International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION
5th Edition

The Development of a Blended Engineering Program in Industrial Instrumentation and Automation

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Abstract
This paper will describe the development of a blended/online engineering program in the area of industrial instrumentation and automation, which was developed in collaboration with senior engineering staff at a number of regional manufacturing industries in the South West of Ireland. The process involved an investigation into the educational needs for such a blended engineering program, to provide an effective method of up-skilling regionally employed production operators. As the target students were in full time employment a novel method of learning was required and a suitable blended learning environment was developed. This one-year certificate program is running for the past three years and feedback from the students and employers has been very positive. This paper will describe the intended direction and projected outcomes of the project/program and how it addressed the issue of remote learning in such a manufacturing environment. As the physical nature of the engineering disciplines requires interactive practical sessions in dedicated specific laboratories, it can be difficult to facilitate the up-skilling of manufacturing industry staff when they are in full time employment. Also, it is important that the concept of interactivity is addressed, as research has found that students' retention of knowledge increases from 20% to 75% when students interact with the learning environment [1]. This can be more difficult to achieve with a remote learning approach. This paper will present the different methodologies and tools that were used, both theoretical and practical in the characterisation of such a blended learning environment. Today's engineers need to have a greater understanding of all the engineering disciplines from mechanical, electronic, mechatronic, production, design, test and manufacturing, this can be achieved by introducing up-skilling content through blended learning environments such as described in this paper.

1. Introduction
The teaching of automation and instrumentation at the University level (3rd Level Education within the Irish context) is critical to providing the students with the necessary skills to graduate into a range of industry based engineering positions, primarily those who will be focused towards associated manufacturing engineering activities, but also those who may be involved in activities from design through to production. In 2012 the Institute of Technology Tralee (ITT) developed a European Qualifications Framework (EQF) [2] Level 6 Certificate in Industrial Automation and Instrumentation [3] in response to the upsurge in ICT and manufacturing related job opportunities both regionally and nationally. This Certificate is an accredited one year online course that was designed to provide current production line and facility operators with the opportunity to up-skill and develop within the manufacuring sector. The course combines the fundamental principles of industrial automation and instrumentation with knowledge of electrical and electronic design, software and mathematics. The program was also funded for development under the Higher Education Authority, Springboard initiative [4].
Springboard was initiated in 2011 in response to the economic crash in Ireland to provide free higher education opportunities to the unemployed. As many of the industries which suffered will not recover in any significant way, Springboard provides people with the opportunity to reskill and get back to work, thus contributing to building Ireland's future. Springboard has enrolled over 10,000 people in courses to date and 40% of those are back in work six months after their course.
This paper will discuss the teaching of the Industrial Automation and Instrumentation and the blended approach that was taking when delivering the program. The program was developed in consultation with regional manufacturing employers to ensure that the modules on the programs were relevant, up-to-date, and geared towards up-skilling or making students fully job-ready.
The aim was to provide a high practical content which complements the theory provided in the online lectures, and provide experience in the build & test of specific circuit designs.

In this approach, experience was gained by:

- The students in specific problem solving scenarios.
- Additional skills gained by the students in practical electronic hardware build & test aspects.
- The educators in addressing the needs to run the teaching style adopted.

The E-learning Development and Support Unit (EDSU) at Institute of Technology, Tralee designs, develops and supports the delivery of blended learning courses, promotes Digital Literacy and administers Blackboard, the Institute's Learning Management System. Established in 2012, EDSU brings together subject matter experts, education developers, instructional designers and content support specialists in a collaborative dynamic environment to produce courses in a blend of face-to-face and online delivery. [5] EDSU supported the development of the Certificate in Instrumentation and Automation.

In *Section 2* we will discuss aspects relating to the topic of Industrial Automation and Instrumentation that are of specific importance to the teaching undertaken. This is followed in *section 3* by an overview of the program and its links to other aspects of teaching. *Section 4* will discuss a number of observations from the first running of the program. The paper is concluded in *section 5*.

2. Aspects and Importance of Industrial Automation and Instrumentation

Automation and Instrumentation is a field of study which focuses on the applications (rather than the theory) of engineering in modern technology. Courses like this provide a basic understanding of the study and practice associated with electrical, mechanical and production engineering and technology disciplines. This programme has produced graduates who are competent to work as automation and instrumentation engineering professionals in a wide range of enterprises, including manufacturing, construction and service organisations. In Ireland more than 200,000 small and medium sized enterprises employ over 655,000 people and contribute €10 billion to the Exchequer each year [6]. Many SMEs employ staff in manufacturing and process-flow automation, including process and monitoring functions. This course equips them with tools and methods based on state-of-the-art automation and instrumentation knowledge, and allows their associated industries to progress both in manufacturing efficiency and quality standards. It is of vital importance in their organisations.

This course was designed for persons who had previously worked in a technical craft area or for those who want to pursue a career in mechanical and electronic (mechatronics) engineering and need to develop their knowledge and skills. The course combines the fundamental principles of mechanical engineering technology with knowledge of electrical and electronic circuits to design, develop, test and manufacture electrical and computer-controlled mechanical systems.

Graduates from this Certificate are involved in a range of careers that include; Process Automation, Robotics, System Integration, Embedded Programming, Sensor systems and Control systems.

3. Program aims and objectives

The aim of the course, leading to a the Certificate in Industrial Automoation and Instrumentation, is to produce graduates who are capable of improving the automation and measurement capabailities in a wide variety of manufacturing industries. The aim of the programme is to deepen theoretical and conceptual understanding, encourage critical thought and analysis commensurate with that of a EQF Level 6 graduate and instil within the student sufficient self–confidence to enable him/her to take their place in the professional world with its requirements to initiate and adapt to the changing requirements of a modern manufacturing industry.

In this course the student learns automation and measurement techniques, and applies them to solve real-world, practical challenges in industry. With the aid of interactive online multimedia, online tests, hands-on, practical tutitian and self-directed learning the students learns to apply automation and instrumentation methods to improve both quality and efficiency in a manufacturing process, see figure 1. The program is based around 3 x 10 Credit modules (3 hours online contact per week for 12 weeks) and 1 x 5 Credit module (2 hours online contact per week for 12 weeks). There is a requirement of attend the Institute to undertake approximately one full day of laboratory sessions each month.

The course modules are as follows:

- Instrumentation (10 Credits),
- Mathematics for Engineers (10 Credits)
- Computer Integrated Manufacturing and Automation Technology (10 Credits),
- Programming, Communications and Interfacing (5 Credits)

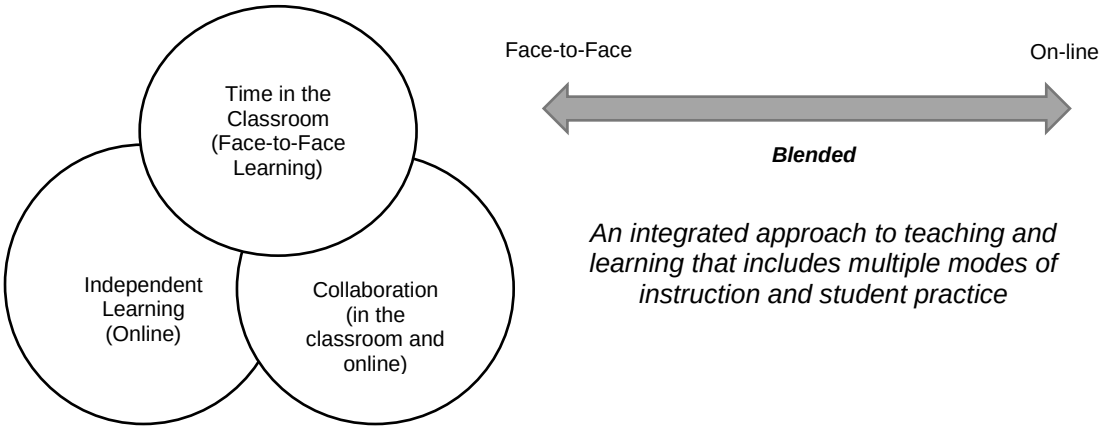

Figure 1: Blended Learning Environment

The objectives of the course are to enable graduates to:

1. Have the ability to adapt to different work and social environments which would provide for a full professional career in automation and instrumentation engineering.
2. Develop habits of learning, understanding and structured thinking.
3. Build on the knowledge and skills developed in the workplace.
4. Achieve an appropriate balance between in-depth knowledge of fundamental concepts and their practical application.
5. Develop analytical skills.
6. Have a capability to contribute to strategic planning.
7. Have the foundation necessary to progress to a higher level degree programme.

The main aims of the program are to:

- Provide a discussion into, and application of, Instrumentation concepts in the manufacturing industry.
- To introduce the design and testing of specific circuit architectures commonly encountered.
- To practice the *build & test* of an electronic circuits emulating a complex digital logic in both fault-free and specific fault conditions within the structured laboratory sessions.

The course has been developed taking into account the new teaching and learning strategies adopted by the institute, including a learning outcomes approach along with different assessment strategies. The modules are delivered in semesterised format, with weekly lectures delivered online through the use of video lectures which can be accessed at any time by the student. Tutorials take place over live video converence facility, with the use of interactive learning tools. All online elements of this course have been developed through consultation with ITTs Instructional Design Team. All practical elements of the course take place over 3 'on-site' days per semester with the student present on campus. This delivery format was been designed to specifically accomodate those students who are currently employed and aspire to up-skill in the area of Industrial Automation and Instrumantation.

4. Observations from the program

As part of the entry requirements for this program the students were asked to complete a portfolio detailing experience within the industrial manufacturing sector. This industrial experience in excess of 5 years was required and was accompanied by a letter of recommendation from suitable management personnel within the company. The portfolio detailed the responsibilities, technical knowledge gained, independent and team-based projects undertaken and the student's role within these projects.

The program was run for the first time in Autumn Semester 2012 to a class of 18 students. Class size was an important factor in the running of the practical sessions. In these sessions work was undertaken in groups of two, with each student concentrating on a particular aspect of the circuit build & test. However, in assessment, individual reports and presentations were required.

The online lectures were arranged such that the basic material required within the laboratories was provided and discussed immediately prior to the laboratory sessions for which the information was

required in. However, a certain level of previous electronic hardware experience and understanding was required, the level of which varied within the class. Where additional knowledge in certain practical skills was required, these were provided on an informal basis by the support staff, in addition to the students providing support amongst themselves.

From personal observations about developing and running the program:

- A large development effort was required to allow linking the online lectures to the laboratory sessions and prototyping/debugging the online learning environment. The laboratory circuits were chosen in order to have two levels of meaning. Firstly, the built circuits could be basically tested and working even if a detailed understanding of the circuit was not known. Secondly, specific subtle features of the circuit operation could be identified by persons who were able to obtain a more detailed understanding of the circuit operation.
- The students gained additional experience in the use of PC software tools that the majority had not used before. In particular, for the project work, detailed reporting was required due to the distance learning element. At first, the majority of the students were somewhat hesitant in learning suitable documentation tools but once they had been shown suitable method reports they were well developed and presented.
- It was interesting to see how the students supported themselves and the effort they put into each of the modules. Online collaboration outside of scheduled classes became the norm.

From feedback from the students themselves, the following observations have been made:

- They responded well to the practical work and felt that it linked into the formal theory within the online lecture sessions.
- Whilst a number of the students had previously worked on electronic circuit/system production test during their previous *work experience*, not all of the students were experienced in dealing with the low-level software programming and hardware build/test required within the program.
- Experience gained by the students was of great benefit when they returned to their employers.

5. Conclusions

This paper has described the rationale and implementation of a new online program in the area of industrial instrumentation and automation. The program is based around an introduction to Mathematics, Robotics, Instrumentation, Computer Programming and Interfacing and is designed to facilitate the up-skilling of current staff within the manufacturing industry when they are in full time employment. This was aimed at providing a blended high practical content that complements the online theory provided. The rationale into the role for the automation and instrumentation engineer in the manufacturing industry and aspects relating to the need for a suitably styled teaching and learning environment was provided. The program syllabus was introduced and the links the to the EDSU support initiative was provided.

References

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