2006-1908: DEVELOPMENT OF AN INTERNATIONAL COLLABORATION IN ELECTRICAL (AND RELATED) ENGINEERING DISCIPLINES BETWEEN THE COLLEGE OF TECHNOLOGY, PURDUE UNIVERSITY AND THE FACULTY OF ENGINEERING, DUBLIN INSTITUTE OF TECHNOLOGY

Richard Hayes, Dublin Institute of Technology

Robert Herrick, Purdue University

Development of an International Collaboration in Electrical (and related) Engineering Disciplines between the College of Technology, Purdue University and the Faculty of Engineering, Dublin Institute of Technology.

Introduction

The College of Technology at Purdue University in the United States of America and the Faculty of Engineering at the Dublin Institute of Technology (DIT) in Ireland have, during the past two years, been working to develop an International Collaboration. This paper will describe in detail the issues related to the successful evolution of the collaboration between the departments of Electrical, Electronic Engineering in the two institutions. The main purpose of this paper is to start the process of documenting the collaboration process and to provide an ongoing source of reference for other institutions undertaking similar collaborations between the United States and Europe.

The emergence of Europe as an economic and federal entity over the last twenty years together with its multicultural and multilingual nature has meant that considerable effort has been devoted to the development of collaborations between academic institutions across the continent at undergraduate, post graduate and at research levels. It is hoped to bring the resulting accumulated experience to bear on the building of this collaboration between the United States and Europe.

European international exchange programs in engineering and technology have been strongly supported through organizations such as Erasmus, Socrates, and Leonardo[1] to encourage mobility within Europe. The United States does not have a corresponding government program that generously supports such interchange. The U.S. Senate declaration of 2006 as the "Year of Study Abroad" combined with the U.S. Senate's Lincoln Report[2] that recommends that 1,000,000 U.S. students need to be studying abroad by the academic year 2016-17 lends impetus to international initiatives and outreach between U.S. universities and the rest of the world[3,4]. Scholarships are highly recommended by the Lincoln Report to encourage this major global outreach of U.S. students, but in the interim it is the efforts of individual universities reaching out that are making the difference. Examples of highly successful U.S. programs are illuminated annually as winners of the Paul A. Simon Award for Campus Internationalization[5] and serve as good examples of proactively bringing the global experience to students.

This paper focuses on the forming of the Purdue College of Technology – DIT relationship and will review the similarities and the differences in teaching and other practices in a number of departments in both institutions and will report on some of the difficulties, successes and failures encountered in the process so far.

The paper will establish the parameters of the collaboration by firstly providing a comparison of the organizational structure at departmental level, identifying programs taught, subjects/courses and their relative levels and time lines.

Collaborative activities include student exchange, faculty exchange and faculty collaboration. The paper discusses the process of encouraging students and faculty to 'buy' into the process and reviews specific cases of exchange and collaboration.

Paper Overview

This paper will firstly outline and review the areas or lines of activity which need to be addressed to ensure a successful ongoing engineering technology international collaboration from the department head's perspective. Each of the areas is briefly discussed in terms of various approaches towards making progress in the form of guidelines, protocol proposals, course and curriculum matching, language and terminology normalisation or matching, calendar comparisons and actions to be taken.

The paper will then go on to provide an overview and then address in some detail the practical and organizational issues which need to be addressed. These will include comparison of departmental organizational structures, curriculum subject mapping, calendar mapping and its impact on travelling students, identification of undergraduate projects, short visit structures, comparison of terminology, and a glossary.

Outline of Issues for Collaboration

This section proposes an outline plan or roadmap which will help to establish a structure within which the development of the collaboration can be managed (see Figure 1). Here we can list problems and challenges we experience (for each of the following points) when pursuing collaboration and expand upon the main areas for collaboration, i.e.

- Faculty exchange
- Undergraduate exchange
- Postgraduate exchange
- Industrial internships
- Research and development projects
- Scholarly work
- Professional society work, e.g., SEFI, ASEE, etc

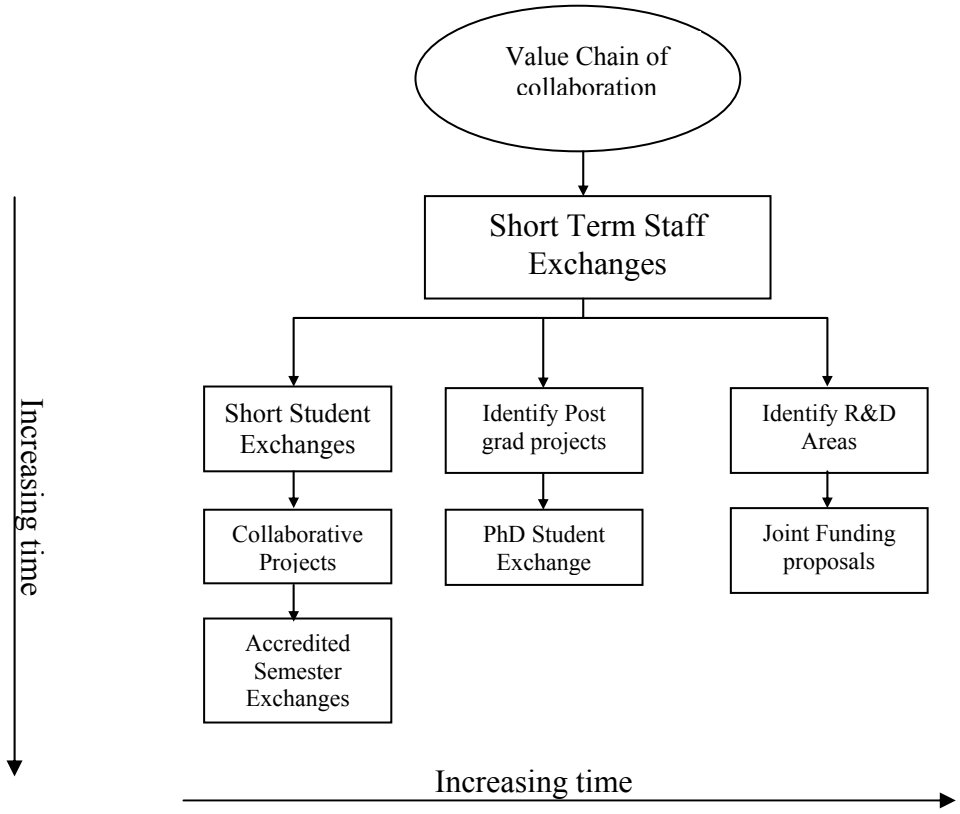

Figure 1 – Value Chain of Collaboration

Faculty or Staff Exchange

The experience of this collaboration is that short-term (i.e., typically no more than three weeks) exchanges work well as an initial step. Peers with similar interest/research areas and who are interested in pursuing short-term exchanges can be identified. When we think about 'exchange', we are often inclined, by default, to pursue synchronous exchange. However, implementing an initial asynchronous exchange proposal has the advantage of hugely strengthening the personal relationships between peers and also ensures that the faculty member has a personal mentor on the exchange site to assist him in his immersion into the new culture. Additionally, this model allows time for detailed discussion of scholarly work, research and development projects, teaching 'best practice' and joint-student project potential This model has already worked well between the School of Manufacturing and Design Engineering at DIT and the School of Industrial Technology at Purdue. Initial short-term asynchronous exchange can build the confidence of participants in the value of the exchange process. Typically, during a short term exchange, faculty members lecture at the exchange site in an area of special interest. Planning and appropriate timing of asynchronous exchange together with the support of management and colleagues are important success elements to minimise disruption at the home site. Asynchronous exchanges can provide the basis for the development of specific joint scholarly work and for the initiation of collaborative student projects. They also provide the foundation to future long-term (e.g., 1 semester) synchronous exchanges between faculty members.

Undergraduate Exchange and Collaborative Teaching
This is an area of huge interest to undergraduates. Short-term student exchanges are an initial step which creates excitement and momentum among the student population for participation in ongoing collaborative projects. The mismatch in semester calendars can provide a window of opportunity for students to pursue short-term exchange without undue disruption of their studies at their home college. Short-term exchange may just involve students attending lectures at the exchange site. The important point about short-term exchanges in the early phase of a collaborative effort is not what they may achieve in formal technical education. Their real value is that they provide an authentic cultural and educational experience among the student body visiting the exchange site. This in turn acts as a very strong catalyst among the student population for the pursuit of future collaborative possibilities (e.g., full semester joint projects or full semester exchange). Short-term student exchange process has already taken place between students from the School of Manufacturing and Design Engineering and the Department of Industrial Technology at Purdue. Joint student projects can be aided by video-conferencing. They also can typically involve a short student visit for final project presentations. The first joint student project between the College of Technology (Purdue) and the Faculty of Engineering was pioneered by Mr. Michael Ring (School of Manufacturing and Design Engineering, DIT) and Professor Miletta M. Tomovic (MET Department, Purdue University).

Longer term exchanges are the final aim of an undergraduate 'study abroad' program. The student will undertake a full agreed semester of study which will fulfil their requirements for the program from the parent institution. Such an undertaking will require careful coordination between both institutions covering everything from travel and accommodation to curriculum matching. This is discussed further in the section *curriculum and subject mapping* below.

Postgraduate Student Exchange
There is opportunity for both staff and students. Staff who may be interested in pursuing PhD opportunities and who meet the entry requirements have the opportunity to pursue the exchange. Equally, qualifying students completing their undergraduate studies may be attracted to undertake at Masters or Ph.D. program at the exchange site. This is likely to be attractive to students who have already pursued short-term exchange, full-semester exchange or joint projects at undergraduate level.

Industrial Internships
Each of the colleges has existing industrial links. In Ireland (and particularly in the greater Dublin area) US trans-national corporations have built a very significant manufacturing (and more recently R&D) presence. Equally, Indiana has a strong industrial base with a strong life-sciences, heavy engineering, motor industry and electronics presence. There may be opportunities for students at either site to pursue their internships abroad (while also linking into existing local college academic supervision process of their internship). Companies in both countries are happy to accommodate students in internships as a means of identifying potential employees.

Scholarly Work
Short-term academic exchange typically identifies opportunities and areas in which to pursue joint scholarly work. This has been found to be the case in the short term academic exchanges pursued to date.

Research and Development
Research and development initiatives will also emerge from healthy and energetic faculty collaborations. It is anticipated that such initiatives will come later in the collaboration. However initial seeds have been sown by virtue of the meetings between Michael O'Hair, Associate Dean of Statewide Technology And Engagement Purdue, and Mr. Tom Flanagan, Industrial Liaison Officer, for the Faculty of Engineering, DIT during the recent visit of a delegation from Purdue to DIT. These meetings included a program of industrial visits that will provide background knowledge and contacts to help with the process of developing ideas and proposals.

Professional Society Work Such as SEFI, ASEE, and IEEE
International professional conferences provide a convenient opportunity for networking with current partners and to explore other potential international relationships. For example, the authors of this article are currently collaborating and co-authoring this paper for the 2006 ASEE Annual Conference in Chicago, Illinois, which further matures the relationship. An additional advantage of this conference is that Purdue University is only a 2-hour drive from the host city, which will provide an opportunity to visit Purdue University again. Another example is the invitation by the Chair of the IEE Irish Signals and Systems Conference 2006, hosted by DIT, for two Purdue ECET faculty to attend and actively participate in the conference as a plenary speaker and to facilitate a 2-day teaching workshop. This invitation is a direct outcome from the international partnership between DIT and Purdue University. Not only will a healthy exchange of ideas occur in this forum, but the potential to expand international connectivity as well as further building of current partner relationships exists. New opportunities beget future opportunities.

Overview of Practical and Organizational Issues

In this section we review in some detail a range of practical issues which have to be addressed to progress the collaboration. These include:

- Comparison of Departmental Organizational Structures
- Curriculum Subject Mapping
- Calendar Mapping and its impact on travelling students
- Comparison of Terminology and draft glossary.

Comparison of Departmental Organizational Structures
This section reviews and compares the structures at departmental level in both institutions. As is pointed out in the comparative glossary below (see Figure 2), the Faculty of Engineering in DIT corresponds to the College of Technology at Purdue University. It is noted for the record that at Purdue there are two colleges directly related to the discipline of engineering, the College of Engineering and the College of Technology. The College of Engineering treats the discipline at

the more theoretical level while the College of Technology operates at the more practical level of implementation and industrial cooperation. While the Faculty of Engineering, DIT, could be said to operate across both these levels the relationship and collaboration described here is between DIT Engineering and Purdue College of Technology. It is worth pointing out that the "memorandum of understanding" which facilitates the collaboration exists at the institutional level and allows for cooperation, initiated correctly, at all levels and between all disciplines in both institutions.

The Dublin Institute of Technology is organized into six faculties, Engineering, Science, Built Environment, Tourism and Food, Business and Applied Arts. The organization of the faculty of Engineering with a focus on the "electrical" disciplines is represented in Figure 2.

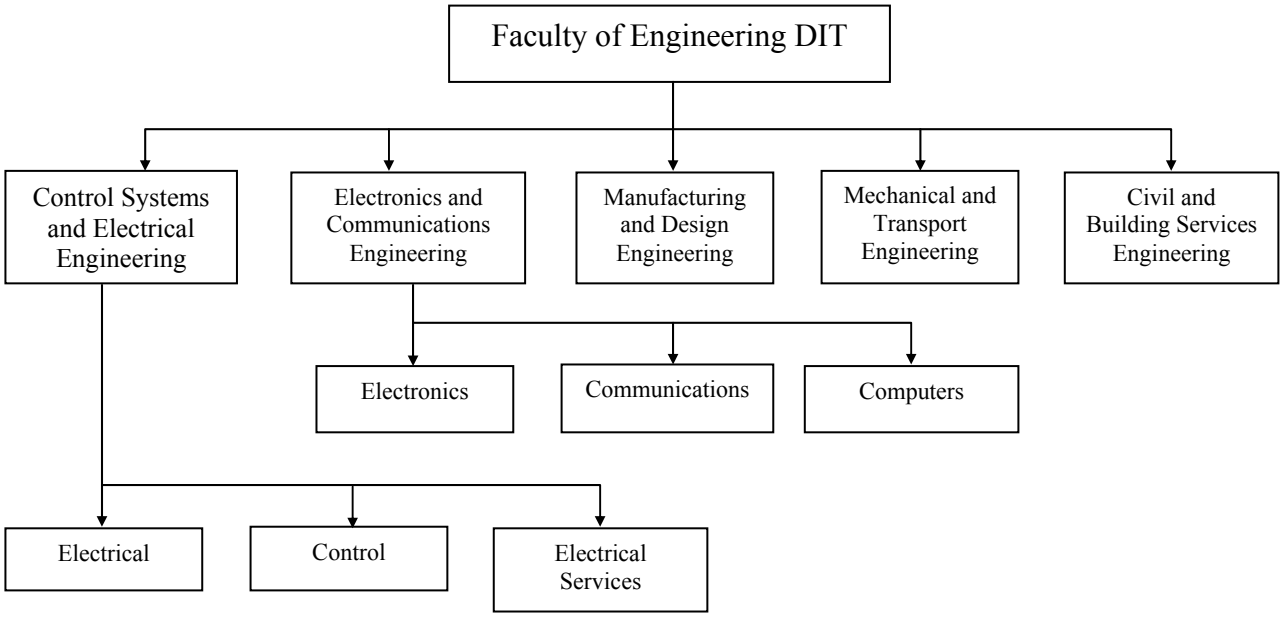

Figure 2 – Faculty of Engineering, DIT Organizational Structure

Undergraduate programs offered in the School of Control Systems and Electrical Engineering (CSEE) and in the School of Electronics and Communications Engineering (SCEE) are listed below in Table 1:

Code	Title	Level Duration	School
DT021	Honours Degree in Electrical/Electrical Engineering	Level 8 4 yrs	CSEE and SCEE
DT009	B.Eng.Tech. in Electrical Energy/Control&Automation Systems	Level 7 3 yrs	CSEE
DT010	B.Eng.Tech. in Electrical Services Engineering	Level 7 3 yrs	CSEE
DT008	B.Eng.Tech. in Electronics and Communications	Level 7 3 yrs	SCEE
DT081	Honours Degree in Computer Engineering	Level 8 4 yrs	SCEE
DT089	Higher Cert in Electronic and Computer Systems	Level 6 2 yrs	SCEE

Table 1- Undergraduate programs offered in Electrical/Electronic Disciplines in DIT

In addition both schools operate and contribute to taught masters programs offered across the faculty

The organization chart for DIT shown in Figure 2 may be compared with that for Purdue's College of Technology shown in Figure 3.

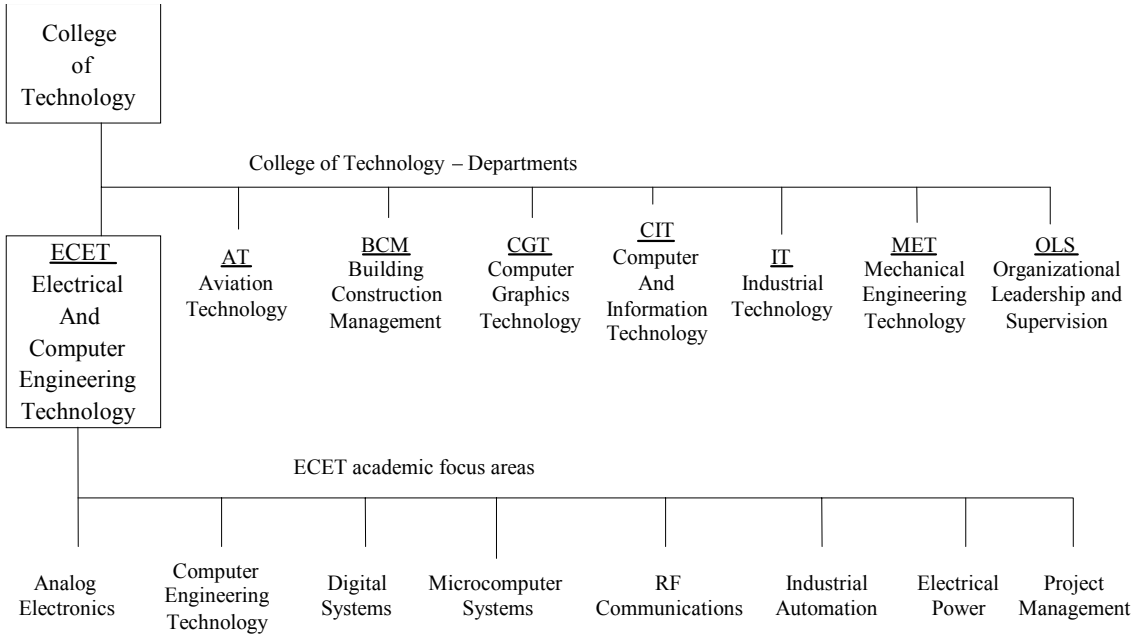

Figure 3 – Organizational Chart of the College of Technology – ECET Department Focus

Purdue's College of Technology is composed of eight departments. The Electrical and Computer Engineering Technology (ECET) Department is highlighted since this article is focused on this Purdue department. The ECET academic focus areas or electronics/electrical discipline areas are also highlighted in Figure 3. At first glance, there does not appear to be a direct correspondence of DIT's Faculty of Engineering program structure with that of the College of Technology's department structure. But upon further exploration, many curriculum content equivalents exist at the curriculum level. For example, Purdue's Electrical and Computer Engineering Technology (ECET) Department has curriculum content similar to that of DIT's (1) Control Systems and Electrical Engineering and (2) Electronics and Communications Engineering programs. Purdue's Mechanical Engineering Technology (MET) Department is a good match with DIT's Manufacturing and Design Engineering. Detailed discussions by the faculty at the course level is required to establish equivalent curriculum content as programs with similar content can be packed in a variety of dissimilar structures.

Notice the terminology difference. DIT refers to the "Faculty of Engineering" while Purdue's equivalent is the "College of Technology", which could be interpreted to be the Faculty of the College of Technology.

The overview of the Purdue University system is shown in Figure 4 to present the larger picture of curriculum offerings at Purdue University. Courses from other colleges at Purdue University would be available to students if prerequisites are met. Purdue was founded in West Lafayette, Indiana in 1869. Three regional campuses were established later as the educational needs of the State of Indiana expanded. Purdue West Lafayette is the largest campus and is considered to be the home campus of the Purdue University system. The College of Technology is one of 11 Colleges/Schools at West Lafayette and is the third largest college by student enrolment count. The College of Engineering is the largest college followed by the College of Liberal Arts.

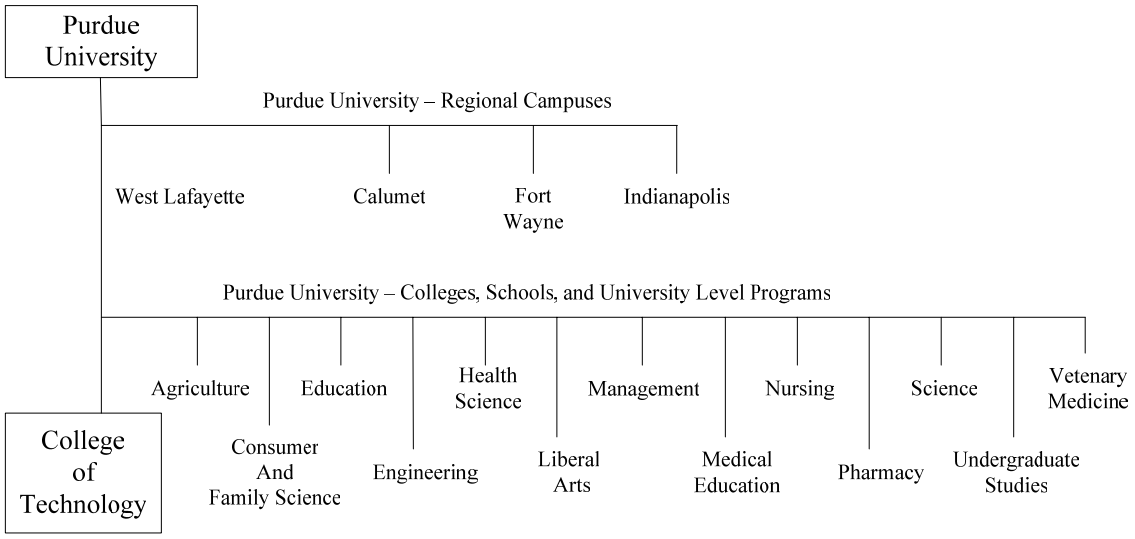

Figure 4 – Organizational Chart of Purdue University

Curriculum and subject mapping
In order to facilitate student exchange and 'study abroad' it is necessary to identify the appropriate material within each institutions curriculum that can be taken and be credited to the travelling student. This process is most important for the case of students taking full semester trips.

Programs taken by students starting out at DIT are listed in Table 1. The student initially chooses a program (course). The student then takes a fixed set of modules until the start of the third year or fifth semester. A choice of a 'major' topic is then available and the cohort breaks up into smaller groups for their major modules. Once this choice is made the student continues to complete a fixed set of modules except for one technical 'elective' available from a limited range in the final year.

Purdue's EET curriculum is very flexible in that the students do not take a given semester as a prescribed, fixed block of courses. The program is laid out in a suggested eight-semester sequence. Each student progresses at his or her own rate and may progress more rapidly in one subject area (such as analog electronics) faster than another; the only requirement is that pre-requisites are met. Figure 3 displays the major discipline areas within the EET program:

- Analog Electronics
- Computer Engineering Technology
- Digital Systems
- Microcomputer Systems
- RF Communications
- Industrial Automation
- Electrical Power
- Project Management

Additional signature areas and areas of interest include:

- Energy Management
- Forensic Engineering
- Power Electronics
- Automotive Electronics
- Cluster Computing

Also, the students come into the program with a variety of backgrounds. True freshmen enter the program from high school with that expected level of experience in mathematics and physics. However, nearly half of the EET program graduates actually started in a different major in the university, typically engineering or science, and have additional skill sets in engineering mathematics and science before transferring into EET.

Comparing DIT and Purdue curriculum content, the mathematics content sequence is different in that the incoming true freshmen typically progress through a four- semester sequence of algebra, trigonometry, differential calculus, and integral calculus. Subjects such as linear algebra and differential equations may have been taken by our transfer students but would not be taken by our true freshmen students until the third and fourth years as elective mathematics (depending upon their area of subject matter concentration).

Based upon this diverse context, Purdue students would not have a prescribed set of DIT courses from which to select; rather, Purdue EET students would select DIT courses based upon their interest, pre-requisite knowledge, and availability. This is a very liberal and flexible approach where each student is a unique situation and would work with their Purdue academic advisor and a respective DIT advisor to select appropriate DIT courses. The credit hour equivalency and course substitution for the Purdue EET program would be determined by the Purdue faculty.

Calendar mapping and implications for travelling students
To examine these issues we consider for example the calendars for both institutions for the academic year including Fall (Autumn) 2005 and Spring 2006.

	DIT	**Purdue**
Fall Semester '05	Class Begins:19th September '05	Class Begins:22nd August '05
	Class Ends: 16th December '05	Class Ends: 10th December
	Exam Schedule:9th-23rd January '06	Exam Schedule:12th-17th December
	Exam Board: 23rd-27th	
Spring Semester '06	Class Begins:30th January '06	Class Begins:9th January
	Class Ends: 12th May '06	Class Ends: 29th April
	Exam Schedule:15th May-June 2nd	Exam Schedule:1st-6th May

Table 2. Comparison of DIT and Purdue calendars for the academic year including Fall (Autumn) 2005 and Spring 2006.

From a logistics perspective, given calendar mismatches, it would seem more appropriate and easier to effect overseas transfers for DIT students in the Autumn Semester (i.e., Semester '05) rather than the Spring Semester. Equally, in usual circumstances, it would seem somewhat easier from a logistics perspective for Purdue students to come to DIT in Spring Semester.

Note there is also opportunity for short 1-week and 2-week interchanges of faculty and students without significant conflict with the home institution's schedule. DIT faculty and students could optimally visit Purdue at the beginning of Purdue's Fall Semester or the beginning of Purdue's Spring Semester. There is not such an obvious optimal exchange in the other direction. Purdue faculty and students would have to miss some course time during the semester to visit DIT. One possibility might be to utilize Purdue's spring break to minimize lost class time.

Some of the issues which have emerged from experience to date for students travelling between the School of Manufacturing and Design Engineering, DIT and the Department of Mechanical Engineering Technology, Purdue are summarised in Table 3 below.

	Students from DIT Travelling to Purdue	Students from Purdue Travelling To DIT
Autumn (Fall) Semester	Be at Purdue approximately a month ahead of usual DIT semester start, i.e., August 22nd versus September 19th. Have approx one months additional break in January i.e. finish in Purdue December 17th and re-commence DIT Spring Semester in DIT January 30th	Go to DIT approx. 1 month after start of usual Purdue semester. Return to Purdue ahead of DIT January exam schedule (to commence Purdue Spring Semester). This could effectively require commitment at DIT to the creation of a special assessment/exam schedule for these students outside of normal schedule probably in the last week of semester (either in-class or otherwise). These students would lose one week of the Semester relative to their Irish counterparts.
Spring Semester	Miss up to 2 weeks Purdue lectures at the beginning of the Purdue semester (since students would be completing Fall Semester Exams at DIT). Equally, they would be finished the Purdue semester as early as May 6th whereas their Irish classmates could be taking exams as late as June 2nd.	Go to DIT approximately 2 weeks after the commencement of Purdue Spring semester and return from DIT approximately 2-3 weeks after the end of the equivalent Spring semester in Purdue having taken DIT exams as normal. (Note if the Purdue students intended to take modules in the Summer Semester, they would miss two weeks of Purdue Summer semester i.e. Summer semester begins May 15th yet DIT exams can go on till June 2)

Table 3. Assessment of Potential Logistical Impacts of Calendar Differences in ’06-‘07 For Travelling Students (based on ’05-’06 calendar differences)

Comparison of terminology
A table showing a comparison of terminology between the institutions is provided for reference. This 'glossary' combines both institutional differences and national/cultural differences.

DIT	Purdue
Program	Course
Semester	Semester
Module	Subject
Lecturing Staff, Member of Staff	Faculty, Member of Faculty
Lecturer	Professor
Faculty (of Engineering)	College(of Technology)
Engineers Ireland (IEI)	American …..(ABET)
Postgraduate	Graduate
Undergraduate	Undergraduate

Comparison of Credit Scheme.

DIT has adopted the European Credit Transfer Scheme (ECTS) which may be summarized:

> Level 8 program, a program which is accredited by the professional institution as leading to chartered membership of the organization consists of 4 academic years at 60 ECTS credits per year. Programs are divided into 30 credit semesters with 6 discipline modules (subjects) worth 5 ECTS credits each. One 5 ECTS module(subject) comprises 100 hours of student effort generally consisting of 12 weeks of 4 contact hours and 52 hours of self directed learning.

The Purdue EET Program has a relatively standard US approach to curriculum plans of study and credit hour ratings:

> The Purdue Electrical Engineering Technology (EET) B.S Program is professionally accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC of ABET). Credit hours are allocated as follows:
> - 1 lecture hour (50 minutes of class time) counts as 1 semester credit hour
> - 2-3 lab hours (100 – 150 minutes of lab time) counts as 1 semester credit hour
> - For each hour of lecture, 2 to 3 hours of outside class time of study is expected
> - For each contact hour of lab, an hour of outside work is expected.
>
> A typical EET class would have a class pattern of 3 lecture hours and 2 lab hours. This would count as a 4-credit course. The total number of hours of expected work would be:
> - 3 lecture hours
> - 6-9 hours of outside work toward lecture
> - 2 lab hours
> - 2 hours of outside work toward lab
> - For a total of 13-16 hours

A Purdue ECET student would normally have 2 or 3 ECET courses during a semester with the remaining classes consisting typically of 3 credit courses in subjects such as mathematics, lab-based science, humanities, and so forth for a total credit hour load of 15 to 18 credits.

The faculty of the home institution must evaluate the equivalent value of work based upon the home institution's evaluation scheme for credit. That is, Purdue faculty must evaluate a DIT course for credit equivalence based upon Purdue's rules for evaluating credit without regard for the course's ECTS value. And likewise, the DIT faculty would evaluate Purdue's courses in terms of the ECTS evaluation scheme.

Conclusion

This paper addressed the first phase of forming an international collaboration and exchange of faculty and students; that is, the discovery and development of meaningful and beneficial relationships that lay the groundwork for an international exchange program. Before any cooperative effort can occur, the potential partners must discover each other and develop a relationship based upon mutual interest areas. In this instance, the approach is a concerted effort by one institution to search out and find similar programs internationally where future collaboration and exchange would be mutually beneficial. This is a major step unto itself. Nothing can progress until viable partnerships are discovered and formed. Also presented is the sequence of events to grow and mature such a relationship in a planned and orderly fashion to confirm the validity of the educational and professional relationship. This is an approach that has been used successfully in the past by Purdue's College of Technology. The establishment of the Purdue's College of Technology and the Dublin Institute of Technology afforded an excellent opportunity to document this major first step of the development of an international exchange program.

The evolution of establishing an international relationship requires multi-staged efforts by both institutions. Typically one party must take the initiative to explore potential matches and seek possible partnerships. For example, a Purdue entourage spent two weeks in June of 2005 visiting institutions in six European countries – strictly exploratory. One of those visits included DIT by one of the ECET faculty members.

If an initial visit is successful and a potential match is seen by both parties, follow up exchange visits by administrators and faculty leaders allows a deeper look and an opportunity to establish real relationships. The authors believe that a true mutually beneficial partnership can only be established through on-site visits so that each can absorb the other's environment: meeting administrators, faculty, and students; and also checking out the location and the facilities. If both parties want this relationship to go to the next level and really desire this partnership to be successful, then a general memorandum of understanding would create a non-binding but meaningful agreement to allow the exchange of faculty/students.

Before long-term exchanges can occur, the faculty need to really understand the opportunities at the other's institution and establish the details for such exchanges. The next stage would be the exchange of faculty, and hopefully some students, for a couple of weeks with faculty/students from each institution visiting the other's institution to allow more time to explore and drill more deeply. This would be a wonderful opportunity to also have the visiting faculty give guest lectures and have faculty/students attend lectures/labs for a really pragmatic sense of the curriculum level. Also this presents an opportunity to explore potential research and internship opportunities (by visiting local industries). Such activities will continue to build the bond between the faculty and the institutions, and prove the match. It will also give the faculty/students a practical glimpse into the environment in a short visit that can be utilized to work out any wrinkles for future long-term exchanges.

The Engineering Faculty of DIT and the Technology Faculty of the College of Technology (specifically the ECET faculty) are now at this juncture of creating long-term exchanges. The opportunity for short-term visits will be an on-going activity as well, especially for faculty.

As this relationship continues to mature, the authors plan to document their growth steps for others who may have interest in international partnerships; and possibly draw from their experiences. And, by way of example, co-authoring papers documenting the experience is another excellent way to expand the relationship and drill deeper into the details.

[1] *Exploring Sources of Funding for Lifelong Learning*, European Commission Education and Culture DG, Unit B1, Brussels, December 14, 2004

[2] Senator Durbin, R.J.; *The Lincoln Commission and Future of Study Abroad*, International Educator (Jan + Feb), 2006

[3] Loveland, E.; Murphy.C. *Education Abroad: Today and Tomorrow*, International Educator (Jan + Feb), 2006

[4] http://www.nafsa.org/

[5] *Internationalizing the Campus Report 2005*, NAFSA: Association of International Educators, 2005