feel that the open scope for problem solution will give them the opportunity to display a wide variety of skills and who find attractive the idea of going public with their work. The lessons of time management, adherence to budget and commercial awareness tend to come as the project progresses.

ADJUSTING TO THE CHANGING LANDSCAPE

The Internet revolution has changed the teaching and learning environment of education irreversibly. It is hard to imagine any contemporary academic programme without Web-based teaching and learning resources. The resources on the Web intend to cater for variation in learning styles and improve accessibility but also in very least constitute a depository of teaching materials that can be downloaded and printed by the students.

It is perceived that Web-based delivery of courses is student-oriented and caters for the ways individuals or cultural groups prefer to receive, process and present information and ideas. A case can be made that learners benefit from exposure to and use of a variety of learning styles. Certainly, the use of Web resources has become a method of choice for many students with access to the appropriate technology, which does not constitute an obstacle in this country.

Most teachers by this time have been confronted with masses of uncritically chosen and largely unassimilated material downloaded from Web sites and presented as the fruits of *research*. It is plain that students must be trained to use this valuable resource effectively; this can be achieved by integrating Web use into the mainstream academic programme in appropriate ways.

Providing administrative, teaching and learning resources on the Web makes for efficiencies and allows access to those materials from remote locations and at any time. Enhanced accessibility poses both opportunities and threats to universities and academics: improved ability to globalise one's own offerings is countered by the possibility of widespread competition. However that competition will not disappear if educators elect not to use new technology and the market surely dictates that institutions should be seen to be making intelligent use of the dominant information resource of the day.

The authors of this paper have intensively experimented with Web-based delivery and assessment of courses and programmes. These have opportunely coincided with the University's developments of the advanced Web-based educational framework, known as the UniSAnet and the student and staff support system - the Learning Connection.

Specific educational uses of Web resources by the authors include:

- Web delivery development tool: a uniform environment which provides a template for the development of consistently organised Web pages for teaching purposes, and which enables students to access them with minimal need to master new protocols. This was undertaken as a final year student project, so there are multiple layers of pedagogical interest [7].

- Experiences in teaching large classes using Web site: unlike the Project Logbook, examines the effects of using Web-based communication (see Figure 3), problem solving tutorials and simulation software with large classes of first and second year students. This is the area in which claimed efficiencies are most likely to be realised. The experimental use of Web-based delivery also focussed on the question whether deep learning could be achieved [8].
- Novel multimedia browser using server-client approach: an approach to the problem of organising data in a specific field, in this case papers on applied magnetism, so that they are readily and efficiently accessible to students and researchers [9]. The benefits are self-evident. The contribution to knowledge is in the form of the organisation, which is transferable to other topics in and outside of engineering.
- Web-based project logbook: a controlled interactive Web-based environment where students are compelled to use to mark progress and maintain dialogue with colleagues and academic supervisors [10]. This provides experience without the distraction of open-ended searching. The logbook has been evaluated for its efficacy in inculcating purposeful use of the Web and its more instrumental role in acting as a channel of communication.

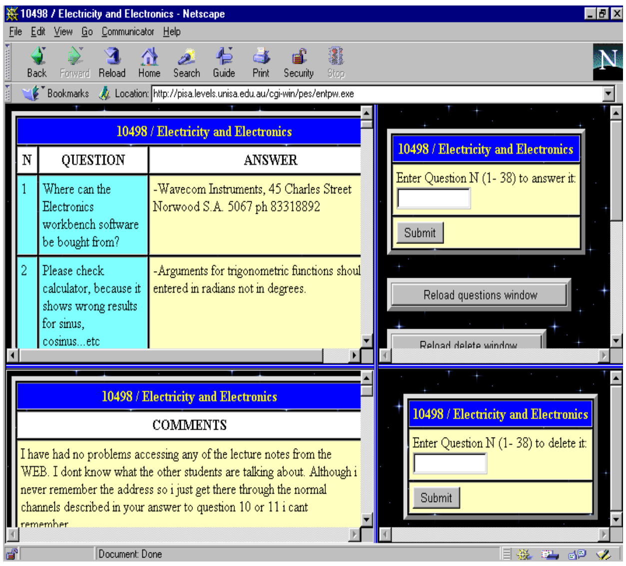

Figure 3: Restricted access page for lecturers from large class Web site.

The outcomes of the design and implementation of Web sites in the course delivery are summarised below:

- Improvement in course administration by:
  - Efficient distribution of teaching material.
  - Having an efficient information system in place.
- Effective communication that supports interaction between staff and students.
- Promotion of formative assessment opportunities through interactive tutorials.
- Setting motivational context both for students and teaching staff.
- Development of students' information literacy skills.

CONCLUSION

The authors have sought to present a sample of educational initiatives and developments from within the School of Electrical and Information Engineering at the University of South Australia. Attention has been focused on the philosophical considerations that inform the actions taken and the particular aspects of enriching students' vision, both technically and in the wider exercise of their chosen profession, and in the adoption of technological solutions to the dissemination of information and control of courses.

The experiments have generally resulted in improvements in academic performance, greatly increased development of generic skills and enhanced satisfaction for students and academics. Recourse to pertinent educational theory, particularly on experiential learning, has enabled the School to be proactive in the advocacy of active learning opportunities for students.

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BIOGRAPHIES

Andrew Nafalski's career spans over 30 years in academic and research institutions in Poland, Austria, the United Kingdom, Germany, Japan and Australia. He holds BEng(Hons), GradDipEd, MEng, PhD and DSc degrees. He is a Chartered Professional Engineer and a Fellow of the Institution of Engineers, Australia, Fellow of the Institution of Electrical Engineers (UK) and Senior Member of the Institute of Electrical and Electronic Engineers (USA). He is currently a Professor and Head of School of Electrical and Information Engineering at the University of South Australia in Adelaide.

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Kevin McDermott is a graduate of the University of Adelaide, Kettering University and the University of Southern Queensland. He is a Fellow of the Institution of Electrical Engineers, the Institution of Manufacturing Engineers and the Institution of Engineers, Australia. He has worked in the electronics, telecommunications and automotive industries before being allured to academic life in 1973. Amongst other positions, he was Chair of the Curriculum Committee of the South Australian Institute of Technology from 1988 to 1990. In 1996, he resigned from his position as Head of the Engineering Discipline and Deputy Campus Director of the Whyalla Campus of the University of South Australia.

He is currently an education and engineering consultant, an arbitrator and mediator, and Adjunct Associate Professor in the School of Electrical and Information Engineering at the University of South Australia. His major research interests are in electrical machines and drives and the education and formation of professional engineers. Most of his publications are in the area of engineering and university education. Active in professional society affairs, he is an International Membership Advisor of the Institution of Electrical Engineers.

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