OPENING PLENARY
SUSTAINABILITY IN ENGINEERING EDUCATION

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ABSTRACT

The Minister for Science, Lord Sainsbury has said 'everyone, especially engineers, should be sustainability literate.' And professional registration in the UK now requires engineers to demonstrate sustainability 'competencies'.

This speaker will discuss why sustainability should be top of every engineering educator's agenda, and how the relevant literacies or competencies might be integrated into the curriculum.

A ROLE FOR FLIGHT SIMULATION IN ENGINEERING EDUCATION

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ABSTRACT

This paper describes the developments and experience gained with the utilisation of a full motion flight simulation facility to support both undergraduate teaching and research programmes and aerospace engineering awareness activities over five years of operation of the facility.

The flight simulation facility has evolved from a research tool primarily used for Industry and post-graduate projects, to a powerful teaching aid for both undergraduate degree programmes. It also provides an insight to A-level students into the opportunities available when considering a career in the Aerospace Industry.

The methodology for developing an interactive learning aspect into existing undergraduate aerospace engineering modules is described. The facility provides a 'vehicle' to reinforce concepts introduced within a more traditional lecture structure, allowing students to investigate flight dynamics and control problems through physics based models and performing real-time piloted simulations trials.

An insight into the development of a 4th year aerospace engineering problem based learning (PBL) module, Flight Handling Qualities, is presented. The success of the module is judged, in part, on the reflective testimonies of those who have undertaken the module. A perspective on the future role that flight simulation may play in Academia closes the paper.

INTRODUCTION

The role of an Aerospace Engineering degree programme is to produce capable graduates for the Aerospace Industry. Such programmes also foster within today's school children the desire to study and work in an exciting and varied field such as Aerospace. Once committed to a degree programme, students should be provided with the opportunity and environment to develop their technical and inter-personal skills as fully as possible through challenging modules and exposure to active learning methods. A key part of this learning environment is the tool used to instil the desire for self-improvement amongst the students.

Over the last twenty years, PC hardware advances in processor power and graphics cards capability have resulted in the price of computing being halved every two years(1). This has allowed the level of processing performance and image quality required for high fidelity simulations to be accessible to smaller, less commercially-oriented institutions such as Academia. U.K. Universities have acquired a range of different flight simulators to support aerospace teaching activities. Such a system, HELIFLIGHT(2), has been in operation in the Flight Science and Technology Research Group at the University of Liverpool since September 2000 and is used for both Industry related research and Undergraduate teaching.

A significant development of the operational aspect of the facility is the use of HELIFLIGHT in undergraduate teaching programmes. New problem based learning modules have been developed and the continued growth in the number and scope of undergraduate research projects using HELIFLIGHT show the value of an integrated modelling and simulation environment in teaching. In addition, a facility such as HELFLIGHT has the potential to stimulate interest in A-level students and attract high calibre students to aerospace engineering and a future career in the industry.

The paper closes with some remarks on the future of simulation in academia and the way in which a more collaborative approach to research between academia and industry will produce more capable aerospace engineers, more fluent in modelling/simulation and concurrent engineering practice utilising a systems approach, to the benefit of the UK quality of life.

THE HELIFLIGHT FACILITY

The main flight simulation facility at the University of Liverpool is HELIFLIGHT. It is a relatively low-cost, turnkey and re-configurable flight simulator with five key components(2):

- selective fidelity, aircraft-specific, inter-changeable flight dynamics modelling software, FLIGHTLAB(3), with a real time interface (PilotStation)
- 6 degree of freedom motion platform (Maxcue), (**figure 1**)
- four axis dynamic control loading (Loadcue)
- a three channel collimated visual display for forward view, plus two flat panel chin windows, providing a wide field of view visual system (Optivision), each channel running a visual database
- a re-configurable, computer-generated instrument display panel and head up display.

The flexibility of the simulator and modelling environment lends it very well to a range of undergraduate teaching and research activities. A library of over 30 fixed wing, rotary wing and tilt-rotor aircraft are available to fly on the simulator for use in undergraduate teaching and research.

Figure 1: HELIFLIGHT 6 d.o.f. motion simulator

UNDERGRADUATE TEACHING ACTIVITIES

HELIFLIGHT has evolved from a research tool primarily used for Industry and post-graduate projects to a powerful teaching aid for both undergraduate degree programmes and pre-University education. The flight dynamics and control systems modelling aspects of industrially based projects have driven the development of high fidelity models, which are then used by undergraduates.
The current simulation environment provides the ability to create models, using FLIGHTLAB and Matlab, from physics-based components within a hierarchical model structure. The software offers the ability to assess trim, stability and handling qualities off-line, and conduct real-time piloted tests.

The growth of facility utilisation in teaching activities is clear in **figure 2**, which shows the number of logged piloted simulator hours used each year since commissioning in 2000. The hours shown do not include the more substantial time spent in off-line analysis and model development and set-up time.

The University of Liverpool is a member of the CDIO Initiative, www.cdio.org and is committed to developing its degree programmes along **C**onceive, **D**esign, **I**mplement and **O**perate guidelines and develop individual programme modules with more interactive teaching and learning. HELIFLIGHT is an excellent teaching tool that allows students to further engage with concepts introduced in a class room environment through modelling and simulation. For example, an undergraduate Aerospace Engineering module, Flight Control Systems, has been developed to take a paper exercise where a student would design a flight control system in order to stabilise an unstable aircraft and add an interactive element using the flight simulator. The students still carry out the paper exercise, but they now have the facility to ‘flight test’ their designs on the flight simulator, reinforcing what at first seems an abstract concept and adding more interaction to a previously passive learning experience.

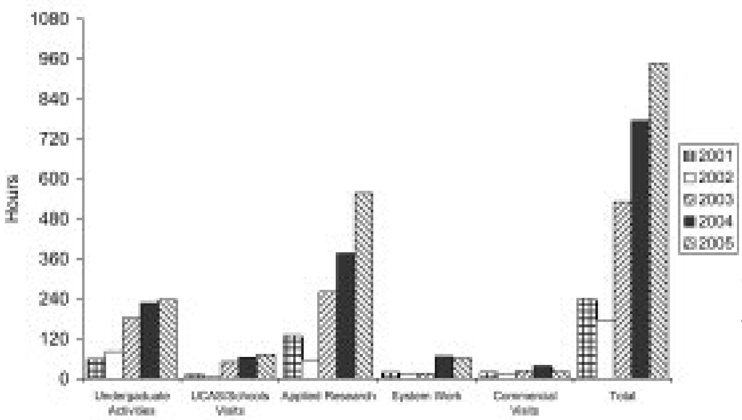

Figure 2: Annual facility utilisation

Indeed, the students have furthered the learning outcomes by creating new roles for the aircraft (ground attack, passenger transport) and assessing the ability of the controller/aircraft to carry out the role, modifying control system gains when performance deficiencies arise.

Other undergraduate modules that adopt a similar approach with the use of the flight simulator include; Flight Awareness, Rotorcraft Flight and Virtual Reality concepts in the Design and Multimedia and Architecture degree programmes.

The next sections describe two facets of the new teaching aspect of HELIFLIGHT.

Flight Handling Qualities – A Problem Based Learning Module

October 2002 saw the introduction of a new Problem Based Learning (PBL) core module into the M.Eng Aerospace undergraduate programme(3). The aim of the module is to equip students with the skills and knowledge required to tackle handling qualities and related total system problems that may be experienced in Industry. The problems were examined using a combination of off-line analysis using FLIGHTLAB and piloted simulation trials using HELIFLIGHT.

Four themes underlie PBL:

- Explore problems using background knowledge and experience
- Analyse problems and formulate hypotheses that might explain them
- Design and conduct experiments or perform theoretical analysis to test hypotheses
- Develop new understandings and formulate problem solutions.

Throughout the module the tutor acts as a facilitator rather than a teacher, encouraging useful lines of questioning rather than providing explicit answers and when appropriate provides problem solving structures or methodologies. This encourages the students to take responsibility for their own learning, engaging in active learning through critical self-reflection, self-assessment and collegial learning.

In the Flight Handling Qualities module, the aircraft with its handling deficiency becomes the focus for knowledge acquisition. This method of learning helps the student to garner transferable, technical and interpersonal skills that will serve them for the rest of their lives. The students formed into 5 Teams of 3 or 4 and each team was presented with a task of assessing and quantifying the Handling Qualities (HQs) of a particular aircraft in a particular role and developing fixes to any handling deficiencies.

Towards the end of the module, the teams presented their work to a 'Customer' (group of staff plus visiting Industrialists) with the objective of demonstrating that the aircraft was now fit for the role. In addition, each individual student was required to maintain a 'Learning Journal', in which they document the development of their understanding of handling qualities from the beginning of the module.

The focus of the Learning Journal is to record the conduct and completion of required tasks. The Journal also aims to encourage self-reflection on what has been learned and how things could be done differently. The Journal provides a rich source of information about a student's self-assessed knowledge and competence in the exercise of skills. The Journal also provides the basis of an external assessment of the student's competence in terms of their technical knowledge and understanding, intellectual skills and ability to apply these skills in practical situations and generally transferable skills, particularly relating to team-work.

Lessons learned during the early years of this PBL module have led to a number of developments. Some of the key areas are listed below;

- Setting of 'deliverable' dates; the module assessment is based on a number of key deliverables, e.g. the final report and Team presentation. It is important to take account of other course-work commitments when setting the dates for these. In particular, clashes with hand-in dates for the individual and group project reports can lead to high workload and deterioration of quality.
- What are Personal Learning Journals? Some students have difficulty with self reflection on their learning and distinguishing between knowledge and intellectual abilities. Engagement of staff from the University's Centre for Lifelong Learning has helped to reinforce the value of this aspect of the module.
- FLIGHTLAB Workshops. When these sessions occur is critical to their value – too early and the students cannot associate; too late can inhibit progress.
- The Importance of Pilot briefings. Teams need to understand the purpose of the pilot briefing and how a common understanding of what is required can save considerable time.
- Preparation for trials. Teams that are well prepared for the piloted tests and have sought the opinions of the test pilot beforehand are likely to have a successful trial; the opposite is also true.
- Dealing with Team Problems. Teams who face their technical and personal problems together and promptly usually achieve an equitable work-share. In particular, Teams experiencing problems with members not 'pulling their weight' need to deal with this in a deliberate fashion; if this does not succeed, they need to raise the problem with the module coordinator.
- Generally, students regard the FHQ module as an integrating experience, requiring hard, co-operative work in Teams to achieve the goals. The module is reviewed annually and subject to continuous improvement.

Headstart at Liverpool

Headstart is an activity of the Engineering Development Trust and forms part of the Royal Academy of Engineering's Best Programme that aims to provide high quality Year 12 (Scottish Year 5) students, who are interested in science and engineering, an opportunity to spend up to a week at University, exploring appropriate degree courses prior to making their UCAS applications. The courses are designed to demonstrate what science and engineering is about, provide opportunities to meet university lecturers, recent graduates and engineering organisations and to show that engineering is a worthwhile and dynamic career.

Since July 2003, students have been attending the Aerospace Focus programme at Liverpool, which has had a theme celebrating the Wright brothers' achievements. A simulation of the Wright brothers 1903 Flyer had already been developed in the Flight Science and Technology Research Group(4) and was used as the baseline model for testing and development. The requirement for the programme was to carry out upgrades to the baseline 1903 Flyer model to produce a vehicle which could be used as a basic observation platform, flying circular flight paths over the ground in winds up to 10kts.

In order to accomplish this, the students carried out a number of research activities to produce an aircraft with improved performance that was evaluated using the HELIFLIGHT simulator. The students operated in teams of five and worked to tight deadlines in order to produce a solution prior to presentations on the final day. The programme took the form of a number of lectures, laboratory sessions and simulation experiments:

- Planning of flight tests – students split into their teams and using the information packages provided were required to scope out a set of flight simulation tests that would highlight the handling quality deficiencies of the aircraft. Each group was required to design a flight test programme and pilot brief detailing the performance standards to be used.
- Control laboratory – although the Wright Brothers did not have access to modern control hardware, the implementation of

a simple flight control system for an unstable aircraft was permitted.

- Materials selection – a computer based exercise to allow the students to gain an appreciation for the structural issues involved with designing an aircraft.
- Wind tunnel tests – each group carried out lift/drag measurements on a Wright aerofoil section compared the results against existing data to determine which wing section will be used on any upgrades.

The laboratory exercises were supplemented by seminars on control systems, aircraft performance and the work of the Wright brothers. Throughout the programme the students had access to a test pilot, whose flight experience was invaluable to give the initial piloted assessment to the complete student body as well detailed group assessments based on the test programmes developed by each group. Significant support from members of the academic and research staff was required during the programme, especially with the implementation of model changes using FLIGHTLAB.

Although the students had not yet embarked on an aerospace undergraduate programme, they were very adept at utilising the resources available to correctly identify the major handling deficiencies of the 1903 Flyer, namely sideslip issues due to limited directional lateral control, tendency for longitudinal axis instability, asymmetric turning characteristics and adverse yaw problems.

A wide range of solutions were proposed (**figure 3**) and implemented by the different groups, who quickly determined that there is no one correct solution for fixing the handling problems presented, rather the solutions tended to be a compromise between the overall operational requirements and the amount of time available to design and test different modifications. Solutions included centring of aircraft engine, engine upgrades to other power plants the groups found on the Internet, relocation of the canard and re-design of the aerofoil sections.

A competitive edge develops between the groups who, at the end of the programme, acted as customers for other groups

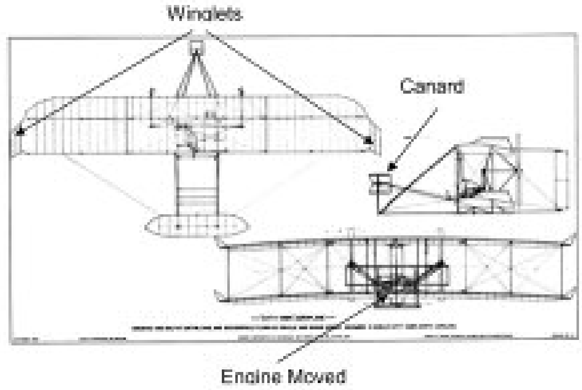

Figure 3: Suggested modifications to 1903 Flyer

upgrades. In the role of customer, the groups carried out a critical review of the final presentations on the last day, before giving out scores for technical content of the initial analysis and upgrade performance, quality of presentation and most technically feasible i.e. could the upgrades be achieved in the period of the Wright brothers.

The aim of the programme was not to assess the students' technical knowledge of aerospace problems, but to set a number of challenging problems requiring significant teamwork to develop a solution for which the group as a whole was responsible. The end result of the course was to give an insight into the type of challenges the students will face both as an undergraduate and then latter in their career, with a view to providing a positive experience which would encourage them to choose engineering. An important facet of the programme was the students enjoyed the considerable technical challenge they encountered and the HELIFLIGHT facility proved to be a valuable teaching and practical tool for the students to try their ideas on. Such facilities appear to be a good advert for attracting students to study engineering at a time when the popularity of engineering courses as a whole appears to be in decline.

UNDERGRADUATE RESEARCH

HELIFLIGHT is extensively utilised as a research tool in a large number of undergraduate projects for both fixed wing and rotary wing studies. In a typical project students are required to research the problem, use the FLIGHTLAB modelling and simulation tools, design and conduct experiments and present their results to an assessment panel. The project work complements the learning and teaching activities that take place in the taught modules. Students have embarked on projects developing simulation models to inform Industry in the design of new aircraft types (e.g. Centaur Seaplane, Fairey Rotodyne, Space Shuttle), novel display systems for flight in degraded visual conditions and more fundamental research on simulation fidelity criteria.

Access to HELIFLIGHT allows the students to draw on the technical skills acquired in the taught modules and apply them in a more practical and interactive learning environment.

A PERSPECTIVE ON THE FUTURE OF FLIGHT SIMULATION IN ACADEMIA

As has been highlighted in the previous sections, the use of flight simulation at the University of Liverpool is becoming more widespread both for applied research and as an undergraduate teaching and research tool. The PBL approach to learning is a positive step forward in producing capable graduates with the skills that are required by the aerospace industry and who can easily integrate into that environment. It is anticipated that additional teaching modules will be developed having a simulation component.

Existing collaborations between Liverpool and the Aerospace industry are important and a closer partnership between the two groups will be desirable to both parties. Cheaper and faster simulation hardware will mean that the simulation technology gap that exists between industry and academia will continue to close and it will become more economical to use academia for research with their large resource pool and expertise. In return, academia will gain access to information and tools that will strengthen their simulation capabilities.
With increasing financial demands being placed on academia, new revenue streams will have to be developed. Flight simulation expertise will provide opportunities to develop new undergraduate aerospace engineering programmes such as the M.Eng Aerospace Engineering with Pilot Studies programme planned at Liverpool. This new degree programme aims to produce a new generation of pilots with enhanced technical skills to meet future demands for pilots in the commercial civil aviation industry.

Academia is faced with a number of interesting challenges and opportunities in the field of flight simulation and it is hoped that this will inspire more students to consider a career in aerospace engineering.

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WIRELESS AND MOBILE TECHNOLOGIES TO FACILITATE PERSONALISED FLEXIBLE LEARNING IN CONSTRUCTION

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Keywords: construction, learning, mobile technology, mobile devices, wireless technology

ABSTRACT

The ever increasing use of mobile devices and continuing expansion of broadband wireless networks are creating new opportunities for integrating wireless and mobile technologies with learning. This technology, combines telephony, messaging and computing is offering a rich medium to facilitate learning anywhere anytime. Such flexibility is extremely convenient for learners particularly to those from the construction field, who will benefit from 'learn-as-you-go' way of learning as they may not always be in a fixed location. This paper defines m-learning and gives an overview of the use of wireless and mobile technologies to aid learning anywhere anytime. It also addresses the need for sharability of learning content to benefit the mobile learner in construction.

INTRODUCTION

Learning is constructive process of actions including solving problems, engaging in dialogues of enquiry and acquiring new knowledge within an environment and reflecting upon it (1). The ever increasing use of mobile devices in every day life opens new opportunities in integrating learning with mobile technologies. As a result, mobile learning has begun to evolve.

Mobile Learning (m-Learning) is e-learning through mobile devices. (2)defines e-learning as learning supported by digital electronic tools and mobile learning as e-learning using mobile devices and wireless transmission. (3)suggests that mobile devices have to be seen as an extension to current e-learning tools rather than replacing it. (4)suggest that m-learning can compliment e-learning by creating additional channel of access for mobile users with mobile devices.

Mobile devices can be used for different activities in a learning environment. An m-learning project at Ultralab is producing learning materials for mobile devices to support the learners with lack of literacy and numerical knowledge(5). LAND (Location Activated Nomadic Discovery) project at the Ultralab explores the possibility of deliver rich context aware information via the mobile devices(6). HandLeR project at the University of Birmingham has developed a mobile learning organiser with the context aware information and provides time manager for scheduling lectures and course manager for organising course materials(7).

Classroom experiences have also proven that mobile devices are able to support a wide range of learning activities such as brainstorming and writing(8). Wireless and mobile technologies were used to create a mathematic classroom where pre-algebra students used mobile devices to explore and learn about mathematical functions(9).

The emerging wireless technologies and standards provide the necessary medium for facilitating on-the-move learning. There are number of wireless technologies with different ranges and speeds of data transmission. This paper defines learning objects and m-learning and gives an overview of the use of wireless and mobile technologies to facilitate learning anywhere anytime. It also identifies the relevant technologies to support learning in a wide range of environments and proposes the idea of integrating wireless technologies to promote 'learn-as-you-go' way of learning in construction.

SHARING CONTENT USING WIRELESS TECHNOLOGIES

Content is the core of learning activities and also expensive to produce. Content can be divided into small chunks of learning that are defined as learning objects. The notion of learning object came from the object-oriented paradigm of computer science where objects can be reused. According to(10), a learning object is a digital learning resource that facilitates a single learning objective. It may be labelled, reused and mixed or matched in different learning contexts. Current research with learning objects are much concerned with the metadata and content packaging aspects. There has been a significant research done in developing sharable learning objects with pedagogical elements(11).

Sharing knowledge and expertise through the exchange of learning objects is one way of enabling education via the use of wireless and mobile technologies. (4)argue that before one can judge and evaluate m-learning, learning objects suitable for mobile devices need to be ready and used in mobile environment. There are number of wireless technologies and standards available with the different characteristics in terms of speed, range and protocols. Bluetooth technology can be used to set up a Personal Area Network (PAN) which then can be used to create a personal learning environment at home. It is widely used to share and exchange documents and files and can also be used for sharing learning objects between educators and learners in a classroom environment. Short range of connectivity and device-to-device transmission make Bluetooth unsuitable for a large learning space. However Wireless Fidelity (Wi-Fi) offers the flexibility of connecting multiple computers together wirelessly. It can be used to create wireless classrooms where learners and educators could share learning materials over the wireless network.

Global Positioning System (GPS) is a satellite navigation system used for determining precise location of anyone. It enables learning resources to be offered to suit learners' learning needs and preferences. 3G is a third-generation mobile telephone technology which provides the ability to transfer both voice data such as phone call and non-voice data such as downloading video, exchanging e-mail, and instant multimedia messaging. It can be used to access and retrieve rich, multimedia learning objects from mobile devices. Worldwide Interoperability for Microwave Access (WiMAX) is a point-to-multipoint broadband wireless access technology. This technology can be used for anywhere anytime learning as it provides wireless broadband connection up to 30 miles from a single point.

Wireless technologies can play part in helping learners to access learning history, download learning objects and communicate with educators and tutors. Mobile devices with the wireless connectivity enable creation of learning spaces wherever needed. The next section explores existing mobile technologies and devices and their capability of accessing content anywhere anytime.

ACCESSING CONTENT USING MOBILE DEVICES

The objective of using mobile devices whether it could be a simple mobile phone or a powerful laptop in learning environment is to access and retrieve learning tools and objects from anywhere anytime. When learning becomes mobile, the learning content should interoperate with various types of mobile devices in order to enable sharability and reusability. While laptops and tablet PCs usually cope with e-learning content produced for desktop computers, smaller hand-held devices such as mobile phones are not capable of viewing such learning objects. Thus, we need to consider mobile devices' characterises and requirements before producing learning objects for mobile learning environments. Learning management systems and learning object repositories need more information the devices where the learning objects are to be delivered.

(12)sees the m-learning as a way to change the learning activities brought by the possibility to access all the information that is available through internet. The unique feature of mobile technologies is the portability. It also provides context-aware information based on the user location. Personalised services will be essential to offer unique experience for mobile users. The vision of mobile computing device is that portable computation, rich interactivity, total connectivity and powerful processing. (13)identify five properties of mobile devices that produce unique educational experiences.

- Portability – the dimension of the mobile devices in terms of size and weight
- Social interactivity – interaction with other learners for sharing information and collaboration
- Context sensitivity – mobile devices can use the context information such as location, time and environment to provide context-aware resources
- Connectivity – mobile devices can be connected to other devices and networks using wireless technologies
- Individuality – learning can be personalized to suit individuals' need and preferences

The above features make mobile computing as a powerful tool which has much to offer to support a wide range of learning activities. There are different types of mobile devices currently available such as mobile phones, smart phones, personal digital assistants, laptops, tablet PCs and game consoles. Each device has different functionalities and provides unique experiences. Some devices have smaller screen where users often find it difficult to scroll through multiple screens of information and to enter large amount of text(14).

Mobile and smart phones have text displays, very limited storage and low bandwidth. They now equipped with built-in Bluetooth functionality which enables learners to access and share learning objects with other learners and devices. Bluetooth enabled phones and devices have the ability to create personal learning space wirelessly at home or work. They are already used to provide educational materials for young people with the literacy problems(5). Personal Digital Assistants (PDAs) have graphical interfaces, low processor speed, limited storage capacity and moderate bandwidth connectivity. However, with built-in Wi-Fi, it can be used to connect intranets at work and other wireless hotpots at public places. A learning organiser is developed for PDAs with the context aware information using GPS to provide time and course managers for scheduling lectures and organising course materials(7).

Laptops and tablet PCs have graphical user interfaces, high processor speed, large storage capacity and high bandwidth connectivity. Wi-Fi and Bluetooth connectivity can also be found on these devices which enable users to connect intranets and internets anywhere within the Wi-Fi range. Laptops and tablet PCs equipped with the 3G data card can be used to connect internet from anywhere anytime via cellular networks which in turn facilitate the 'learn-as-you-go' way of learning.

Thus, these devices offer unique experiences in order support classroom instruction and on the job training. The next section identifies the flexibility of using wireless and mobile technologies in different learning environments and explores how these facilitate anywhere anytime learning.

HOW TECHNOLOGIES FACILITATE ANYWHERE ANYTIME LEARNING

The mobile communication devices provide flexible learning solutions with respect to learners' needs, preferences and goals. There are number of research projects which are carried out to investigate the potential use of mobile devices in learning. A study by(15) evaluates the use of PDAs as a tool for reading course materials in a distance learning settings. Another study by(16) who aimed at delivering rich, multimedia learning content to PDAs evaluates the interactive multimedia applications created for adults to use on PDAs. They suggest that these technologies combine with communication and networking capabilities of mobile devices provide more holistic learning environments and collaborative and sociable learning experiences. Limited bandwidth and responsiveness requirements are the most important problems posed by mobile applications in supporting learning.

The emerging wireless standards and technologies promise the availability of higher bandwidth of data transmission over long distance. Mobile devices also now equipped with more processor speed, additional

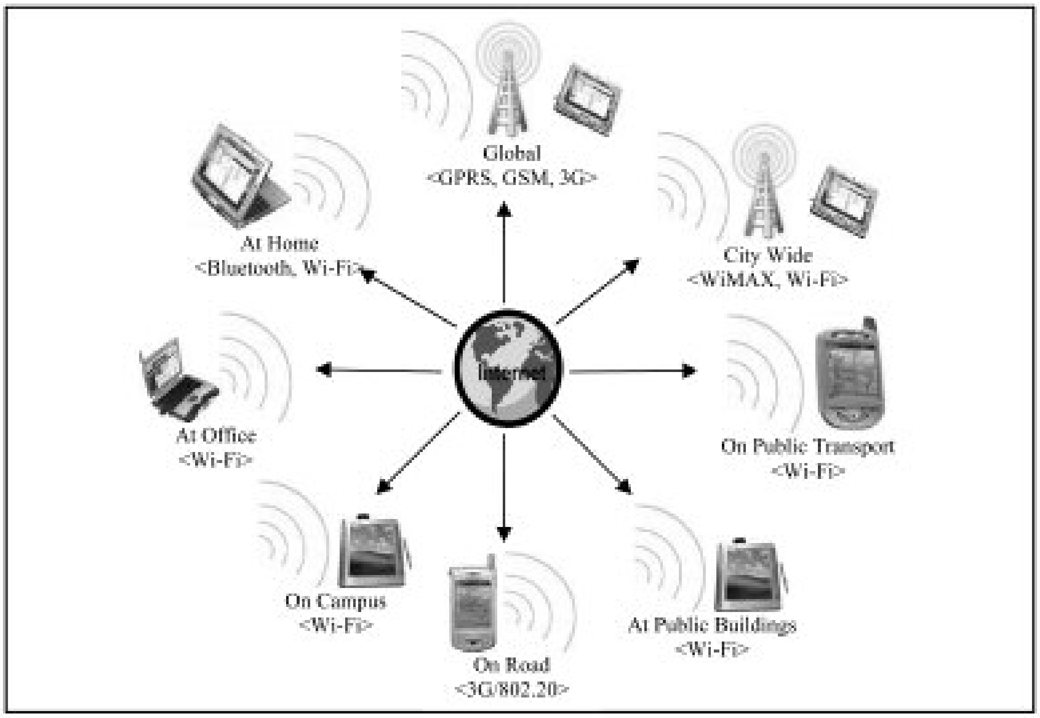

Figure 1: Anywhere anytime learning with wireless technologies

memory and external storage capacity which provide the necessary requirements to run rich learning applications. **Figure 1** shows how the wireless and mobile technologies facilitate learning in different learning environments. The following section explores the possibilities of supporting learning in geographically spread areas and identifies the technologies that facilitate such learning in construction.

ANYWHERE ANYTIME LEARNING IN CONSTRUCTION

Construction industry is in continues demand for graduates with intellectual and practical skills. It also needs to promote Continuous Professional Development (CPD) for its employees to identify their learning needs, assist in career progression and to encourage enhancement of knowledge and skills. However, competitive nature of the industry and the pressure it faces for delivering targets on time make it difficult to continually send its employees for daily courses in order to gain CPD. Therefore, this cause for the need for flexible learning environment that makes them learn from anywhere anytime. The enabling technologies such as wireless and mobile technologies overcome these problems whereby learners can access learning materials and communicate with instructors from anywhere anytime.

WiMAX will enable communications beyond the physical building constraints encountered with Wi-Fi. Although WiMAX has not yet configured through mobile devices, it could soon offer wide range of opportunities to enable learning anywhere.

Figure 2 shows how the emerging WiMAX technology together with the Wi-Fi creates a wireless space where construction offices and sites can be connected wirelessly. Construction sites and offices which are located within the reach will able to access the wireless broadband anytime. Learners who are located at construction sites and offices are able to use wireless broadband to access learning resources over the internet and also can participate in a wide range of learning activities from work places. They could able to create virtual collaborate learning spaces with other learners and instructors via the wireless and internet technologies which enable them to learn in a rich virtual learning environment.

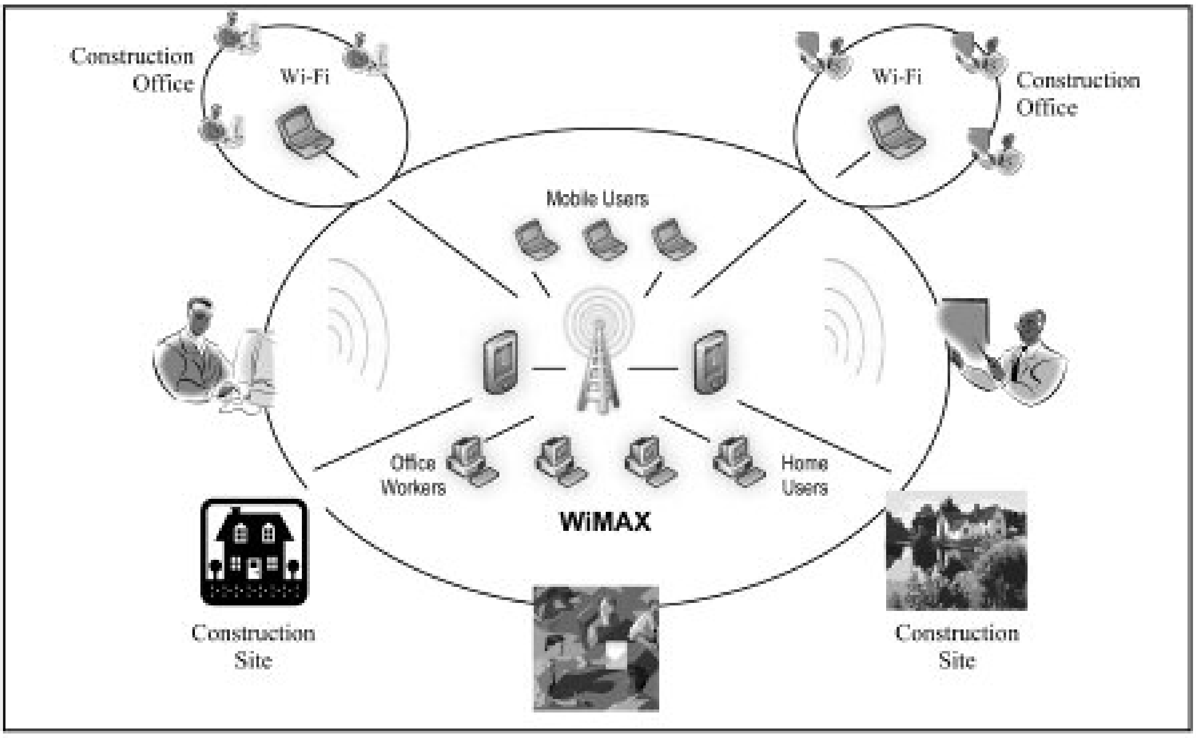

Figure 2: Anywhere anytime learning in construction

CONCLUSION

Wireless and mobile technologies allow real-time, convenient interactivity and data transfers with other networks without the need for a cable and physical connection. These technologies allow construction learners to be located at various places within construction sites and communicate with each other as well as with instructor over the wireless networks. WiMAX networks provide superior range of connectivity and bandwidth which let construction personnel always be connected with internet and corporate network. WiMAX can be integrated with Wi-Fi in order to extend its range and bandwidth to support a wide range of activities on site. Wireless and mobile technologies enable creation of personalised learning environment where the information and learning resources suit to learner's particular needs, goals and preferences.

There are some limitations with the thin mobile clients such as PDAs and smart phones which have smaller screen and less processing speed. The major challenge of delivering learning objects to such thin clients is delivering appropriate contents which suits to that particular device. In the near future mobile devices will have the capability of retrieving and displaying most of the learning contents which will facilitate learning anywhere anytime. Further work will focus on the development of case studies to enhance CPD in the subject of project management using the technologies described in this paper.

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THE USE OF GENERAL PURPOSE SOFTWARE AS A TEACHING TOOL IN ELECTRONIC ENGINEERING

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ABSTRACT

In engineering education, it is widely accepted that practical experience aids and reinforces students' understanding. In recent years this practical experience has often been focused on specialist high-level computer-aided design and simulation tools, enabling rapid and efficient designs and simulation results to be obtained. However this approach often restricts the in-depth understanding of the students, due to the sophisticated and specific nature of the software. Furthermore, it may often be the case that the software used does not have all of the required functionality, and can be prohibitively expensive for the students' personal use, thereby preventing students from developing their experience outside the regular scheduled classes.

The authors have found that by encouraging students to use general purpose software, namely a spreadsheet program, simulation results can be developed directly from the equations and mathematical models covered within the basic theory. As well as widening access to such simulations by using widely available software, this approach allows effective graphical output, including useful animations, to be readily obtained, and thereby enhances the students' understanding and appreciation of the concepts.

This paper describes the authors' use of this approach for a number of different application areas within electronic engineering, including passive and active filter circuits, digital systems, artificial neural networks, and analysis of continuous-time and discrete-time signals and systems.

INTRODUCTION

In technical education, student learning of concepts is enhanced by teacher demonstrations and hands-on practical experience and experimentation on the part of the learner. A number of software packages, such as PSPICE, CODAS and MATLAB, are available which can readily produce quick results for a wide range of technical areas covered within a typical electronic engineering curriculum. Whilst such packages are clearly valuable in engineering education, they can, in some cases, be counter-productive, and can lead students to rely on such software to generate solutions without fully understanding the underlying concepts. In this paper the authors present, and discuss their experience with, the use of spreadsheet software in the presentation of technical material within taught engineering programmes. The authors have developed and used this approach in the delivery of several modules, at all levels, in undergraduate engineering courses. In each module where this approach is used, students are guided through the construction of a spreadsheet incorporating the basic mathematical models representing a particular concept. Example spreadsheets are made available to the students, and discussed within the lectures so as to clarify the implementation of aspects of the theory within the spreadsheet. Students are then encouraged to develop their own simple simulations directly from the appropriate theoretical models presented in the lectures and course notes. The easily accessible graph plotting facility available within the spreadsheet software then enables simple access to various types of graphical description, which can be made interactive and animated using macros activated by on-screen buttons. As well as encouraging the students to develop their understanding by producing simulation results from the theory, the use of generally available, standard software makes this approach readily accessible to a significantly wider audience than is currently the case when using specialist software. This paper includes a section which briefly discusses the development of the spreadsheets, and further sections which present several examples covering technical material from a range of modules within electronic engineering courses. The examples presented in this paper include passive and active filter circuits, digital systems, artificial neural networks, and continuous-time system analysis (s-plane analysis). Further spreadsheets in these areas and others have also been developed by the authors (Varley *et al*. [1], Peak *et al*. [2]).

SPREADSHEET DEVELOPMENT

In this section, a brief explanation is given of how Microsoft Excel spreadsheets (Liengme [3]) are created and used to produce dynamic graphical results. The example presented in **Figure 1** simulates the simple AC theory application of a passive filter. The first few rows of the spreadsheet are used for parameters which may be varied by the user, such as (in this example) resistor (R) and capacitor (C) values, frequency range limits and a sample frequency value. The appropriate formulae are evaluated for many different analysis parameters (in this case, this corresponds to a 1001-row table evaluating the component voltages for different frequencies over the specified range), and are then plotted. Figure 1 shows a screenshot of the spreadsheet with the plots reduced in size so as to make the table of calculations, normally hidden behind the plots, visible. Macros are used to implement repeated processes enabling dynamic display: in this case a macro selects successive rows from the 1001-row table and plots the voltages as a moving phasor diagram, and as a moving marker on the frequency response plots. These macros may be activated by clicking on-screen buttons which control the operation of the spreadsheet. Simple colour coding is employed to enable identification of different areas of the

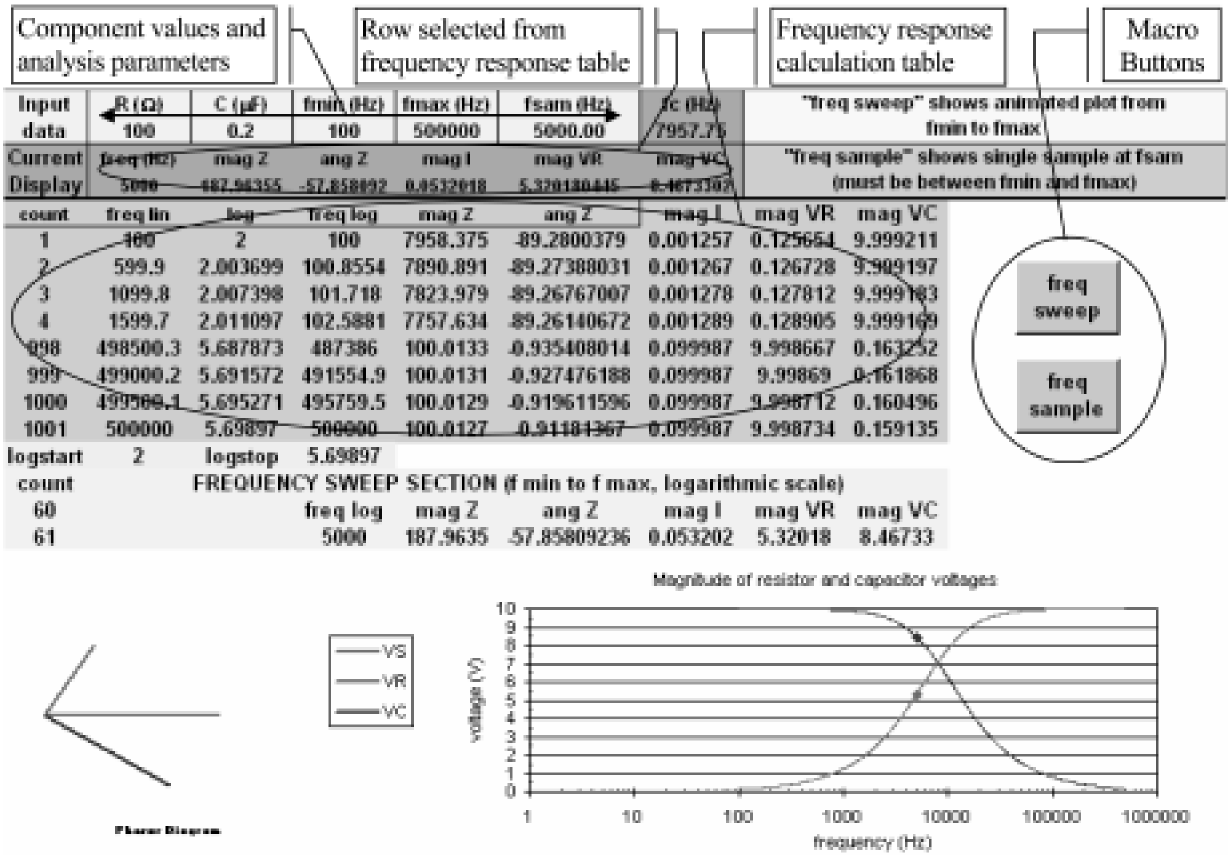

Figure 1: Example screenshot showing different areas of the spreadsheet (2)

spreadsheet and plots, corresponding to different types of parameters and results.

SPREADSHEET SIMULATIONS FOR APPLICATIONS IN ELECTRONIC ENGINEERING

This section presents selected applications from a number of modules in undergraduate degree courses in electronic engineering and related areas. Spreadsheets are introduced to the students at an early stage during their first year, for example for simulation of aspects of analogue electronic circuit theory and basic digital electronics within level 1 modules. The students' knowledge and experience are further developed by using spreadsheets in the level 2 modules 'Signal Analysis and Processing' (to aid the explanation of areas including s-domain system analysis and Fourier series), and 'Artificial Neural Networks' (in which the training of single neurons and of various neural network models is presented). Further spreadsheet analysis is included in the level 3 module 'Digital Signal Processing', where this approach effectively demonstrates concepts including digital filters, z-plane analysis, and the chirp z-transform.

Analogue Filter Circuits

This section describes the use of simulations to explain and enhance understanding of AC circuit theory and
analogue filters. The AC theory part includes resistor-inductor (RL) and resistor-capacitor (RC) networks, phasor representations, and resonant (RLC) circuits. The example shown in **figure 2** presents the simulation of the response of a series RC circuit over a range of input frequencies. In this circuit, the voltage across the resistor increases, and the voltage across the capacitor decreases, as the input frequency is increased, due to the decreasing capacitive reactance. Figure 2 shows a screenshot of a spreadsheet which evaluates and plots the magnitude of the voltage across each of the two circuit elements, R and C, over a range of frequencies. A colour-coded phasor diagram shows the phasor relationship between the supply voltage V_s, the resistor voltage V_R and the capacitor voltage V_C at a specific frequency f_{sam}, or over the frequency sweep range f_{min} to f_{max}. The frequency response plots are also marked at the sample frequency, or the current frequency in the sweep. The frequency sweep or the single frequency sample are selected by the on-screen macro buttons. The user can specify the values for R and C, and the frequency

Input data	R (Ω) 100	C (μF) 0.2	fmin (Hz) 100	fmax (Hz) 500000	fsam (Hz) 5000.00	fc (Hz) 7957.75	"freq sweep" shows animated plot from fmin to fmax
Current Display	freq (Hz) 5000	mag Z 187.963549	ang Z -57.8580924	mag I 0.0532018	mag VR 5.320188445	mag VC 8.46733016	"freq sample" shows single sample at fsam (must be between fmin and fmax)

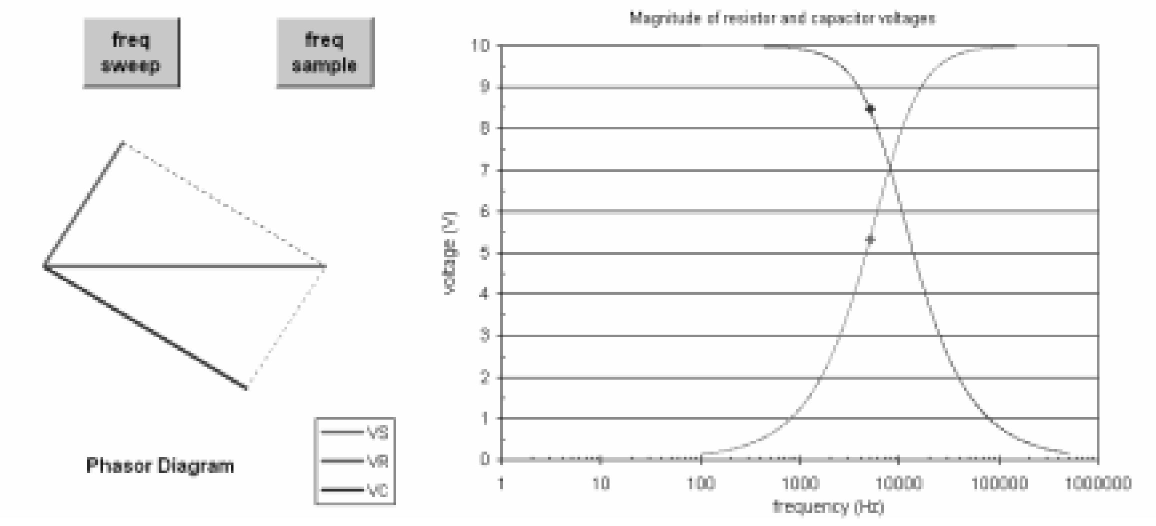

Figure 2: Frequency response analysis and phasor diagram for RC circuit (2)

values f_{min}, f_{max} and f_{sam}. Following in-class development of this spreadsheet, the students are encouraged to develop similar spreadsheets for RL circuits and series resonant (RLC) circuits.

Digital Systems

Simple combinational and sequential logic systems readily lend themselves to simulation using spreadsheets. The example shown in **figure 3** is the simulation of a Moore state machine (Yarbrough [4]) implementing a single-digit binary coded decimal (BCD) up/down counter. This state machine has ten valid states representing the ten decimal digits, requiring the use of four separate bistable elements. In this example, four D-type flip-flops are used, and the next-state logic is specified such that the counter is self-starting (all unused states having a direct or indirect path to one of the ten states representing the valid BCD digits). The design and simulation also include an output logic block, which decodes the four flip-flop outputs to drive a seven-segment display, also simulated within the spreadsheet. A single-bit input specifies whether the counter counts up or down, and on-screen macro buttons enable the user to toggle the input between 0 (down-count) and 1 (up-count), and apply a clock pulse to the system to initiate a state change. Along with other examples, this material may be used to present combinational and sequential logic systems. Students can readily simulate Boolean expressions and thereby confirm the validity of their designs.

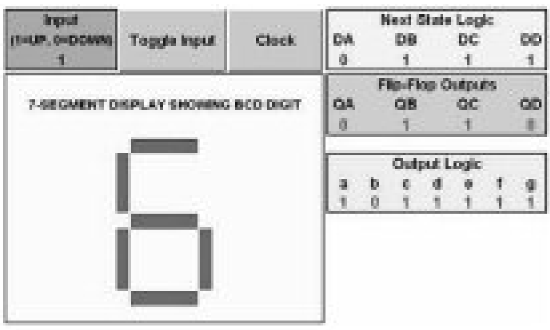

Figure 3: Simulation of BCD up/down counter with 7-segment display

Artificial Neural Networks

The authors have developed several spreadsheets to demonstrate various concepts presented within the level 2 module ‘Artificial Neural Networks’, including: training algorithms and decision space visualisations (2-dimensional and 3-dimensional) for single McCulloch Pitts (MCP) neurons, the error back-propagation training algorithm for multi-layer networks, and the design and analysis of Hopfield (single layer) networks (Picton [5]).

The spreadsheet simulation presented in this section illustrates the training of a single MCP neuron with three binary inputs using the delta rule training algorithm. The neuron’s output is binary; an output of 1 or 0 defining ‘firing’ or ‘not firing’ respectively. The function of the three-input neuron is defined by the neuron’s three weights W_1, W_2 and W_3, and its threshold T. Training is implemented by sequential application of a defined set of training patterns (known as the ‘training set’), with each pattern specifying the three input values and the required output R. The weights and threshold of the neuron, and thereby the function of the neuron, are updated as defined by equations (1) and (2):

$$W_i(new) = W_i(old) + \alpha\rho X_i \quad (1)$$
$$T(new) = T(old) - \alpha\rho \quad (2)$$

where is a user-specified ‘learning rate’, and ρ is the difference between the required output R and the actual output F, i.e. $\rho = (R - F)$, for the current input pattern. The sequence of training patterns is restarted after applying a pattern for which ρ / 0, and thus training is complete when R = F for the final training pattern, since this can only occur when $\rho = 0$ for all patterns.

The function of a three-input MCP neuron at any stage of training can be represented as a 2-dimensional plane (known as the ‘decision plane’) in a 3-dimensional input space. The spreadsheet implements the training of the three-input MCP neuron using the user-specified training set, initial weight and threshold values, and learning rate ?. The initial values of the weights and threshold are copied to the working part of the spreadsheet using the ‘RESET’ macro button. The ‘STEP’ macro button single-steps the algorithm (i.e.

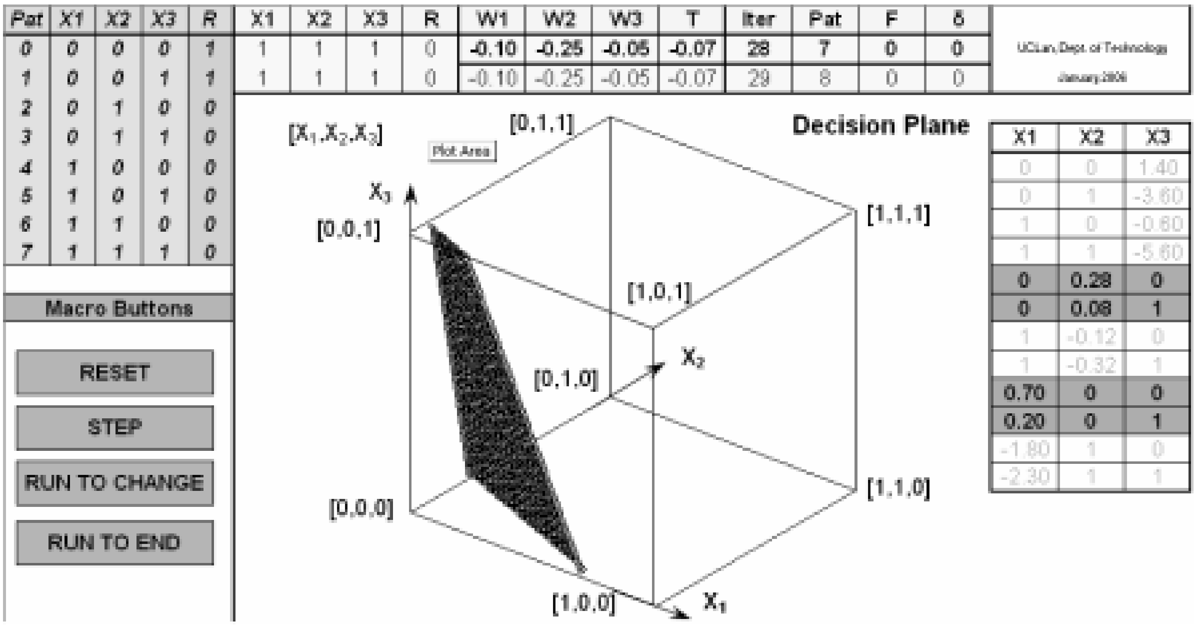

Figure 4: MCP neuron training using the delta rule training algorithum

one training pattern is presented and processed), whilst the 'RUN TO CHANGE' macro button presents a number of training patterns up to the next point where the weights and threshold are changed. The 'RUN TO END' macro button resets the system, and then runs the algorithm until training is complete. **Figure 4** shows the completed training of the neuron, trained to perform the specified logical function. This spreadsheet-based approach has the clear advantage over a procedural programming language such as C, and neural networks software packages such as MATLAB Neural Networks Toolbox, of allowing the students to see the training process iteration by iteration and the corresponding changes in the decision plane position as training progresses, and thereby enabling them to readily assess the effects of different starting conditions and learning rates.

Continuous-Time Signal and System Analysis

The level 2 module 'Signal Analysis and Processing' develops the ideas introduced at level 1, by using spreadsheets to illustrate areas including s-domain analysis and Fourier series representations. The example presented in this section is for active filter analysis, in which the user may specify an s-domain transfer function H(s) in terms of up to four poles p_i and four zeros z_j (magnitude and angle), and its scale factor K. The pole/zero locations are plotted on an s-plane diagram. If the user requires less than four poles and/or zeros, then some poles and/or zeros may be disabled by specifying an angle greater than 360 , in which case these poles/zeros are ignored in the subsequent analysis. Frequency analysis is carried out in the s-domain using the distances between the poles/zeros and the frequency point of interest (on the imaginary axis in the s-plane) for the magnitude response, and the angles from poles/zeros for the phase response. These distances and angles are displayed as dp1, dz1, angp1, angz1 etc., allowing students to check their manual calculations against the spreadsheet results.

The example shown in **figure 5** illustrates the response of a 4^{th} order Butterworth band-pass filter (Sedra and Smith [6]) with cut-off frequencies of 1 kHz and 4 kHz. Three plots are shown: the s-plane diagram, the magnitude response and the phase response. As with the AC theory example discussed above, frequency range and frequency sample values (f_{min}, f_{max} and f_{sam}) may be specified and on-screen macro buttons used to select analysis for a single frequency f_{sam} or for a sweep from f_{min} to f_{max}. Markers are shown on the s-plane and frequency response plots to

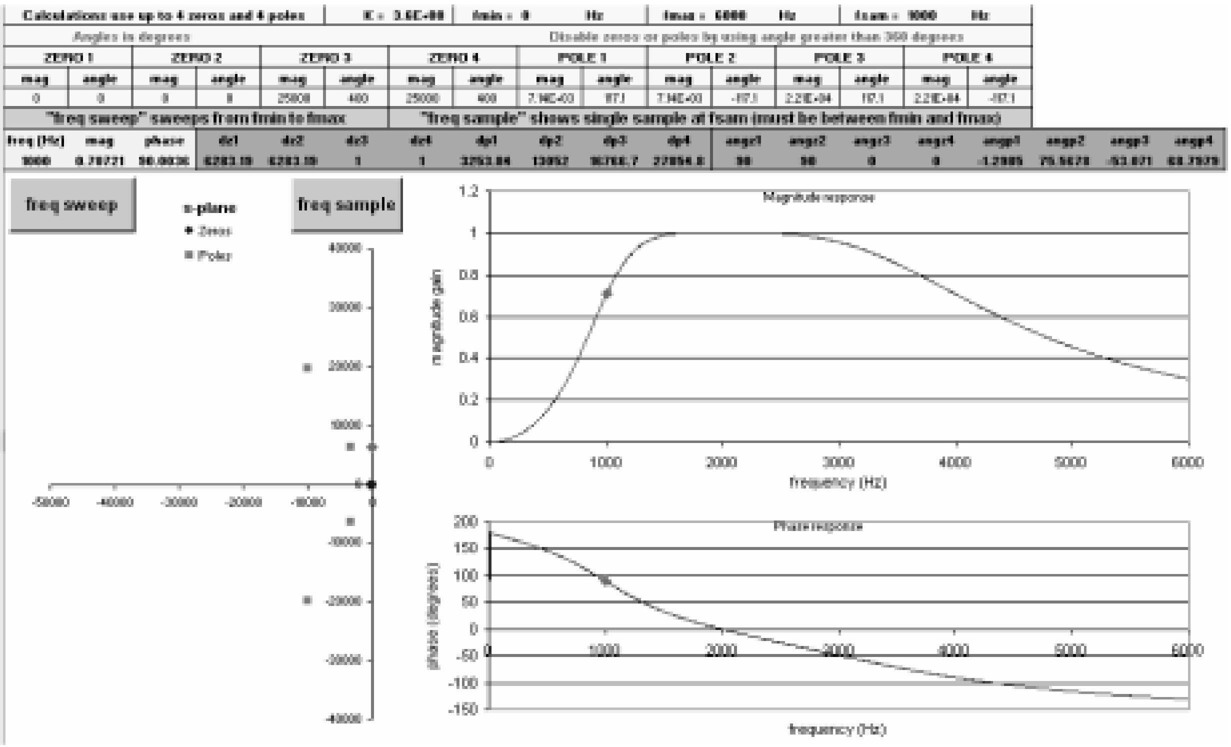

Figure 5: Analysis of Butterworth band-pass filter using s-plane poles and zeros

indicate the frequency value for analysis. Students are encouraged to experiment with this spreadsheet for investigating the topics and examples covered in lectures, and to develop similar spreadsheets to investigate other s-domain systems. The follow-on level 3 module 'Digital Signal Processing' uses a similar approach to develop spreadsheet-based simulations of z-plane analysis and design, including digital filter implementation and analysis, and chirp z-transform analysis.

CONCLUDING REMARKS

This paper has presented a discussion of the use of spreadsheets for a number of different application areas within electronic engineering, along with some technical content of the applications and illustrative screenshots. The authors have used this approach across several modules and other application areas, and found it to be helpful and constructive across all levels of undergraduate study. The easy access to animated graphical descriptions encourages students to develop their own simulations, and helps them to gain a deeper and more complete understanding of the theory. The use of specialist high-level design and simulation tools is still maintained, and complements this spreadsheet-based approach.

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USING THE INTERNET TO DELIVER AUDIO TECHNOLOGY

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ABSTRACT

Whilst the use of the Internet is now common-place as a means to teach a range of subjects, this project at Glasgow Caledonian University utilises the Internet as both a delivery method and as a topic of the syllabus being taught.

In association with Coatbridge College, one of the University's partner colleges, this project aims to

- *investigate the technologies and techniques that can be used to deliver and develop audio technology over the Internet.*
- *develop an appropriate system and programme to allow collaborative working in audio over the Internet.*
- *evaluate the efficacy and impact of the resultant system*
- *explore the effects of students at an FE college being exposed to University level teaching*

Whilst only at the initial stages the project aims to show that the technology used has the potential to open up this expanding area immensely for the wider audio technology education community, particularly in Scotland where remote communities can now have the potential to be fully integrated into future teaching programmes.

INTRODUCTION

Glasgow Caledonian University and its partner Coatbridge College, a local FE college, have an established track record of providing high quality education in audio technology and production at undergraduate level over the last 12 years.

Students who complete an HND in Sound Production at Coatbridge College can articulate into the 3rd year of one of two BSc (Hons) Audio Technology Degree programmes which are currently available at the University. As with other education providers both institutions now make extensive use of the Internet as a method of distributing educational materials to students, including the use of Virtual Learning Environments (VLEs)(1). What however has been missing across FE and HE education has been an attempt to place the teaching of audio technology and production techniques within the context of using the Internet.

The University and Coatbridge College have now embarked on a joint project, which aims to equip students with a detailed knowledge of the Internet and how it works, in the context of professional audio recording. Therefore as well as learning about production techniques and the use of the Internet to deliver audio, students will have the opportunity to participate in remote recording sessions whilst being 10 miles apart on the site of their respective institution.

The importance of fully understanding the operation and capabilities of computer networks by professionals in the audio industry was reinforced by the results of a survey carried out of recent graduates from the Audio Technology degree programme at the University. In the survey almost 70% of graduates stated that the knowledge and skills that they gained from a module which covered how computer networks and the internet worked, proved to be useful or very useful in their subsequent careers. Anecdotal evidence further suggests that employers within the audio and in particular the broadcast industries were showing a keen interest in the computer networking skills of any new graduate.

ARTICULATION ISSUES

The issues regarding articulation between Further Education (FE) and Higher Education (HE) have been well documented, both in a generic sense(2,3) and in the particular curricular area of audio technology(4).

To briefly reiterate the evidence suggests that the key to a successful and seamless transition between FE and HE depends on

- high levels of specific support both at pre-entry and during the programme of study at HE
- a good match between the FE and HE syllabuses.

The resultant support mechanisms are fairly generic in nature, which is to be expected as students' problems during articulation are generally the same regardless of their programme of study.

The seamless match between the FE syllabus and the HE syllabus is maintained by the close links that staff at the University have with colleagues in the FE sector including Coatbridge College.

One problem of a modular programme such as the BSc (Hons) Audio Technology that is on offer at Glasgow Caledonian University is that students study subjects such as computer networking as part of a group that will involve students from other programmes, such as computer engineering or multimedia technology. Feedback from students suggest that where possible they prefer to have their learning of general technologies such as computer networking contextualized into the area of audio.

With the advancement in networking technology it is now possible to carry out remote recordings using industry standard technologies, which gives artists and engineers the opportunity to collaborate in a way that was impossible only a few years ago.

Building on these technological advances this project aims to provide prospective degree level students experience of Higher Education, rooted firmly in the context of their area of interest. For those already studying in Higher Education the project aims to contextualise their studies within their main area of interest, namely audio.

AIMS OF PROJECT

The project will allow students to record musical performances from remote locations. For BSc (Hons) Audio Technology students at Glasgow Caledonian University this will allow them:

- to contextualise their learning of networking technology within the specific area of audio technology and production;
- to continue to develop their audio production skills in an innovative environment.

For HND Sound Production students at Coatbridge College the project will allow them:

- to be exposed to more advanced levels of technology than is currently in their curriculum;
- to enhance their production skills in an innovative environment

Recording studios at both locations will be equipped with technology to allow transmission and reception of audio over the Internet. In addition further communication networks will be established as required to allow recording sessions to take place.

TECHNOLOGY BACKGROUND

The audio industries have used remote recording technology extensively based on Integrated Services Digital Network (ISDN) technology(5). With the advent of the Internet, the transmission of audio for domestic purposes is now commonplace, examples include Internet radio and more recently Podcasting(6). As a result the professional audio industry had begun to use the Internet for high quality feeds as a replacement for ISDN.

Rocket Networks were the first company to offer the technology to allow remote recording over the Internet in the late 1990s. However the

Internet at that time was unable to provide an acceptable Quality of Service(QOS)(7,8) at an acceptable cost to the end user, As a result Rocket Networks went out of business(9), another example of a good technology at the wrong time. As with a number of cutting edge technologies, it was not that the service wasn't desirable but had been offered at the wrong time at the wrong price.

With the advent of a more reliable Internet service and easier access to high speed connections, the professional audio industry is now beginning to seriously look at the possibilities that the Internet offers to carry out remote recordings and work collaboratively over the Internet(10). The possibilities that the Internet can offer to the professional audio industry have already been discussed at length elsewhere(11) and demonstrated on a number of occasions(12).

These demonstrations have however limited themselves to one off situations. What so far has not been attempted is to use such technology in an educational context and with such regularity.

BENEFITS TO STUDENTS

What essentially is proposed here is that students will collaborate on audio recording sessions with students from another institution.

In using industry standard tools and software it is intended that the students can use the opportunity to expand and develop skills that they are acquiring as part of their studies, but gain experience and knowledge of the latest networking technology and practices. As mentioned earlier this is key, as it deals with that issue of contextualization which is often expressed by students. Although attempts are made to tailor the materials covered, it is often not possible to fully embrace the full possibilities of such technology in their field of interest for logistical reasons.

Also central to the experience will be the exposure that HND students will gain to the higher order skills expected of university undergraduates, primarily that of reflective practice. The advantages and benefits of being a reflective practitioner are well documented(13). In this project the students will be asked to reflect on both their experiences of using such state of the art audio tools and also to reflect on their educational experience.

HND students at Coatbridge College will also be exposed to the teaching methodology and philosophy employed at a University, which will better prepare them for the transition to degree level studies after their HND studies should they choose to do so.

It also broadens the students' exposure to other potential opportunities within the audio industries, which their HND studies might not cover given its vocational focus on gaining the skills and knowledge to operate as a sound production technician within the music and audio industries.

EVALUATION

Students of both institutions are well versed in the use of a Virtual Learning Environment (VLE) as part of their educational experience.

Consequently is it planned to use a VLE as part of the evaluation and reflective process. Using the discussion forum facilities it is planned to assess the student's experiences of the educational situation by means of a semi structured discussion on a forum. It was felt that an open ended discussion could be too challenging to HND students with limited experience of reflection in action. Therefore the discussions will take place centred around questions posed by tutors, to try and elucidate the student experience as fully as possible

On the technical front, in an attempt to ensure that innovation stays to the forefront of the project, it is intended that the students will complete a wiki detailing the operation of the recording sessions and the technology involved. The uses of wikis in education are many(14,15) and in this case the creation of what is essentially a student written online manual is felt to provide ample opportunity for students to clearly express their understanding of the process involved in remote recording. In using a wiki the authors aim to ensure that the project makes full use of the available technologies.

Wikis as text books/manuals are becoming more common with perhaps WikiBooks being the most high profile(16). Clearly a difficulty with allowing students to create their own manual is that they might get some of the details wrong or misinterpret their actions in some way. Therefore tutors involved in the project will monitor the creation of the Wiki manual and edit contributions as and when required. Clear feedback will be given to the students to indicate if an error or misinterpretation has taken place.

WIDER USE

In this pilot study the authors are aware of the potential for such a system to be rolled out to a wider national and international audience. In the case of Scotland such a facility has great potential for the many areas that are geographically distant and difficult to reach. The UHI Millenium Institute, which is a network of colleges within the Highlands and Islands of Scotland provides a good example of the use of computer networks to bring educational opportunities to those communities that previously have been disadvantaged(17). The Scottish Executive is also very keen for communities and business in rural areas to have access to high speed networks(18). This project will show the opportunities that such audio technology can present to the business community in rural areas.

CONCLUSIONS

Although at only the pilot stage the authors believe that this project can have an impact on the learning experience of students on vocational programmes in audio technology, both at HND and degree levels. Both HND and degree students will have the benefit of their generic technology education contextualized within audio using the latest technologies.

Similarly it is expected that students on both programmes will be better supported in the transition between programmes as a result of their involvement in this project. This adds to the list of other support mechanisms that the University and the college already provide and which have proven to be very successful.

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