Mechatronics by On-Line Distance Learning – The IT Sligo Experience

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Abstract - The paper relates the experience of Institute of Technology Sligo (IT Sligo) in the delivery of a Bachelor of Engineering Degree in Mechatronics by On-Line Distance Learning. The Mechatronics programme is set in the Irish academic and industrial context, seen from the perspective of a medium-size Institute of Technology on the North-West coast of Ireland. The unique position of the Institute of Technology (IoT) sector in the Irish education system is presented, as well as that of the Irish manufacturing sector in a national context. The National Framework of Qualifications is explained, so that the Mechatronics Degree can be placed in an international setting. The laboratory support structure is described, with reference being made to on-going research into new and innovative ways to enable remote access, as well as optimizing the benefit to student learning of visits to the Institute campus. In addition to describing the current state of supply and demand for mechatronic skills in Ireland, this paper describes how Institute of Technology Sligo has developed a rapid development approach to the creation of online courses, including a "top-up" B.Sc. in Mechatronics, which has unearthed a huge demand for convenient access to education from mature adults working in manufacturing industries. The paper describes a pedagogic approach to online distance learning which largely mirrors traditional third level educational methods, by concentrating on the use of synchronous and asynchronous Internet communication technologies (as opposed to content development), making it easier for lecturers to adapt to the new approach and getting rid of the need for significant financial investment.

I. INTRODUCTION

The demands of Continuing Professional Development (CPD), and Lifelong Learning in general, are driving significant changes in the approaches taken to learning, both by learners and learning providers. The requirement for personnel to attain qualifications, itself driven by the demands of regulatory authorities, such as the Health and Safety Authority (HSA) in Ireland or the Food and Drug Administration (FDA) in the USA, as well as the internal Quality Assurance procedures in companies, has resulted in enormous growth in on-the-job learning at all levels in manufacturing industry. This demand has presented educational institutions with opportunities to expand their teaching activities into industry. Along with this demand has come the challenge of making learning available to people at work, in a way that takes account of their commitments, both to their employers and to their families, as well as being accessible at times that are compatible with their social and professional lives.

The development of on-line learning methodologies in IT Sligo has enabled the Institute to address the significant demand for accredited learning in Mechatronics in Irish manufacturing industry. This demand is not restricted to Mechatronics alone, but the example serves to illustrate the technologies, the learning methodologies and the learning provider experience, since the Institute started its e-learning project in 2002.

II. INSTITUTE OF TECHNOLOGY SLIGO

Established in 1970 as one of five Regional Technical Colleges, later to be upgraded to Institute of Technology status, the Institute has grown steadily in student numbers, diversity of programmes and levels of award. The Institute of Technology (IoT) sector of Irish education has seen rapid expansion since 1970 to the current position where there are fifteen Institutes, with IT Sligo ranked in the top five, having approximately four thousand full-time students and a further one thousand part-time students. The Institute is also one of only five Institutes with authority to make awards at all levels up to Doctorate (PhD).

The Institute is organized in three academic schools;
- **Business and Humanities**: (Social Studies, Fine Art, Industrial Design, Computing, Business, etc.)
- **Science**: (Environmental Science, Pharmaceutical Science, Forensic Science, etc.)
- **Engineering**: (Civil Engineering, Interior Architecture, Mechatronics, Mechanical Engineering, Electronics, Product Design, Quality Management, etc.)

III. THE NATIONAL FRAMEWORK OF QUALIFICATIONS

In 2003, in order to rationalize the academic awards structure within Ireland, while at the same time establishing comparative norms for mobility and transfer within the EU, to meet the demands of the Bologna accord, the National Qualifications Authority of Ireland (NQAI) published its Framework of Qualifications. Based on a Learning
Outcomes model for the attainment of academic goals, an awards structure is defined, which prescribes ten levels of award, the upper five of which are embraced by the Universities and Institutes of Technology. These are:

- Level 6 Higher Certificate
- Level 7 Ordinary Bachelor Degree
- Level 8 Honours Bachelor Degree and Higher Diploma
- Level 9 Masters Degree and Post Graduate Diploma
- Level 10 Doctorate (PhD)

Taking the example of the Mechatronics programme at IT Sligo, students are offered:

- Level 6: “Higher Certificate in Engineering in Mechatronics”, after two years of study,
- Level 7: Bachelor of Engineering (“BEng in Mechatronics”), after a further one year of study.
- Level 8: (“BEng (Hons) in Product Design”), for students continuing for two further years of study.

IV. MANUFACTURING INDUSTRY IN IRELAND

The drive towards industrialization, initiated in the mid-nineteen sixties with a view to transforming from a largely agriculture-based, tariff-protected economy to one focused on free trade, involved the establishment of the Industrial Development Authority (IDA), whose function it was to attract foreign direct investment, primarily in the area of manufacture. An essential infrastructural support mechanism for this development was an educational system which would guarantee a steady supply of Technician level graduates. This level of education was not the remit of the Universities; hence the establishment of the Regional Technical Colleges, later to become Institutes of Technology.

By targeting a limited range of industry sectors, the IDA achieved remarkable success, attracting multinational investors from the USA, Germany and Japan, initially in Electronics, Software, Automotive Components and “White Goods”, and later securing a presence in Ireland of all the world leading Semiconductor manufacturers and most of the larger Medical Device and Pharmaceutical manufacturers.

With the transition throughout the period from high-volume, low value-added manufacture towards the high-tech, high value-added end of the manufacturing spectrum, the demand for graduates with higher qualifications in specialist areas of Science, Engineering and Quality Management grew. Because of their history of rapid development of new areas of study and their flexible internal structures, the IoT’s were well positioned to respond to this demand.

V. INDUSTRY DEMAND FOR MECHATRONICS

With the inevitable departure of high-volume, labour-intensive industries to low-wage economies across the world, the remaining manufacturing operations in Ireland experienced the urgent need for automation, in order to remain competitive. This they have done with remarkable success, the manufacturing sector still generates forty percent (40%) of Gross Domestic Product (GDP), while employing ten percent (10%) of the workforce. With a total workforce of two million⁴, the value per job to the overall economy is on average seven times the value per job in the remainder of the economy. This fact alone points to the reason that demand for ever higher levels of qualification continues to grow.

Having achieved satisfactory results from the launch in 2002 of the first ever undergraduate degree programme to be offered fully on-line in Ireland, the Department of Mechanical and Electronic Engineering in IT Sligo decided in 2005 to offer a suite of programmes at Levels 7, 8 and 9 by on-line distance learning. Among these was the BEng in Mechatronics at Level 7. In recruiting fifty (50) people to the programme, the Institute far exceeded its target. The interest generated already points to a further increase in demand in the current year. The challenge presented by the recruitment of large numbers onto on-line courses is one which the Institute welcomes.

VI. LABORATORIES AND EQUIPMENT

IT Sligo has invested heavily in laboratory equipment to support its Mechatronics programme. The equipment/laboratories currently available are:

- Advanced Automation laboratory with
  - 16-stations for advanced PLC programming on customised training rigs, using Siemens S7 controllers and Allen-Bradley SL/05. Soft PLC’s are also available for programme simulation.
  - Custom designed rigs, implementing current industrial field bus networking systems are also installed. (Industrial Ethernet, ASI bus, Profibus DP, Devicenet)
  - SCADA capability on all sixteen stations (In-Touch).
  - 16-seat Robotics programming and robotics cell simulation using COSIMIR Educational. Simulated programmes can be downloaded to six-axis Mitsubishi robot.
  - Educational, modular production system (MPS), with integrated Profibus Siemens S7 controllers. This is the system used in the World Skills in Mechatronics.
  - Interactive whiteboard and data projector
- Pneumatics laboratory comprising
  - 13-seat pneumatic/electro-pneumatic training boards for basic to advanced.
  - Micro PLC programming and training
board control
- Pneumatic and Electro-pneumatic simulation and emulation using FluidSim, Easy I/O and Soft PLC
- 2x FESTO hydraulic training rigs
- Feedback motor control demonstration system, allowing build and design of different types of motors
- Instrumentation laboratory
  - 16-seat laboratory, with eight NI PXI systems, comprising cards for data acquisition, vision, motion control, GPIB, DeviceNet, CAN Bus, real-Time controller, waveform generator, temperature logging
  - 8x USB Data Acquisition devices (low-cost student kits available, to enable online students carry out practical work at home)
  - 8x FieldPoint distributed I/O systems (Temp control, DIO, Analog)
  - Labview graphical programming for instrumentation and control
  - SCADA/HMI programming, using NI Lookout
- Computer Integrated Manufacturing laboratory equipped with FESTO iCIM. This is a completely integrated manufacturing system, comprising:
  - CNC Mill,
  - CNC Turning Centre, served by six-axis robot on linear slide,
  - Assembly Station, with vision inspection,
  - Quality Control Station
  - Cartesian Storage/Retrieval system.
- The system is modular in construction and implements ASI and ProfiBus, with SCADA control. In addition, virtual factory software allows access to a full ERP package. Web access, to support online learning, is currently under investigation.

VII. THE RAPID DEVELOPMENT MODEL

The School of Engineering in the Institute of Technology Sligo has adopted what we describe as a "low-cost, rapid development" approach to making programmes available online. The reasons that this approach has been adopted are as follows:
- It was felt that low cost would be more sustainable in the longer term. (It was observed that funded projects did not often yield sustainable systems.)
- The effort required in applying for funding and in documenting progress in funded projects would not necessarily be worth the funding that might emerge from such an application, and would considerably slow down the development.

The model of online distance learning developed at IT Sligo was inspired by the "wrap-around model" described by Mason. The approach can be characterised as follows:
- It is not necessary to create new content for courses, either traditional distance learning texts or online multimedia. Existing learning materials are used where available, including textbooks, lecturers’ existing notes and presentations, and third party websites.
- Student learning is based on activities (assignments) which encourage engagement with learning resources.
- Live (synchronous) classes, broadcast using internet video-conferencing tools, and also made available as recordings, are considered to be learning resources as opposed to learning activities.
- Continuous support is considered to be a key element of the learning process, both from lecturers and fellow students. This is provided through asynchronous online discussion fora hosted within a Virtual Learning Environment (VLE). Feedback on assignments is also considered to be an important part of the support process.
- Learners are required to attend IT Sligo for four days per year, to carry out practical work, attend classes on topics which are difficult to teach over the Internet and to meet their peers and lecturers.

Although this approach is similar to traditional distance learning, in that it requires the learners to undertake independent learning activities, it is worth noting that it may be closer to the traditional approach of full-time campus education, in that no funding is made available for the development of materials, and lecturers use existing resources (or create them as necessary) and base learning activities on these. In the past, this approach has been considered to be unsuitable for distance learning, probably because the isolation of learners required a very high level of quality in the preparation of learning materials. However, we believe that the excellent communication facilities available on the Internet can make this approach effective as any shortcomings in the ad-hoc approach to the provision of learning materials can be easily and quickly rectified when identified.

VIII. HISTORY OF THE DEVELOPMENT OF ONLINE DISTANCE LEARNING IN IT SLIGO

A pilot course, consisting of the final year of a B.Sc.(Hons) in Quality Management and Technology was set up in 2002. Although, on the surface the purpose of the pilot was to test the effectiveness of the delivery model, it was realised that the lecturers involved would not reach their full capabilities as online lecturers, before the pilot study was launched, and that the study would also act as a learning experience for the lecturers. Because of this, distance learners who were already trained in Quality, and who had significant experience in the field, were chosen. We realised that this would weaken the findings of the pilot study from a scientific point of view. However, we were interested only in finding out whether the technique would work, and also, just as importantly, we were interested in developing online teaching skills, as well as gaining information on how to improve the technique. The
original pedagogic approach was much as describe above, except that we did not have the facility for live classes on the Internet.

IX. STAFF TRAINING AND QUALITY ASSURANCE

It was felt that teaching staff would not efficiently gain new skills if training occurred too far in advance of their application of these skills to actual courses. For that reason, a *Just-In-Time* approach was taken to staff training. Training was kept to a minimum before the delivery of their first module. They were trained in using a VLE for communicating with learners, making resources available, facilitating discussion, facilitating submission of assignments and providing support and feedback. Teaching staff were also introduced to the concepts of independent learning and activity based learning, techniques which many may not have been exposed in their campus based teaching. During the first delivery of modules, staff development continued in the form of weekly one-hour classes and online forums that provided a high level of support in carrying out their regular online teaching activities. As expected, this ‘minimalist’ approach to staff training did result in a variation in standards of teaching and learning. A simple continuous improvement system was put in place in order to deal with this. This comprised of an electronic student survey at the end of each module which were analysed privately by each lecturer (because of existing working agreements), and followed by a half-day continuous improvement workshop where all lecturers discussed both the problems and successes of their teaching.

X. CHANGES AFTER THE PILOT STUDY.

Although the pilot course was two years duration, towards the end of the first year, as the feedback from students was satisfactory, it was decided to do a full online launch of the course. In general the students were satisfied with the service they were receiving and examination results were more than satisfactory. However, there was a problem with learning mathematical topics through independent learning and this was not helped by the wide spacing of visits to the Institute. A web-based video-conferencing system was introduced in the second year, to facilitate weekly live teaching of mathematical topics and the provision of recordings to those who could not attend live sessions. This proved very effective. It also proved popular with staff and students in modules that were not particularly mathematical.

XI. MECHATRONICS ON-LINE

The B.Eng in Mechatronics, the modules of which are designed to be delivered over one academic year, commenced on-line in September 2005, having previously been delivered as a part-time, on-campus evening course. The full programme takes two years to deliver on a part-time basis. As stated earlier, the numbers recruited exceeded expectations. A very large number of those recruited were mature learners working in manufacturing industry in the maintenance of production equipment. Their previous qualifications were frequently in the craft area, primarily electricians. The minimum entry requirement to the BEng in Mechatronics was a National Craft Certificate, (Level 6), together with at least five years relevant industrial experience.

XII. INDICATIONS FOR FURTHER IMPROVEMENT.

In general distance learning students have been quite satisfied with the programmes being made available to them. As with any engineering programme, access to equipment to carry out experimental work is essential. The requirement to travel and the loss of working time run contrary to the concept of distance learning. This presents a challenge to the learning provider. At the moment three main areas stand out as being most obviously in need of improvement:

1. *Communication between students:*
   - Peer to peer support has not developed in the way we would have hoped for in these courses. In our attempts to make the courses more convenient for learners, we have tried to keep campus visits to IT Sligo to a minimum. The excellent communication facilities available, and in particular the ability to give live classes on the Internet, has made it possible to manage with little, or in some cases, no face-to-face contact with learners. We suspect that this may be a major reason why this support system has not developed. We hope to improve this situation by doing several things: increasing the length of the orientation visit to IT Sligo for new learners, dividing learners into smaller groups and keeping them in these groups throughout their course insofar as is possible, and giving learners more group based activities during the courses.

2. *Varied Standards of Online Teaching:*
   - In the interests of rapid development, our online courses mimic the approach taken in full-time courses where staff have the freedom to choose how they teach. Staff may decide on the frequency of on-line lectures and independent learning sessions, the use of on-line self-assessment quizzes and assignments. For them we are using the student surveys and end of course continuous improvement workshops, to expose teaching staff to the good practice of others and to encourage innovation in teaching. In addition to this we are considering the possibility of having a higher level of standardisation of modules with, for instance, a specified number of on-line lectures, specified numbers of assignments, including collaborative assignments, and specified feedback requirements.

The use of web-cam and web-enabled interfaces offer great opportunities in providing the required level of access to laboratories, so that students may carry out real experimental work, without the necessity to travel to Sligo. Initiatives involving collaboration with other providers, both nationally and internationally, are underway. It is hoped that the benefits of this work will be available to
on-line learners in the coming academic term.

XIII. CONCLUSION

We in IT Sligo believe that it is possible to develop online courses, without any significant financial investment, and in a short time-frame. This involves using a *communications-based* as opposed to a *content-based* approach. We believe that students are satisfied with the resulting courses, but we hope that by a process of continuous improvement, these standards will continue to rise over time.

XIV. ACKNOWLEDGMENT

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XV. REFERENCES

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