Remote Access Education of Machine Vision Engineers via the Internet

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Abstract

The aim of this paper is to discuss the issues involved with the development and implementation of an on-line postgraduate course in *Computer and Machine Vision* for remote access students. Significant opportunities exist for the development and introduction of such on-line postgraduate courses. This is especially relevant for students who wish to pursue postgraduate qualifications, or to update their skill base, while continuing with their career. While remote access education would not be considered by the author as the delivery method of choice for the majority of an engineering student's educational needs, there will always be niche educational demands that can be addressed by such an approach.

Although the electronic presentation of course notes via the Internet is becoming more common place, the ideas outlined in this paper go beyond this basic concept. The emphasis of any remote access based educational technique has to be on the interaction between the tutor and the students, and not on note presentation. It is the author's view that the approach taken is novel, and one which has attracted interest from other universities wishing to implement remote access teaching.

1 Introduction

Significant opportunities exist for the development and introduction of on-line postgraduate courses for remote access students. Studying a course via the Internet means that the student can communicate with their tutor and fellow classmates via e-mail, electronic conferencing and a host of World Wide Web (Web) tools, submit their assignments via e-mail, and participate in electronic tutorials from home. This educational method requires a high degree of motivation and maturity on the student's behalf. Therefore it is more suitable for postgraduate and senior undergraduate courses. This is emphasised by the fact that on average a third of those who enrol in general distance education programmes never complete the course [Stryker, 1995].

A key element of the strategy for the use of the Web for remote access teaching is the high degree of interaction between the course tutor and the students. The technical difficulties in implementing any strategy must also be addressed. Other important design factors outlined in this paper include the educational effects of remote access teaching, maintenance of material, running examinations and coursework assignments, the use of automated review questions, practical implementation issues, legal and intellectual property control concerns. The cost structure of the proposed solution, both to the end user and the course provider, is also discussed.

The work outlined is based on the successful running of such a remote access course, namely *Computer and Machine Vision (EE544)*, during the academic year 1996/1997. This course ran as part of a pilot phase of the *Remote Access to Continuing Engineering Education* (RACeE) initiative at Dublin City University (DCU). A key motivation behind the RACeE programme, was the need for key research laboratories within the School of Electronic Engineering to transfer the specialised skills associated with these laboratories to industry and to educate students in these respective research areas. This phase of the RACeE initiative has had a small number of students undertaking the *Computer and Machine Vision* course on a 100% remote access basis. The majority of these students are drawn from a number of multinationals based throughout Ireland. There are two options for people

wishing to take this course. Under the *Full Course* option the student will fully participate in the course (including coursework and examinations) and would partially fulfil the requirements for the *M.Eng./Grad. Dipl. in Electronic Systems* degree offered by the DCU. The second option excludes coursework and examinations, and is suitable for those who wish to update or expand their skill base, without adding to their qualifications. See Section 3 for more details.

This paper will report on the conclusions of this pilot phase, and discuss some of the issues that have arisen during the running of this course. The approach outlined builds on many of the ideas outlined in MIT's recent report on *Education via Advanced Technologies* [Penfield & Larson, 1996].

2 Implementation: Access, Action and Interaction

The key elements of the on-line education strategy adopted by the author are *access*, *action* and *interaction*. Access refers to the ease of access of the student to the course material. The technology adopted by the course provider should not be so advanced that the general computer user cannot use it. The access should be intuitive and be capable of running on an average computer connected to the Internet. The student should not be frustrated in the learning experience by the poor use of technology. To ensure that this was the case, the on-line course was tested using a range of Web browsers on a basic configuration PC (i486), connected to the Internet via a commercial Internet service provider, using a 14.4K baud modem.

Action refers to the student's ability to implement the ideas outlined in the course remotely. This specifically refers to student assignments. Many of the traditional assignments may have to be redesigned to account for the fact that students will be running simulations or design tools over the Internet, or alternatively software should be made available to the students to download and run locally.

The final element, interaction is vital for any on-line educational strategy to work. A dynamic must exist between the student and the course tutor. Lack of such a dynamic will cause the student to feel isolated and frustrated and possibly abandon the course. There is a wide range of techniques to help foster student interaction. Techniques such as mailing lists, direct communication, posing questions/issues which will force students to contact fellow class members or the course tutor and encouraging remote access students to communicate amongst themselves.

Key to this model is the concept that the remote access course runs in parallel with a full-time, conventional version of this course. Full-time students attend lectures as normal, but they also have access to all the on-line material used by the remote access students. All course material and general class notifications, such as assignment deadlines, are presented to the full-time and remote access students via the Web. Full-time students are also encouraged to use the mailing list as an additional means of asking questions or resolving issues relating to the course. This has the advantage of allowing remote access student's converse with those students taking the course in the traditional way. Having a mixed peer group of remote access students and traditional full time students helps remote access students feel less isolated and encourages greater interaction. This combined with weekly class updates helps the remote access student keep in touch with issues raised during the course of the traditional lecture. Previously archived weekly updates and frequently asked questions and responses are also available to all students.

2.1 Detailed Course Design

When the student enters their username and password they are presented with the course main index, Figure 1. This page is colour coded to ease the student's navigation through the course material. The main index will point the student towards basic information about the course, such the course syllabus, a list of course texts and a reading list. Links to software utilities, such as postscript viewers, are also included. This ensures that the student can quickly access the utilities suitable for their local machine. The *Coursework Materials* link contains all the necessary material for the assignments. This includes the MvT (Machine vision Tutorial) software development environment developed at the Vision Systems Laboratory at Dublin City University [Whelan, 1996a]. MvT contains many of the algorithms

that are discussed in the course notes, thus allowing implementation of the complex issues discussed throughout the course [Batchelor & Whelan, 1997]. The MvT scripting facility simplifies this process by enabling students to develop software programmes using English like expressions. A wide collection of sample images is also provided to the student.

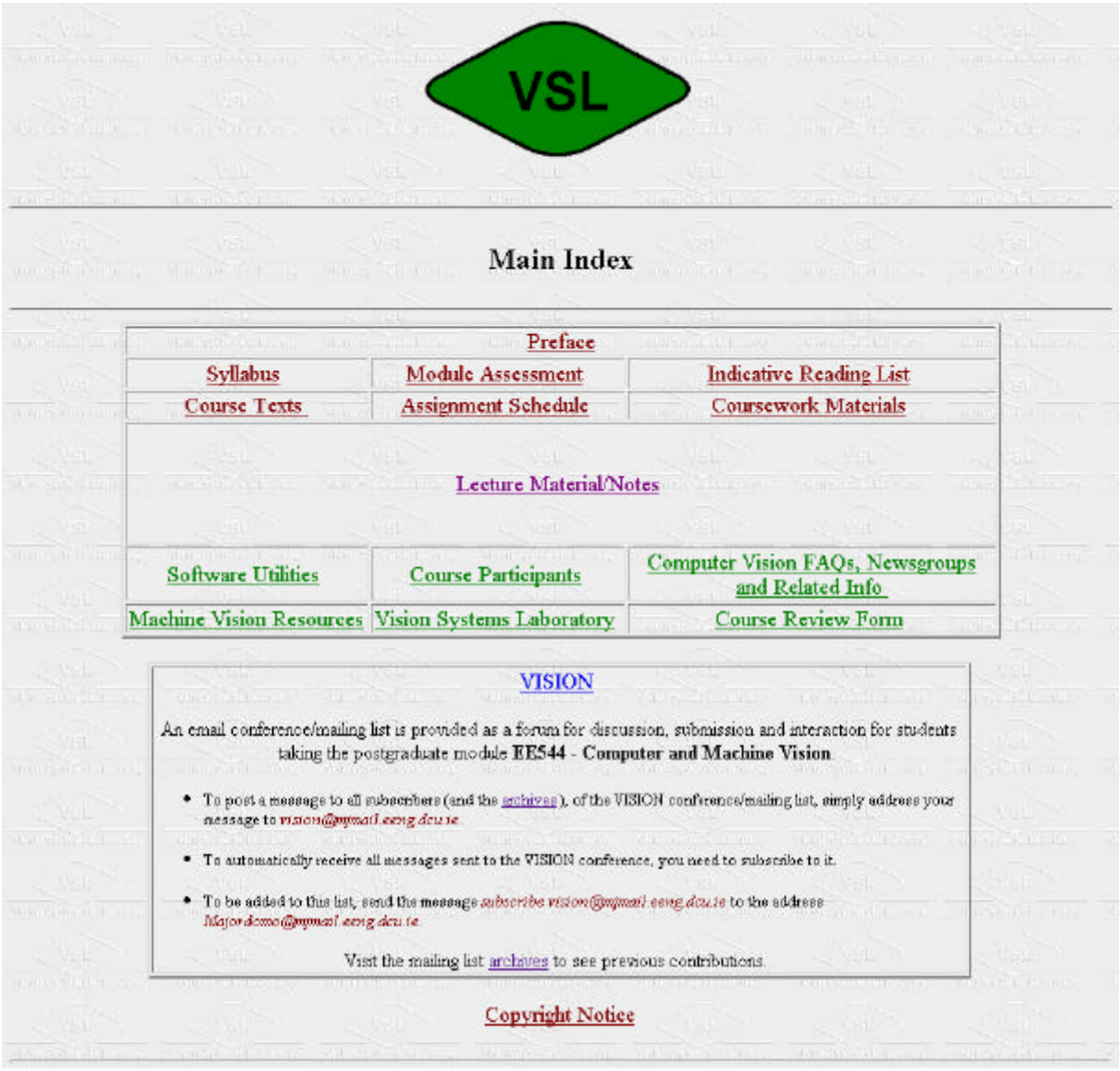

Figure 1. *Computer and Machine Vision* course main index page.

A directory of course participants, both full-time and remote access is provided. This list is only available to students registered on their course. The aim of the list is to encourage interaction between all students, as well as student/staff interaction. It is also important to give detailed deadlines of all course deliverables, such as assignments. A link from the main index helps students to keep up to date with such deadlines. Students are also linked to a widely available external newsgroup and FAQ site. Students are also encouraged to examine the *Machine Vision Resources* home page [Whelan, 1997]. This is an open access Web site with a wide collection of links dealing with many aspects of practical machine vision systems design and engineering, Figure 2. Feedback from the students on the course content and presentation is encouraged using an on-line course review form.

Figure 2. Sample segment of the *Machine Vision Resources* homepage [Whelan, 1997]. This is an open access Web site for practitioners in machine vision engineering. Contributions to this Web site are always welcome.

The VISION mailing list is crucial for student/student and staff/student interaction. Remote access students benefit from the interaction between full-time students taking the course. Any issues that arise during the standard lectures are relayed to the remote access students via weekly updates mailed to the mailing list. This ensures that questions that arise in the standard lecture are also presented to the remote access students. This helps the remote access students to pace themselves and also encourages a class dynamic. The mailing list is also a useful mechanism for dissemination of additional notes and clarifying issues that arise during lectures to both the full-time and the remote access students. The majority of the material to be referenced by the student can be found under the *Lecture Material/Notes* link. This will take the student to the course material index page illustrated in Figure 3.

The course uses Web pages as a means of guiding the student to material. Course notes are only provided in postscript/portable document format. Students can then read these notes using freely available viewers such as *Ghostscript* or *Acrobat Reader*. This is done to ensure minimal maintenance of course material, and to prevent out-of-date material appearing to remote access students. If the original notes are changed by the course tutor, then they are only required to generate a new postscript file from their word processor and to ensure that the Web version of the notes are updated. This method of course presentation has a number of advantages:

- Note presentation is not tied to a specific software package.
- The course tutor has greater protection of material and it is therefore easier for them to retain control over their intellectual property.
- Ease of development.
- Allows students to easily generate a paper copy of the notes. As Thomas [Thomas, 1997] points out learning from information displayed on a computer screen is not always acceptable.
- Low cost for the student: They only need to go on-line to request notes/software and for interaction with the course provider.
- Low cost for the course provider: Course maintenance kept to a minimum.
- Additional use of data compression for course material to reduce connection time.

- Direct students to related material elsewhere on the Web. This can be maintained independent of the course notes. Such links are listed in the *Aims and Issues* section of each study package.

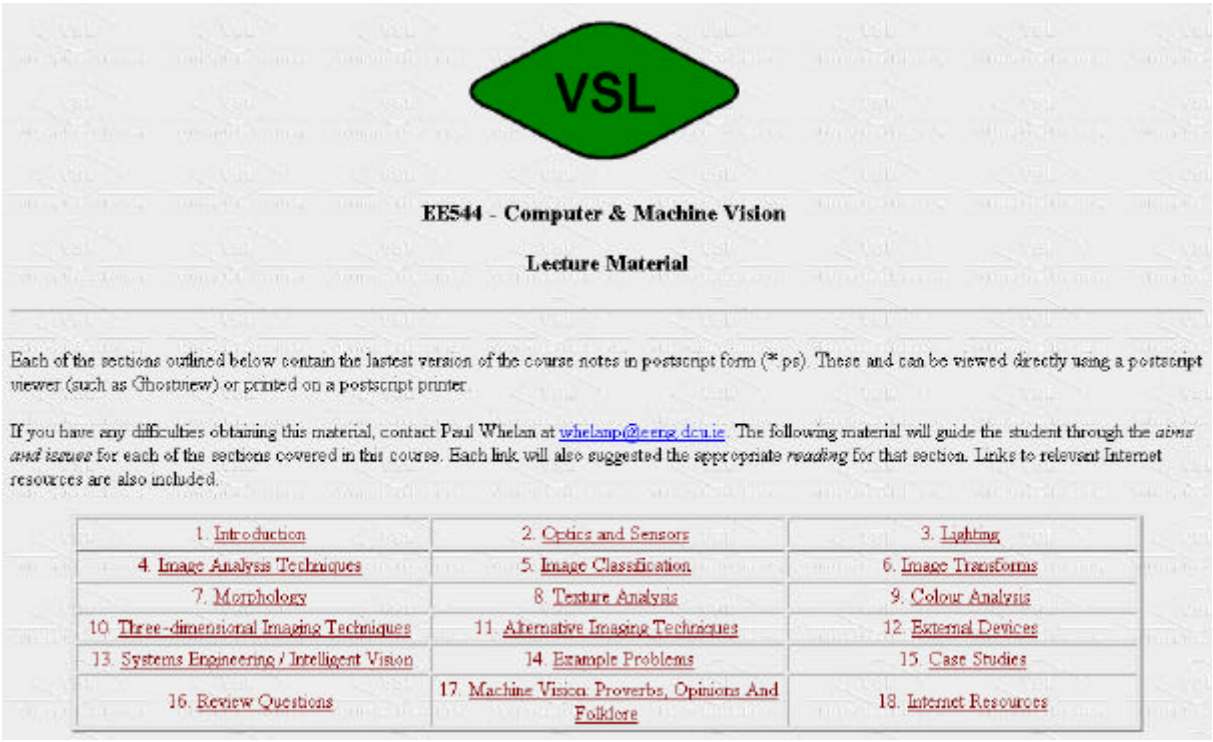

Figure 3. *Lecture Material/Notes* index. This directs the student to the study packages associated with the on-line course.

The Web pages concentrate on course support material, such as the aims and issues relating to each lecture, reading lists, review questions, pointers to other sites, audio-visual clips, and feedback rather than note presentation. It should be noted that the audio-visual clips are optional, therefore students with slow connections to the Internet can safely ignore them, see Figure 4.

Clearly stated aims and issues are very important for remote access teaching. Automated self-assessment questions, and detailed review questions are also provided to encourage the remote student to participate in a problem based learning strategy. Having a wide range of detailed review questions which are representative of the standard expected by the course tutor, is very important for remote access students. The aim of on-line assessment is to help the students pace themselves through the course material. The students receive an automated reply once the assessment has been submitted. A copy of the student's attempt is also automatically emailed to the course tutor. Note that the correct answer is not given, this is used as a means to encourage students to investigate the problem further. While multiple choice questions are limited in nature, they act as a warning sign for the students. The automated self-assessment questions and the on-line course review forms are implemented using PERL scripts.

3 Application and Registration Procedure

It would be wise to have a range of fees depending on the level of interaction by the user. Consideration should also be made as to whether students are self-funded or financially supported by a company. For example, the cost of an Open University [Open, 97] postgraduate course in software development is in the region of ST£550. In the US there is a price differential of approximately 30% between the cost of an on-line course for a non-profit and a for-profit institution. Under the RACeE initiative there are two options for people wishing to take the *Computer and Machine Vision* course. A special discount exists for all registrants not financially supported by their company (i.e. self-funded).

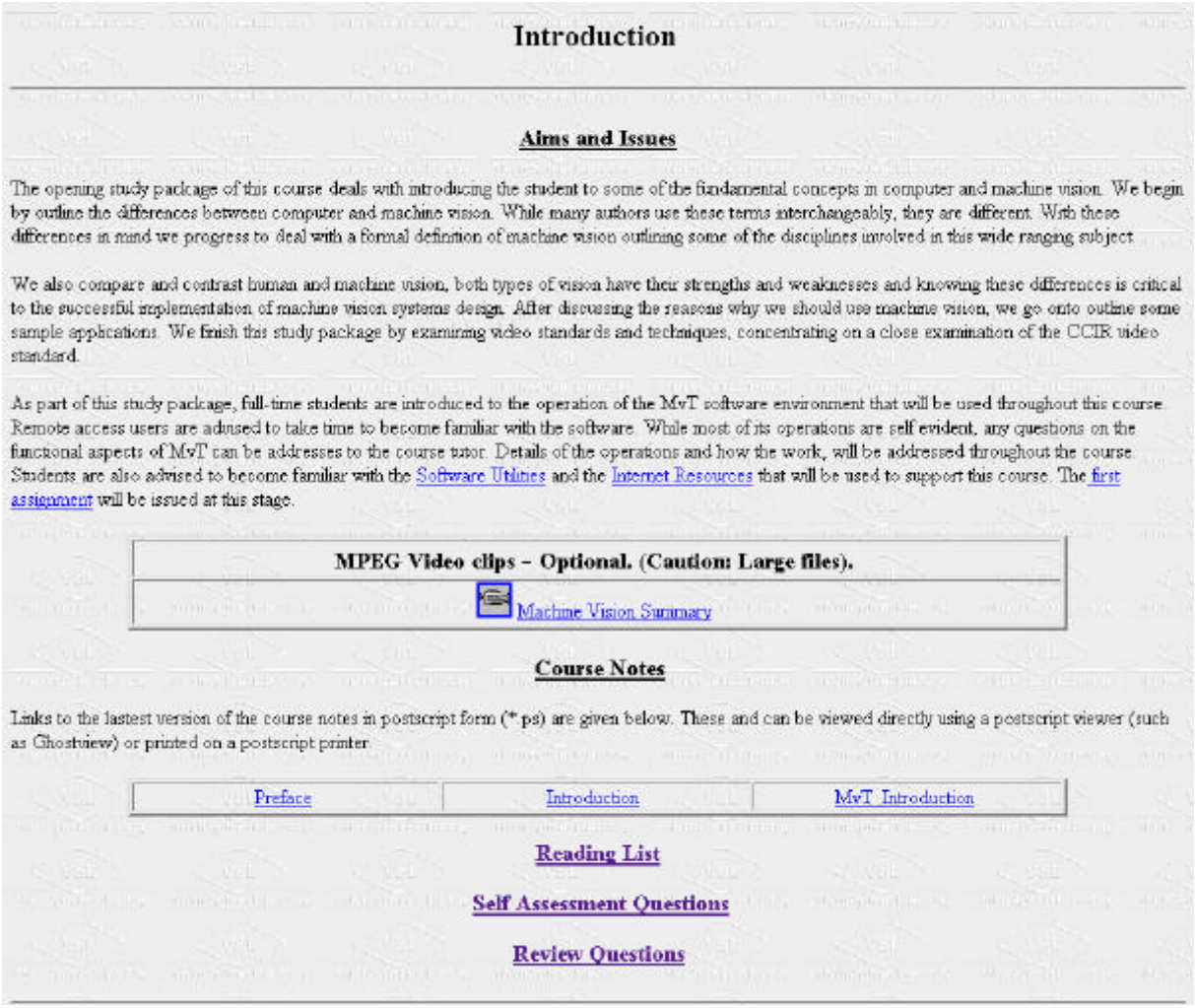

Figure 4. Sample study package page. This includes details of the aims and issues for the study package, any appropriate links (both local and global), audio/video clips (optional), links to course notes (supplied in postscript format), course reading list, self assessment questions (where available) and detailed review questions.

3.1 Full Course

In this mode the student will fully participate in the course. As well as full access to all course materials, the student will be supplied with a fixed number of hours of on-line tutorial support. Assessments will be submitted electronically. Examinations will be taken in DCU in conjunction with full-time students taking this course. Special arrangements may be made for sitting examinations outside DCU, but this will involve an additional charge. Students will gain full credits for single module (subject) courses (including a transcript of their results and a letter of completion). Single module courses partially fulfil the requirements for the *M.Eng./Grad. Dipl.* course within DCU, or similar courses within Europe. Examinations were held at DCU for the pilot phase of this course. Cost structure: Self-funded: IR£400, Company funded: IR£550.

Since this course runs in parallel with the full time course in *Computer and Machine Vision* students have to register within the same time frame as full time students. Applicants are accepted based on their academic qualifications and their previous experience. Prior to registration, students must provide the programme co-ordinator with a signed declaration stating that they are taking this course for private study, that they will not reuse any of the material (i.e. course notes, software ... etc.) for any other purpose other than private study. Once registered, students will be provided with a username and password to enable them to access all course materials.

3.2 Course Material Only

In this mode the student will gain access to all notes, software and course material, but will be expected to work independently without any on-line tutorial support. No examinations or assessments will be submitted. This mode would be suitable for students/employees who wish to update or expand their skill base, without adding to their qualifications. Cost structure: Self-funded: IR£300, Company funded: IR£400.

The registration procedure is similar to the full course outlined above, with the exception that this option will be provided throughout the academic year. Further details of the registration procedure can be found on-line [Whelan, 96b].

4 Conclusions

The general response to the pilot phase of this course has been overwhelmingly positive, although to date our experiences are based on a small number of highly motivated students. The long-term viability of remote access education has yet to be established. At the very least it will act as a niche educational delivery format for people in the work place unable to attend university on a full time basis. It is clear that this form of education requires a strong maturity on the student's behalf. By adopting a low maintenance model, which emphasises the interaction aspects of remote access education, we can ensure that our traditional educational role is not skewed by the addition of this form of education. Within the School of Electronic Engineering at DCU, we plan to expand the availability of the *Computer and Machine Vision* course in the coming academic year and to add three additional remote access courses. The new on-line courses are *VHDL and High Level Logic Synthesis*, *Broadband Networks* and *Artificial Neural Networks*. Our intention is to have a wide range of postgraduate courses available via the Internet, although is should be acknowledged that an on-line educational strategy may not be suitable for all subjects. The content and structure of these single module courses are designed to meet the higher skills and educational requirements of graduate engineers.

While the model outlined in this paper was designed specifically for a course in *Computer and Machine Vision*, the general concepts can be applied to a wide range of courses. The introduction of a new on-line courses will bring with it new challenges, and the model proposed in his paper may not always be sufficient. It is important that whatever model is chosen must be based on sound pedagogic foundations and not just on the availability of materials [Thomas, 1997] [Maki & Maki , 1997]. One key problem that remains is the running of assignments. As mentioned previously, the MvT software package used for assignments was developed in-house, therefore we have no difficulty redistributing it freely to students registered on the program. But this will not always be the case. We are currently investigating ways of running a wider range of assignments remotely using a multi-platform language such as JAVA, i.e. without the need for students to download custom software. This would provide remote access educators at DCU with a more general model for on-line assignments.

It has been the authors aim to approach the problem of remote access teaching from the educational standpoint, and not from the need to produce attractive and overly complicated Web documents. Another strong motivational force in the design was the need to address genuine educational needs not covered sufficiently by the traditional educational model. Remote access education will continue to be an important niche educational market in the foreseeable future, since it presents educators with a new and potentially powerful medium for teaching. It allows us to respond to the changing needs of the engineering workforce, who need to update their qualifications and/or skill base without leaving the workforce.

While the remote access course outlined in this paper could run independently of the traditional educational model, a key aspect of the design is the need to run it in parallel with a traditional version of this course. The paper has shown that this brings a number of significant advantages to the remote access student.

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