How The Infinity Project, the LEGO Mindstorms NXT Robot and National Instrument's LabVIEW Software are being Combined to Transform Engineering Education in Ireland at Fourth Grade Primary School and Upwards

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Abstract

The Infinity Project© is a programme created in the late nineties by Southern Methodist University (SMU) in Dallas, Texas, USA. It is presently taught in high schools in over 37 states throughout the United States to interest students in engineering and technology as a career and in universities to help retention. The programme was designed to answer the perennial student question "why do I need to learn this" by connecting the relevance of science and mathematics to everyday digital devices such as: cell phones, MP3 players, the Internet, etc. The School of Electronic and Communications Engineering (SECE) at the Dublin Institute of Technology (DIT) is the first third level School outside the USA to facilitate the teaching of The Infinity Project. The Project's curriculum is included in the first year of all SECE's programmes. SECE is also supporting the implementation of The Infinity Project in a number of secondary schools in Ireland. This is the first instance of a collaborative initiave between the US and Ireland in second level education. A modified version of The Infinity Project now forms part of the Pre-Apprenticeship/Youthreach programmes which are designed for early school leavers (15 to 20 yrs) and funded by the Irish Training and Employment Authority (FAS). A further stage of development of The Infinity Project began in February 2009 when elements of the Project began to be introduced to the curriculum in Primary schools (age 9+ years) using the LEGO Mindstorms NXT robot as a platform.

Introduction

Over the past number of years the government and state agencies have made several attempts to promote Ireland internationally as a knowledge based and innovation-driven economy. However, the development of a knowledge economy is dependant on a strong supply of scientists, engineers and technologists. One of the most important economic and educational challenges we face in Ireland is the shortage of young students pursuing careers in engineering and technology[1]. Today, our students continue to see little relevance in the traditional mathematics and science curriculum and this sadly suggests that the unfortunate trend will continue into the foreseeable future. Recent studies have shown that every engineering job generates five additional jobs, but that the gap between supply and demand for engineers and technicians is growing far too quickly [2]. Latest figures released in August 2008 show that, despite the current economic downturn, there are 10,000 vacancies in the computing and IT sector, and 5,000 jobs available in engineering.

"The failure to fill all available places on honours engineering courses is a constant cause of concern, and is linked to the issue of the numbers achieving at least a grade C3 in Higher Level Maths"[3]. This provokes considerable debate each year, with calls for greater emphasis on maths all the way through primary and secondary school. In an Irish Times interview on 'the drop-off in interest in the sciences', Dr. Danny O'Hare, (Ex-President, Dublin City University) stated "The State now finds itself confronted by a marked fall-off in interest in the sciences in the educational system. The development has nothing to do with job opportunities for science and engineering graduates. It is to do with what is taught in our schools and how it is taught. There is too much talk and chalk involved in the teaching of science in secondary schools".

Results published in August 2008, show that 5000 of the 50,000 students who sat the Leaving Certificate examina-

tion in June 2008 failed to gain a pass grade in any of the mathematics programmes offered. Poor performance in mathematics, however, is not just an educational concern. It also has potentially severe economic consequences, given Ireland's desire to develop a knowledge-based economy. The low numbers of female students taking higher level papers in mathematics and science subjects in the Leaving Certificate further compounds this problem.
In 2004, Ireland had the equivalent of 5.7 researchers per 1,000 of total employment, compared to the OECD average of 6.6 with peaks of 17.7 in Finland and 10.6 in Sweden.

A programme, called The Infinity Project[4], created in the late nineties by Southern Methodist University (SMU) in Dallas, Texas is used currently in over 37 states throughout the United States to help high schools incorporate state-of-the-art engineering and advanced technology into the curriculum. The programme was designed to help students understand the real-world relevance of science and mathematics and thus attract them to high-tech careers. A number of US based universities have adopted The Infinity Project in an attempt to improve student retention in engineering programmes. Michael Tully of the School of Electronic & Communications Engineering (SECE) in DIT [5] obtained the support of SMU to use The Infinity Project in SECE programmes and to facilitate and support its implementation in secondary schools in Ireland. Ireland is the first country outside the US to be permitted to do this.

Student Progression at Third Level

Progression continues to be a major problem in engineering and technology programmes. In some disciplines, half the college engineering students do not progress to their second year and the overall graduation rate is often less than 40%. This problem is largely due to the lack of preparedness of students entering engineering and technology programmes after secondary school. In particular it has been attributed to the lack of a strong foundation in mathematics which results in few students having the skills required to succeed in college engineering programmes.
Another important contributory factor, is poor initial choice of programme which results in students having no clear motivation for attending. In Ireland, under-graduate third level education in institutions supported by the government is free. Unlike in the US, for example, few students fail to complete their chosen programme due to the financial burden of tuition fees [7].

The Infinity Project©

In the mid 1990s, the United States also experienced falling student numbers entering engineering and computing programmes. A key solution was found by The Institute for Engineering Education at Southern Methodist University (SMU), Dallas, Texas. Helped by substantial industrial and federal funding Dr. Geoffrey Orsak, Dean of Engineering headed the creation of a programme aimed at increasing the quantity, quality and diversity of students entering college engineering programmes. The programme, called The Infinity Project, began in 1998, and is the first in the US to help high schools incorporate state-of-the-art engineering and advanced technology into the curriculum. The programme was designed to help students understand the real-world relevance of science and mathematics and attract them to high-tech careers. The goal of The Project is to make sure that every high school student has access to an exciting engineering curriculum at a time when it can influence their choices about advanced courses in mathematics and science and about potential careers in technology. However, The Project is a very useful introduction to technology that will benefit all students irrespective of their choice of future career. It teaches a systematic and logical approach to problem solving which is a very necessary skill to develop in our future labour force. The Infinity Project Kit is shown in Figure 1.

Figure 1

In its first two years more than 2,000 students in nine states participated in the programme, and 65% of them enrolled to pursue engineering in college. Young women formed 55% of these students of which nearly 50% came from minority and disadvantaged backgrounds. At present the programme is taught in over thirty seven states. The curriculum of The Infinity Project focuses on the mathematics and science fundamentals of the information revolution and teaches students how engineers create and design the technology around them. Hands-on laboratory exercises utilise advanced digital signal processors (DSPs), the technology that powers electronic devices ranging from cell phones to dishwashers. DSP is the fastest-growing segment of the semiconductor industry. The Infinity Project is unique and innovative. Not only in content but also because it is taught through specially designed laboratory-based exercises that encourage interactive and collaborative learning. The laboratory programme uses National Instrument's LabVIEW software.
The Infinity Project curriculum encourages students to be curious about mathematics and science by connecting their relevance to modern technologies such as: MP3, CD and DVD players; cell phones; portable video players; digital cameras etc. The Project curriculum sharpens mathematical and science based problem-solving skills and encourages students to be innovative and to develop a logical thinking process.

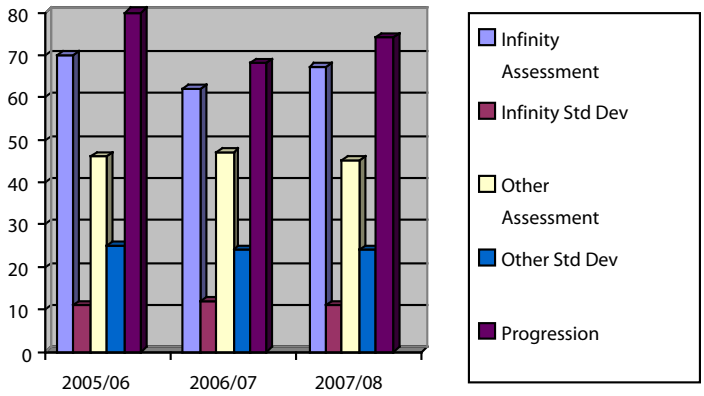
The Infinity Project in DIT

The School of Electronic and Communications Engineering (SECE)[5], Dublin Institute of Technology, has equipped a special purpose laboratory with the necessary hardware and software to enables it to teach The Infinity Project. Two stand-alone modules have been developed based on The Project and are included in the first year of all SECE's programmes.

Programme delivery is over two thirteen week semesters of four hours per week. Implementation is fifty percent laboratory/lecture time. The laboratory work consists of hands-on exercises that are carefully integrated with the course materials. The laboratory exercises are implemented using a cutting-edge signal processor and graphical programming software LabVIEW both of which are produced by National Instruments. These exercises permit the students to build complex systems using simple functional blocks.

The Infinity Project is in its third year of implementation in DIT. It commenced in 2005. In the academic year 2005/2006, students achieved an overall assessment mark of 70% in The Infinity Project. The standard deviation was 11. In other subject areas the overall mark was in the range 50% to 55% and the standard deviation 20 to 25. Attendance in the Infinity Project laboratory was almost 100%. The progression rate of students was 80%. These results are in line with some universities in the US [8][9].
The results for the three academic years 2005 to 2008 are shown in Figure 2.

Figure 2



The Infinity Project in Secondary Schools in Ireland

One of the key recommendations of a report in 2005 titled "Educating the Engineer of 2020" from the National Academy of Sciences in the US, stated that engineering schools should lend their energies to national efforts to improve mathematics, science and engineering education at 2nd level [10]. The School of Electronic and Communications Engineering (SECE) is supporting a pilot of The Infinity Project in a number of secondary schools in Ireland. SECE is following the same process of implementation as in the US. To date over 80 secondary school teachers of mathematics and science have attended SECE for training. The teachers attended in their own time and at their own expense, which is undoubtedly a true testimony to their dedication and the strength of The Project.

Mr Michael O Leary, National Coordinator, Transition Year said " The Infinity Project is a very exciting and innovative programme. The aim of transition year is to be educational, vocational and to help students in their personal development. The implementatoin of this Project in transition year has my full support and I can give it my highest recommendation."

The Project is supported by industry notably by The American Chamber of Commerce in Ireland which represents over 600 US based companies. Students of Loreto Abbey School, the first all female school, demonstrate The Infinity Project to US Ambassador Thomas Foley in May 2007[11]. See Figure 3.

Figure 3

Teacher Feedback

Mr. Brian Mooney, educational correspondent for The Irish Times wrote in a special report on Science, Engineering

and Technology in May 2007 titled “New Project Makes the Right Connections”:
“Recently, teachers involved with The Infinity Project, and working with students on their selection of subjects for the Leaving Cert, have reported a dramatic improvement in interest in higher level maths, chemistry and physics along with a strong interest in the new Leaving Cert Technology subject being offered to students for the first time in September 2007. For these schools it has been claimed that this increase in interest can be attributed to a combination of factors including the new junior cert science curriculum, improved facilities and links to the real world of science and technology which they can explore through The Infinity Project”[12].

The Infinity Project in the State Training and Employment Agency (FAS)

A pilot of a modified form of The Infinity Project was undertaken in five Community Training Centres (CTCs)[13] which are funded by the Irish State Training and Employment Authority (FAS). It is called The Infinity Project for CTCs (IPCTC) programme and concluded in July 2008. The learners are early school leavers, aged 16 to 20 years, who have not completed any formal State educational programme. The FAS programmes in which The IPCTC has been included are Pre-Apprenticeship (PPA) and Youthreach which are government initiatives to promote second chance education.

The Infinity Project for CTCs (IPCTC) is broadly based on the curriculum of The Infinity Project but employs teaching materials of a more visual nature. In addition to modern digital technology, the curriculum includes the use of a diverse range of software packages such as Computer Aided Design and Web Page Design. As a result the learners are provided with the opportunity to acquire a wide range of computer skills.

The curriculum material is presented through a series of PowerPoint slides in the computer laboratory. Conventional classrooms are not used. The object of the programme is to stimulate the learners back into more traditional education. Some learners may have learning difficulties, such as dyslexia and textual content is minimised where possible. The laboratory activity of the programme is the predominant element and accounts for 75-80% of the total teaching time. A series of step-by-step laboratory exercises beginning with the creation of very simple systems as block diagrams allow the learners to become relaxed and confident in the use of National Instruments LabVIEW software.
The learners proficiency in the use of the software increases rapidly to a stage where they can build complex Virtual Instruments such as the vending machine illustrated in Figure 4.

Figure 4

The IPCTC was evaluated under several objectives most important of which was to evaluate the effectiveness of the pilot in developing learner conceptual skills.
The salient points are listed below:

- The majority of CTC staff view access to The Infinity Project as a "God-given right" as it has "tremendous riches" for all students.
- The reception of The IPCTC was overwhelmingly positive among CTC staff and allows students to get some appreciation of "the technology under the hood".
- Several instructors commented that a great strength of The Project is its contribution to fundamental learning and offers transferable skills e.g. conceptual skills, logical reasoning, planning skills and problem solving skills.
- A great virtue of The IPCTC is that it can help the learners come to terms with this technology and that it is not something to be frightened of.
- Both The Infinity Project Director and the CTC instructors were amazed at the "phenomenal pace" at which students progressed through the laboratory material.
- The pilot of The IPCTC has stimulated clear enthusiasm. It is evident that this energy is being communicated in the classroom and is proving to be very significant in retaining the attention of students.

An Introduction to The Infinity Project in Primary Schools

A pilot of a programme which could be considered to be the first steps to The Infinity Project began in primary schools in February 2009. The pilot is being implemented as a component of the DISC Computerisation Project which is constituent part of DIT's Community Links programme headed by Professor Tommy Cooke [14]. The DISC Project operates in 38 Dublin inner-city disadvantaged primary and secondary schools. DISC is involved in the installation of computer resources in schools and the implementation of teacher training as a means of integrating the use of computers into the learning/teaching process in all curricular areas.

The LEGO Mindstorms NXT robot was chosen as the platform for the pilot and the pupils selected are girls and boys aged 9+ years. Fourth class pupils of George's Hill Girls Primary School are featured in Figure 5 during a Mindstorms class session. The LEGO Mindstorms NXT forms an ideal platform since its graphical programming software NXT-G is also written by National Instruments. The pilot programme uses NXT-G as a first step in learning graphical programming techniques leading to the building of simple Virtual Instruments using LabVIEW. It is also used as a mechanism to bring relevance to their daily classes in mathematics.

To date the pupils have shown great interest and enthusiasm. This is a most important development in education in Ireland. The Mindstorms robot has been used by teachers to stimulate interest in engineering for a number of years. However this connection to The Infinity Project is unique and would not have been possible without the vital link of LabVIEW software.

Figure 5

Conclusions

Ireland, like so many other countries, is facing a crisis due to the poor take-up of programmes in science, engineering and technology at third level. Latest figures released in August 2008 show that, despite the current economic

downturn, there are 10,000 vacancies in the computing and IT sector, and 5,000 jobs available in engineering [3]. The problem is that students see mathematics and science as boring and irrelevant.

The Infinity Project is innovative and allows students to see the application of mathematics and science to modern digital technology at first hand. The Project material can be included early enough in their studies to encourage them to pursue advanced mathematics and science courses at a level which will allow them access to future careers in technology and engineering.

This is a great opportunity to make a real and substantial addition to the second level curriculum and to promote technology. A real danger exists that if we, as a nation fall behind in our production of engineers and technicians, it has the potential to have a serious negative impact on our economic growth.

The inclusion of The Infinity Project on engineering programmes at third level has a very positive effect on student retention. Increases are in line with US universities.

The FAS/DIT programme, based on a modified version of The Infinity Project (IPCTC), allows learners to come to terms with mathematical and science concepts previously considered beyond their scope. The learners are acquiring new computer and problem solving skills and a genuine insight into modern digital technology which would have been inconceivable before the adoption of this programme.

The addition of primary schools to the programme is a most important advancement as it is well noted that attracting students to mathematics, science and technology must begin at the earliest possible stage in a student's development. The LEGO NXT programming language NXT-G, based on National Instrument's LabVIEW software also drives The Infinity Project exercises and therefore provides a vital link and an ideal platform for beginners.

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