

## **A LEAN APPROACH TO ENGINEERING EDUCATION ONLINE**

Brian Mulligan, Brian Coll and Grace Corcoran

Institute of Technology Sligo, Ireland

E-mail: [brian.mulligan@gmail.com](mailto:brian.mulligan@gmail.com)

### **ABSTRACT**

Traditionally, the transition of courses from classroom based to online and distance learning has required significant investment of capital and long lead times for development. This can be contrasted to full time education in which minimal capital investment is made in learning materials and relatively little time required to plan and make programmes available. However, the availability of rich communication technologies on the Internet, both synchronous and asynchronous, may change this by facilitating the development of online distance learning programmes that use similar pedagogical approaches to campus based education and also result in a similar financial cost model. This paper describes how Institute of Technology Sligo has rapidly grown its online distance learning programmes in engineering using such a communications approach, leveraging existing content, rather than developing new content. It will describe three case studies of such online teaching in the areas of mathematics, manufacturing technologies and manufacturing management. The paper concludes that this approach to teaching online is effective and should be financially viable. It also suggests that in the future this approach could lead to the breakdown of differentiation between distance and campus based learning.

### **INTRODUCTION**

E-learning courses, having originated before the widespread adoption of the Internet, originally evolved towards a model very similar to traditional distance learning, where the emphasis was on the development of content. At this time communications between tutors and learners was difficult and expensive and so it was important to have very high quality learning materials that facilitated a high level of independent learning. In general, both traditional distance learning and online courses have resulted in a cost-model that involves significant, and sometimes extremely high, investment costs. This is illustrated by the high usage of interactive and pre-recorded video by universities as described by Reisman [2]. It is now widely believed that online courses are more expensive than traditional courses (Fielden 2002, p.12, cited in Weller 2004, p.295) [4].

This approach to development can be contrasted with the traditional campus-based approach in third level education. Normally no investment is made in learning materials. Lecturers source suitable existing materials, such as text-books, and create materials of their own to fill any gaps they perceive in such materials. Campus based teaching normally affords a high level of communication (ie. classes) between the lecturer and the learners. Indeed much of the content of the course may be embedded in this communication and not necessarily available in the learning materials. Although the running costs of such a method of teaching can be high, it does facilitate agility in that

new courses can be developed and made available very quickly without any significant financial investment.

Many progressive lecturers are now adding e-learning features to their campus-based courses. Typically these are in the form of: links to websites (further reading, images, animations, videos, simulators); text-books with associated online resources; low-cost multi-media materials; rapidly developed multi-media materials; recordings of live lectures; discussion fora; multiple choice quizzes and electronic assignment submission and grading. Again, these are rarely paid for by the institution and thus the cost-model for such courses is not significantly changed. However, it is becoming apparent that by adding these features, such courses are becoming increasingly flexible, to the point where virtually no face-to-face attendance is required.

### **Distance Learning at IT Sligo**

The above observation has been behind the development of distance learning in the School of Engineering at Institute of Technology Sligo since 2001. Online distance learning was launched in September 2002 with an add-on honours degree with an enrolment of five students. In September 2006 this had grown to 200 students over 8 available programme years now increasing to 12 programme years in September 2007 ([www.itsligo.ie/online](http://www.itsligo.ie/online)) and about 37 lecturers involved in teaching online.

### **The core approach**

Each lecturer who is starting to teach online in IT Sligo is introduced to a core approach to which more can be added later. This core approach is facilitated by two main technologies (i) A synchronous web-conferencing system (Adobe Connect) which allows a lecturer to give live classes over the Internet and also record them for later viewing, and (ii) A Virtual Learning Environment (VLE: Moodle) which facilitates asynchronous (non-live) communication between all participants in many ways. Lecturers are asked to provide certain minimal services to students as follows: (i) A regular live class (usually weekly- also recorded); (ii) Access to independent learning resources (eg. text-book, notes, websites etc); (iii) Independent learning activities (Assignments) with timely feedback; (iv) Asynchronous support via online discussion fora hosted within the VLE with a maximum of two day response time to queries; (v) an end of module survey.

In addition to the above, lecturers may add other features including attendance at the Institute for specific requirements if they deem them necessary. This decision, to limit the constraints on lecturers was made deliberately for the following reasons: motivation, increased innovation, differing nature of topics and preferred teaching styles. It might be remarked that the rapid growth may be due to the use of many lean manufacturing principles (already familiar to the academic staff teaching on these courses) in the development and delivery of the programmes. These lean manufacturing principles could be described in the following ways: reduced set-up and lead times, reduced costs, simple design of procedures (including teaching), delegation to shop floor (lecturers), continuous improvement (as opposed to deterministic design), knowledge management and sharing of best practice.

The different approaches to teaching online, beyond the core requirements can best be illustrated by the following three short case studies which span the main types of topics typically taught to engineering students; mathematics, technology and management.

### **Case Study I – Mathematics**

The mathematics module on the BEng in Mechatronics is delivered using both asynchronous and synchronous methods. The moodle VLE is used to present learning resource material to the students and to give online quizzes for both formative and summative assessment at the end of each new topic. It is also used as a communication tool to send messages and to discuss exercises that are assigned to them.

Adobe Connect is used to deliver a two hour live lecture once a week (equivalent day class is 3 hours per week). This replicates to a great extent what is done in a normal face to face lecture. The lecturer did not find that the lack of face to face contact to be a problem. Most questions about lack of understanding of a concept were dealt with during the lecture session using the chat option. But if a problem was unresolved in this way, the option was there to pass control of the white board to the student where they can then write on the board or to allow them to use a microphone. Prior to class the notes were uploaded to the site for the student to download. Also additional material such as page references to a text book or websites were also supplied.

### **What worked and didn't work**

**Notes:** Students liked to have notes ahead of the class. They would print these out ahead of class and write additional notes in class.

**Whiteboard:** If the material was relatively straightforward, pre-prepared power point slides worked well. The lecturer could present the slides and write on the slide as you talk about each line. In actual fact the lecturer involved preferred no to use PowerPoint and preferred to use a blank whiteboard in much the same style as the traditional teaching of mathematics. The whiteboard is better than a normal board as you can select different colours very easily. One can highlight text or point with the arrow and can go back very easily to a previous page.

**Assessments:** At the end of each topic the students were given an online assessment using the quiz tool in Moodle. Students found these very useful. They formed part of the continuous assessment process. La-tex was used to write the equations. It was felt that more self assessment quizzes would improve student learning.

**Feedback:** Queries were responded to on the same day that they were received. The online quizzes reduced the number of queries as they students get immediate feedback to their answers.

**Length of class:** The lecturer gave a two hour lecture each week. This was very exhausting. While delivering the class the lecturer was very conscious of gaps in the delivery as it was all being recorded. Short, twenty minute, recordings worked better,

especially for play back of recordings. It wasn't always possible to have 20 minute breaks due to the length of time a topic or question took to answer.

### **Case Study II - Technology**

**Live classes:** The Adobe Connect conferencing system is able to replicate all PowerPoint animations when imported for broadcast. It was possible to use PowerPoint to create graphic animations of the operation of engineering equipment (eg. operation of a stepper motor). It is also possible to include videos, however, for students with narrow-band connections, it was recommended that they download these and run them on their own PC. Adobe Connect also facilitates application sharing. Thus it was possible to run simulators on the lecturer's PC which could be viewed live by the students with the associated commentary by the lecturer. The students were, of course, able to ask the lecturer to clarify issues during the lecture if necessary.

**Asynchronous Communication:** The VLE (Moodle) was used for many purposes beyond the standard requirements of posting materials (eg PowerPoint slides), making announcements and answering queries. In addition to posting links to third party videos on the web, students could download free simulators to run on their own PCs in order to carry out assignments (eg. PLC programming). An important use of the VLE was the posting of quizzes. These quizzes, which included many illustrations were very popular with students, particularly as they gave them the confidence that they were coping adequately with the content being presented.

**Student Satisfaction:** The end of module survey indicated that the students were extremely satisfied with their learning experience. The most recent delivery of this module was the second time it was delivered. After the first delivery it was found that the students felt that they did not have enough practical work in the Institute. This was rectified in the second delivery and no comments on this were made after this delivery.

### **Case Study III - Engineering Management**

One of the difficulties in transitioning subjects to an on-line format is the loss of interactivity with and between the students. One such subject 'Case Studies in Quality Management' had been traditionally taught in a classroom environment where the lecturer introduced the case and a discussion on the merits of the case took place. Case studies play an important role in developing the student's analytical skills. It also allows them to put the theory they gained from across the course syllabus into practice through analysing the case and coming up with recommendations as to a course of action to take. The challenge in moving this subject on-line was to maintain the development of key skills such as team building, collaboration, communication, problem solving and presenting. This case study reviews the transition of a Case Studies subject from full time to on-line students at IT Sligo.

Over the course of a semester, students were given four case studies to analyse broken down as follows: **Week 1:** Introduction to the Case – Presentation by lecturer, **Week 2:** Review and Analysis of the Case – Group discussions with lecturer feedback, **Week 3:**

Presentation of the groups Case – Group Presentations with assessment and feedback by lecturer. This cycle would then repeat for the second case and so on. The class was broken into groups of three with one student taking responsibility to present the results of their analysis. In the first semester this subject was taught online, the presentation of the case was submitted in a written report back to the lecturer. However, it was felt that a significant learning opportunity for the students was being lost due to the asynchronous nature of reporting on the group's review of the case.

It was decided to use Adobe Connect for the presentation of the groups review and analysis of the Case Study. This feature of Adobe Connect allows the lecturer to hand over control of the on-line lecture to the student so that they could make a presentation to the class. Each group in turn gives a 10 minute presentation on the Case followed by a 5 minute Question & Answer session which is conducted live across the internet. The format for the group presentation was as follows: (i) Background to the case, (ii) Problem Identification and analysis, (iii) Contributing factors as to what caused the problem, (iv) Recommendations as to lessons learnt. At the end of each group presentation, the lecturer transfers control to the next student presenter before taking back overall control of the on-line lecture and providing feedback and marks to each group.

### **What worked and didn't work**

**Technology.** In order to pass control of the on-line lecture system to the student, they must have a broadband connection and a microphone. It was also important to provide training on the system to the presenter. This was achieved by placing a Help file onto Moodle and also doing a dry run with the student prior to the formal presentation.

**Group working.** Although group working can cause problems, it can work well if structured appropriately. Having one student lead the group for each case allowed the student's to assume different roles for each case study.

**Real Life Scenarios.** While traditional Case Studies (Harvard Style) were utilised, it was found that more benefit was gained from the analysis of real life scenarios such as product recalls. Some examples used were: Sony Battery Recall; Ford Firestone Tyres; Cadbury's Chocolate Flake; Charite Spine device; Bausch & Lomb ReNu with MoistureLoc contact lens solution.

**Assessment and Feedback.** Real time feedback and marking by the lecturer on-line was received favourably by students. When written reports were submitted on-line, it took the lecturer at least one week to review and provide feedback to the students. By that time, the students were already immersed in the subsequent case study. Providing the students their mark on-line also introduced a competitive element between the groups and the quality of the presentations was seen to improve each week.

### **Overall Conclusions – The Future of Distance Learning**

This initiative can be considered as an action-research project insofar as the continuous improvement processes embedded in the operation are continually providing information

on the success or failure of very many techniques. From our work to date we have drawn some general conclusions:

**Effectiveness:** It works. Student surveys to date have shown that the distance learners are largely satisfied with their learning experiences. Examination results have been as good if not better than full time students taking the same examinations. This has led us to conclude that the approach is pedagogically effective. However, to achieve high quality learning experiences, the core model is rarely enough and lecturers have to be encouraged to add other appropriate features and to pay significant attention to the results of end of course surveys. It can be argued that this may also provide a higher quality learning experience than traditional distance learning as it solves the problem of lack of tutor-student interaction associated with traditional distance learning as described by Sherry [3].

**Financial viability:** Wright and O'Neill have listed the issues in education that are pushing universities towards business oriented models of operation [5]. Certainly it cannot be justified moving into new markets if it drains resources from existing activities. This operation is currently at about breakeven point. However, there are many hidden institutional costs that have not been fully quantified or considered in our analyses. IT Sligo is currently undertaking formal research into full costing of such operations which will result in a financial model that can be used to predict the required level of enrolment to make such courses breakeven. We are hopeful that these enrolment levels will be low enough to justify the approach.

**Future of distance education:** According to Moran and Myringer there is already a move towards dual-mode institutions that provide the same programmes in campus and distance learning format [1]. The ability to capture the classroom activity of campus based courses and the increased use of online technologies for communication outside of the classroom has now made it possible for students to take part in courses with minimal campus attendance. This type of technology supported flexible learning which is being encouraged in most universities is almost identical to the form of online distance learning described here. In future there may be no need to develop separate distance learning offerings as the campus offerings may be sufficient in themselves.

## REFERENCES

1. Moran, L., Myringer, B., Higher education through open and distance learning: World review of distance education and open learning: Volume 1, 1999, Routledge, London, pp. 57-71
2. Reisman, S, Information Management, 2001, Idea Group Publishing, Harrisburg PA.
3. Sherry, L., International Journal of Educational Telecommunications, 1996, vol. 1, no.4
4. Weller, M., Open Learning, 2004, vol. 19, no. 3, pp.293-302
5. Wright, C. & O'Neill, M., Higher Education Research & Development, 2002, Vol.21 No. 1.