DEGREE EXTENSION FOR TECHNICIANS (DEFT)

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Abstract

The Degree Extension for Technicians (DEFT) programme addresses a particular niche in Irish engineering education by offering qualified technicians (currently working in Irish electronics industry) an opportunity to undertake, principally via the Internet, a flexible learning programme leading to a professional engineering degree. This paper addresses the various aspects that make such a mode of learning appropriate to the programme and also looks at the motivation behind the decision to develop a new virtual learning environment (VLE) in-house. The paper also documents the implementation of a challenging project schedule which brought the DEFT programme and VLE to fruition over a 10-month period. The current status of the project, together with experiences to date, conclude the paper.

Key Words
Remote learning, Internet, engineering education.

1. Introduction

The benefits of Internet-based education have been clearly documented elsewhere. Specifically, they focus on the flexibility and facilities inherent in this medium, including:

1. Integration of computing and communications facilities [1],
2. Self-paced learning [2],
3. Many different routes to access the same information [3], though this can cause some confusion [4],
4. Ideal medium for continuous professional development [5],
5. Easy provision of computer-based testing for instant feedback [6,7], and
6. Freedom from discrimination [8].

However, several disadvantages of Internet-based education have also been identified, including:

1. Loss of the interpersonal skills of the instructor [9],
2. Lack of gestures and movements which add to the educational experience [10],
3. The missing positive aspects of classroom competition, and
4. The difficulty in self-pacing and retaining motivation.

The main motivation behind the development of the DEFT programme in its current form has been the good 'score' obtained in matching the characteristics of DEFT against the benefits of Internet delivery, as listed above, while retaining the possibility of minimising any disadvantages. In particular, DEFT is specifically aimed at mature learners, therefore mitigating disadvantage 4. In addition, one of the further drawbacks of Internet-based education is the difficulty in including practical content in educational programmes. DEFT addresses this directly by having sufficient on-campus laboratories, which also helps to address drawbacks 1 to 3 above. Furthermore, the authors believe that an Internet-based medium is ideal for engineering education, which typically requires significant computing power, graphical capabilities and uses a variety of computer aided design and simulation tools. Internet-based learning can easily integrate these featured with the educational medium and the communications with the host university.

A major decision on the DEFT programme was to develop a new virtual learning environment (VLE). Given the wide variety of VLEs currently available commercially, this might seem like a surprising decision, but was essentially due to the cost (and cost structure) of commercial VLEs, coupled with the availability of in-house expertise. However, one of the major challenges of the DEFT programme was the project management and software project management required to bring DEFT to fruition in a 10-month period. This, together with the novelty of DEFT (and its particular match with the advantages of Internet-based education) and the rationale for (and development of) a new VLE, provide the main contributions of this paper.

The paper is laid out as follows. The DEFT programme is described in Section 2, while the VLE is documented in Section 3. The implementation of DEFT and the VLE, including project planning, is outlined in Section 4, with the current programme status and intended developments given in Section 5. Finally conclusions are drawn in Section 6.

2. The DEFT Programme

The DEFT programme provides flexible access to the content and degree qualification of the existing BE (Electronics) degree at NUI Maynooth for diploma-qualified technicians who wish to continue in full-time employment while upgrading their professional skills and qualifications. The two essential objectives of the programme are (i) to provide a high quality learning experience (and degree qualification) for the students while also (ii) maximising the flexibility of access and scheduling for the students.

While DEFT is an educational service directed primarily at the prospective student pool, it also seen as a service for the electronics industry, which currently experiences and predicts continuation of a shortage of skilled engineers [11]. At the same time, companies would prefer not to lose productive time from employed technicians while filling the higher skills need. DEFT offers a solution to this dilemma and also offers a means by which companies may reward valued technician employees by supporting their participation in DEFT. Many major electronics industry representatives have enthusiastically supported the DEFT programme.

Target students are typically in the age group 21 to 35 and have identified a career progression need for qualification upgrade while at the same time being encumbered by domestic and social requirements to maintain a full-time salary income. Working hours are sometimes long, sometimes irregular and in many cases are worked in 24-hour, three-shift patterns. Considerations of geography alone often dictate no other possibility for accessing part-time continuing education.

The full-time BE degree at NUI Maynooth has been structured in a modular and semesterised format since its inception. In the DEFT context, modularity is essential for allowing the desired flexibility of scheduling for students. The modular nature of course content also facilitated step-wise and prioritised conversion of content from lecture-style content to e-learning style. It is important to note this point, viz. that the development and relatively rapid implementation of the DEFT programme described here was greatly facilitated by the existing modularity of the full-time degree on which it was based.

The full-time BE degree is a four-year programme and the DEFT programme allows direct access to content of years 3 and 4 for electronics technicians who have received a suitable grade at diploma level. DEFT students are allowed to choose their own schedule of module-study over a two to four year period, subject only to the particular sequencing conditions of some modules (Table 2.1). Practical module requirements such as Industrial Work Experience (3rd year of full-time degree) and 4th year project are fulfilled in the students' workplace. Typically, it is expected that most students will choose a schedule to complete the programme in three years.

Code	Module Description	Co-/Pre-requisites
SEMESTER 1		
GE301	Signals & Systems	
GE302	Embedded & Real-time systems	**GE304**
GE303	Computation & simulation	
GE304	Complex analysis & vector calculus	
EE301	Analogue & Power electronics	
EE302	Electromagnetics & Electromechanics	
GE401	Digital Signal Processing	**GE306**
GE402	Computer & Communications n/w	**GE301,GE303**
EE401	Control System Design	**GE301,GE303**
EE402	ASIC Design & Architecture	**GE302,EE301**
GE404	Management Practice	**GE305**
SEMESTER 2		
GE305	Project Planning	
GE306	Modulation & Coding	**GE301**
EE403	Microwave & RF	**EE301,EE302**
CE402	Computer Control Systems	**GE301,GE303,EE401**
CE401	Adaptive & Intelligent Systems	**GE301**

Table 2.1: DEFT Programme Taught Modules

For prospective students who did not hold the specified grade of diploma for direct entry to DEFT, a preliminary course and assessment in Mathematics was prepared, with admission to the full programme being conditional on passing assessment. This Foundation Mathematics course was designed as an assessment mechanism as well as acting as a re-orientation and re-awakening to the rigours of academic study for students who have been absent from this activity (for more than 10 years in some cases).

In the initial realisation of DEFT, on-line delivery of the programme modules has been synchronised with the on-campus degree delivery of the same modules. This approach was adopted somewhat reluctantly as it restricts the DEFT students' choice, i.e. each module is available on-line through the period of only one semester in the year. However, this significantly minimises extra resource requirements from lecturing staff in the provision of course leadership including tutorial support, laboratory supervision, assignment corrections and examinations. Here, the overall objective was to try to achieve a satisfactory balance; on the one hand the desire was to maximise flexibility for the student, on the other hand delivering a quality service demanded that the Department staff would not be overloaded. This is particularly a danger in the initial year.

Synchronised delivery of on-campus and on-line modules also brings the benefit that both sets of students may sit the same examination, thus reinforcing the relationship between both programmes, an important factor for student and accrediting body. Further, laboratory set-ups are utilised by both sets of students through the same period and do not require all-year set-up.

The requirement for practical laboratory sessions provides a challenge to one primary goal of DEFT, viz. remote study. Obviously, a practical subject such as Engineering requires that some subjects include hardware laboratory exercises and these sometimes require student attendance in a dedicated laboratory. In the first instance, all modules were reviewed to identify the optimal number of such laboratory sessions. In achieving this, it was agreed that students would be asked to acquire their own copies of MATLAB®, the mathematical simulation tool; then, some practical exercises in suitable subjects, which would otherwise have been undertaken in a laboratory, were re-configured to be undertaken as MATLAB® based assignments. The DEFT students carry out these assignments in the home or workplace according to a prescribed schedule and submit the results report via the web-based VLE. Where a practical exercise is not transferred to MATLAB® or other pc-based or home-based format, student attendance in the laboratory is required. Such required laboratory attendance has been optimised at an average 6 to 8 sessions per semester (depending on student choice of modules in a semester). With such small numbers of laboratory sessions it is possible to facilitate students' scheduling requirements through provision of evening time sessions and allowing multiple separate exercises in one student campus visit.

Monitoring and assessment of progress is a crucial factor for remote students who do not have the classroom or peer-group setting to support this and DEFT addresses this issue by means of on-line quizzes and forums for all modules. Forums are considered particularly important for developing a feeling of community among the remote students. It is well accepted that a feeling of isolation and lack of support mechanism is one of the main causes of remote student disenchantment and eventual drop-out [12]. Each DEFT module has its own announcements forum where lecturer announcements are posted and a discussion forum moderated by the lecturer. There is also a global forum covering non module-specific topics.

3. The DEFT Virtual Learning Environment

During the inception and elaboration of the DEFT project the following key VLE requirements were identified:

1. Good support for equations and diagrams throughout the VLE, but particularly for interactive tests. This was critical for delivering technical engineering subjects.
2. Comprehensive statistics collection for feedback and customization of modules
3. Easy to use and with interface that aided instructor productivity, e.g. batch upload of test questions.
4. Flexibility to experiment with novel teaching methods as needs developed.
5. Reasonable initial and ongoing costs. License costs which scaled with the number of student users were not desirable.

Commercial VLE products from WebCT [13] and Blackboard [14] and four freely available VLEs were evaluated against the requirements. The commercial products were eventually rejected on the basis of inadequate equation support, limited flexibility and perceived value versus cost. None of the open source solutions was sufficiently complete to be used without additional software development and their user interfaces were unsatisfactory.

The feasibility and costs of developing a proprietary VLE were also evaluated. Using an open source VLE as a base on which to build was rejected as technical evaluation of the implementations suggested that very significant reimplementation would still have been necessary. Nevertheless it was determined that a proprietary VLE could be developed for a reasonable cost with all the important requirements satisfied. An in house VLE has the added benefit of being an enabler for further e-learning research and experimentation and can be enhanced with new features on a time scale compatible with Department needs. Figure 1 depicts the main features supported by the DEFT VLE and their organization within the web interface.

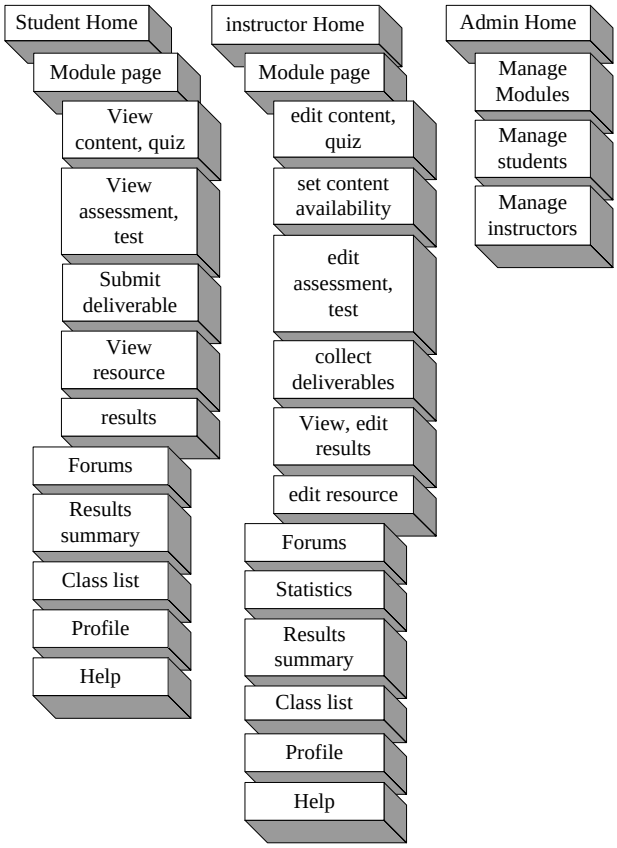

Figure 1 Main Pages of DEFT VLE

3.1 User Interface

The user interface was designed as an easy to use web interface which allows access to all significant features using as few clicks as possible.

Material for each module is logically divided into self paced content (corresponding most closely to on campus lecture material), assessments and resources (additional web sites links, media, documents and other downloads).

A common problem with e-learning is that a student may skim material rather studying it in sufficient depth. The VLE allows the instructor make availability of content conditional on date or on demonstrating sufficient knowledge of earlier material via a self assessment quiz. The latter approach (an interactive multiple choice, multiple answer test which does not contribute to student grade) is preferred as it gives students more flexibility in their study schedule. The self assessment quiz can also be used by students for self assessment and revision at any time.

Development of the combination of self assessment quiz, content ordering and conditional availability of content proved to be a particularly time consuming aspect of the development effort. Several iterations were required to stabilize on a user interface which was intuitive and aided instructor productivity.

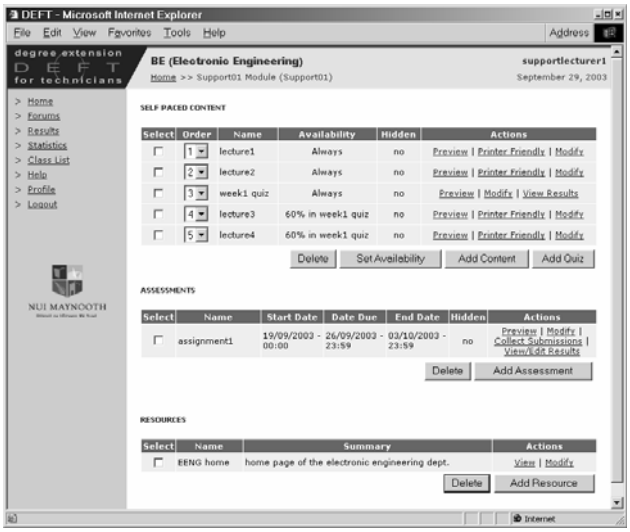

Figure 2 Instructor Module Page

The VLE supports two broad assessment mechanisms: test based assessments and document based assessments. A test based assessment is very similar to a self assessment quiz except that the resulting mark automatically contributes to the overall grade of the student. These may be used by instructors as an alternative to on campus class tests with the proviso that they are unsupervised and should hence be designed as open book tests.

A document based assessment, corresponds more closely to a traditional assignment. Managing assignments (and particularly student submissions) is often time consuming and troublesome. The VLE provides a virtual drop box which is a significant improvement on alternatives such as email. The drop box confirms time of receipt to both students and instructors and simplifies collection of deliverables for instructors. This feature may be used to streamline the management of on campus modules in addition to remote DEFT modules.

Both students and instructors may view results at any time. Students may view a summary over all modules or detailed assessment results. In each case a class average is displayed (subject to a minimum class size) to give the student feedback on their performance relative to the class. Instructors can view the results by module, assessment or student to identify potential problems.

Finally the VLE supports and encourages two modes of student-student and student-instructor communication: discussion forums (public) and email (private).

3.2 Architecture

The VLE is a conventional web based application with the client interface provided by an ordinary web browser. To ensure a robust and reliable platform the following widely used open source components were used in its construction: Linux, Apache, MySQL and PHPBB. The VLE itself was implemented using the PHP language. Indicators of the VLE complexity are: 17 database tables, 85 files and 14338 lines of code.

4. DEFT Implementation

At the initial stage in the DEFT life (early 2002) the opinions of various industry and education representatives were canvassed through various contacts including a workshop organised on NUI Maynooth campus. The universally enthusiastic response encouraged further feasibility study under the headings of prospective student numbers, student interest, available technology, Departmental resource requirements, funding. The project was given the University imprimatur to proceed in December 2002, with a view to going live at start of semester in September 2003. Figure 4 shows the organisation put in place to realise the delivery of the DEFT programme. The Gantt chart of Figure 3 shows the planned (and realised!) schedule of work with major work modules identified.

The VLE development was managed by NUI Maynooth staff and executed by in-house staff supported by external contract software developers. The intention, which has

been fully realised, was to develop a commercial quality product serving all anticipated early needs while providing an open platform for further development and research within the Department. The product requirements specification was developed with reference to existing commercial products as well as anticipated modes of use established by canvassing academic staff. The development followed an Agile programming process that turned out to be especially suitable to the dynamic nature of the requirements specification, with regular iterations of an integrated system with subset functionality (10 in total). This approach has paid off in the feature richness and quality of the final product.
With the development group operating as a quasi-independent project team, the remainder of the implementation group advanced other aspects of the project. As a new programme, DEFT required University academic approval and liaison with the Engineering accreditation body, the Institution of Engineers of Ireland. Start-up costs funding was secured from the University and the state funding body, the Higher Education Authority, under the National Training Fund.

Marketing of the programme took place mostly through the months of April to June through advertisement in the national press and direct contact with major employers, initially those in the immediate locality. The outcome of this activity has shown that the active support of a major employer provides a strong boost to numbers of prospective students. As we proceed in future years, and with the confidence of experience, we will focus more marketing effort on major employers, on a national scale. A key point in developing the programme beyond an immediately local service is the facility to have practical laboratory sessions local to the student. This is envisaged to be realisable through cooperation with partner colleges, and possibly major employers, for provision of local laboratory facilities and tutorial support.

This project was the first venture into e-learning for most of the academic staff of the Department and it was important that all staff should appreciate the issues associated with it. A not-insignificant concern was the extra effort required to generate high-quality e-learning content, with estimates of preparation time being up to 5 times greater than that for classroom delivery [3]. Also, to ensure a high-quality student experience, it was deemed important that the content should not just be a linearly delivered electronic book but rather a richer, multi-media supported interactive experience, while at the same time having no desire to overwhelm the students' senses with too many "bells and whistles". Training seminars for academic staff were organised to develop these issues and to encourage a commonality of understanding and approach among staff members.

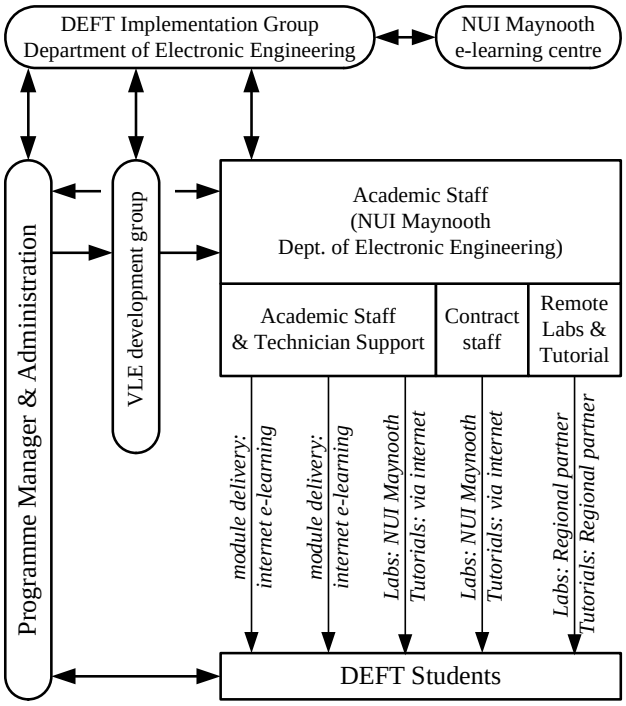

Figure 4 DEFT Implementation Organization

As for lecturers, this is the first distance e-learning

Work module	person-weeks
Programme feasibility	6
VLE development - feasibility, specification	8
University approval and financing	4
Go-ahead decision	
VLE development - build & test	54
Marketing - PR, brochures, industry visits	6
Administration - academic, entry reqts., fees	6
Training - lecturers	3
Content preparation	various
DEFT Launch	
Post-launch VLE refinements	18

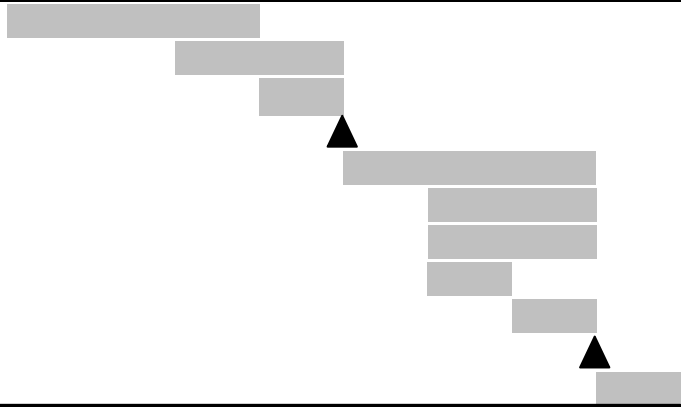

Figure 3 Schedule of Work

experience for most students. Students were given an orientation session shortly before start of term, which included tips on e-learning practice, overview of the VLE and encouragement to avoid isolation through participation in forums and maintaining email, telephone and visiting contact with peers and department staff.

In summary, the project implementation required developmental activity across a range of disciplines and functions. While the VLE development was the largest single activity, this was matched by extra developments in other functional areas such as administration, marketing and e-learning practice.

6. Current Status and Future Plans

The DEFT programme went live on 22nd September 2003 with its first cohort of students. The VLE, complete with all core features, was fully tested and available for upload of content by lecturers one week prior to launch. Lecturers and students are so far very satisfied with its functionality and usability.

Further VLE developments currently underway include refinements to administrative features such as statistics collection and export. Also, the package is being prepared for automated installation and adaptation to other programmes. After this, development will explore opportunities for even better quiz support, more multi-media content and uses of instant messaging and other features for "virtual classroom" improvements.

In the next year it is hoped to expand the enrolment to DEFT of students throughout Ireland. As described in section 2 this depends on the establishment of regional partners for provision of laboratory exercises and, possibly, tutorial services. It is not anticipated that this will be a problem. In future years this model may be extended to an international scale.

With the freeing-up of start-up resource commitments, it will become possible to offer increased flexibility to students, if required, by offering all modules in all semesters, i.e. not forcing a synchronisation of delivery of DEFT and on-line modules.

Conclusions

The generation of an Internet-based educational programme presents a significant challenge, in terms of establishing the organisation, administrative and educational structure, in addition to generating the content. However, by tight project management, coupled with a programme which has high Internet suitability and some in-house software expertise, such a programme can be successfully devised and delivered. Only time will tell if the user experience will be as positive as that of those that devised the programme!

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