

# Engineering Education in Ireland's Institute of Technology Sector\*

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*To secure a place at either a university or institute of technology a second-level student must accumulate a specific number of points in the national Leaving Certificate examinations. Points are awarded on the basis of student performance in either a higher level or ordinary level Leaving Certificate subject. As the mechanism for entry is competitive in nature, students do not always get the course of their choice and often accept courses for which they are unsuited. The national trend is that a decreasing numbers of students and students with a decreasing number of points accumulated are opting to study engineering. This is a trend that must be reversed if Ireland is to sustain its current levels of economic growth. This paper concentrates on the characteristics, challenges and innovations in the engineering education domain. It outlines the generic structure of education programmes currently offered by the institutes of technology sector in Ireland. Details are given of course entry requirements and how the institutes work with industry and respond to the needs of incoming learners. The author's course development and delivery model is included to give a flavour for course development and delivery across the sector.*

## INTRODUCTION

IRELAND has a binary third-level system of education mainly comprised of universities and institutes of technology. Both sectors offer the traditional range of courses in what may be termed the science, engineering and humanities areas.

To secure a place at either a university or institute of technology a second-level student must accumulate a specific number of points in the national Leaving Certificate examinations that are normally sat at age 17–18. The number of entry points that a student requires in any given year will vary, as the demand for the finite number of available places fluctuates annually. Each year students rank a number of courses they are interested in pursuing and hope they accumulate sufficient points to gain a place.

A situation has existed for a number of years where the overall demand for places far exceeds the overall supply. The result is that students have to compete for available places on the basis of the points they accumulate at Leaving Certificate. Projections suggest that this situation will continue into the early years of the next millennium. As the mechanism for entry is competitive in nature, students do not always get the course of their choice and often accept courses for which they are unsuited.

Points are awarded on the basis of student performance in either a higher level or ordinary level Leaving Certificate subject. The points scoring system is shown in Table 1.

Typically students will study 5–7 Leaving Certificate subjects at higher level, ordinary level or a mix of both levels. A student's highest scoring 6 subjects are considered in the points accumulation process. Therefore, students can accumulate points ranging from 600 ( $6 \times A1$ ) to 120 ( $6 \times D3$ ).

If we examine a random snapshot of the points required for entry to some university or institute of technology courses, as shown in Table 2 below, it is apparent that students with higher points are not selecting courses in the engineering domain. Unfortunately, this appears to be a characteristic of most education systems around the world.

Looking at the national picture for engineering courses the average points required to enter a four-year university engineering degree course for the year 1997 was 413. The average points required to enter a law degree in the same universities in the same year was 483. The average points required to enter a two-year institute of technology mechanical engineering certificate course was 194. The average points required to enter a two-year business studies course in the same institutes in the same year was 246. Students entering the certificate programme may also attain a degree-level qualification within the Institute of Technology sector. This point is dealt with in greater detail below.

The national trend is that decreasing numbers of students with decreasing points accumulated are opting to study engineering. This is a trend that must be reversed if Ireland is to sustain its current levels of economic growth.

The remainder of this paper exclusively concentrates on the characteristics, challenges and

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Table 1. Leaving Certificate scoring system

	Higher points	Ordinary points
Grade A1	100	60
Grade A2	90	50
Grade B1	85	45
Grade B2	80	40
Grade B3	75	35
Grade C1	70	30
Grade C2	65	25
Grade C3	60	20
Grade D1	55	15
Grade D2	50	10
Grade D3	45	5

innovations in the institutes of technology engineering domain.

### ENGINEERING IN THE INSTITUTES OF TECHNOLOGY

The Institutes of Technology comprising DIT and the former RTCs with some 65,000 students and 3,000 staff are significant players in Ireland's third level education market. They have an established and internationally recognised record of cost-effective academic achievement.

Dublin Institute of Technology, the oldest of the institutes, has a long tradition of producing engineers and technicians who have excelled in their chosen fields of work both nationally and internationally.

The majority of the remaining institutes were established as Regional Technical Colleges (RTCs) in the early 1970's as a direct response to Ireland's decision to move from a largely agrarian to a more industrialised economy. Allied to this decision was the desire to increase equitable, regional access to third-level education. At the time those responsible for the creation of the institutes could hardly have known that they were laying the foundation for a binary system of education that was to find admirers the world over.

Table 2. Snapshot of points required for entry to some courses (1997)

College	Course	Points
UCD (Univ. Dublin)	Law	490
UCD	Commerce & French	530
UCD	Physiotherapy	560
UCD	Engineering	465
UCG (Univ. Galway)	Commerce & French	495
UCG	Corporate Law	465
UCG	Marine Science	410
UCG	Mech. Engineering	380
DIT (IT. Dublin)	Design Visual Med.	855
DIT	Leisure Management	365
DIT	Tourism & Marketing	420
DIT	Mechanical Eng.	305
G-MIT (IT. Galway)	Art & Design	500
G-MIT	Business Studies	340
G-MIT	Heritage Studies	305
G-MIT	Mechanical Eng.	280

Many commentators have recently remarked that the institutes of technology had laid the human resource foundation underpinning Ireland's current economic success. This statement carries a high degree of truth in that most of the inward investment in Ireland over the past few years has been by organisations that require large numbers of technicians with certificate and diploma level qualifications in Engineering and Information Technology.

Recent achievements by the Industrial Development Authority (IDA) have meant that the sector will face an enormous challenge if it is to meet the projected demand for technician engineers over the next three years. This challenge is all the more daunting when we consider it against the backdrop described in the introduction of this paper.

#### Course progression and awards

A quasi-generic model of what Institutes of Technology do is represented by Fig. 1. The key design features of the model are that it is an education continuum with multiple entry and exit points.

A full-time student is initially offered a two-year certificate study programme. After two years of study successful students receive a certificate at pass, merit or distinction level. Those students with merit or distinction awards are eligible to apply for a year of further study and attempt to obtain a diploma level award. Successful diploma students receive awards at pass merit or distinction levels. Those diploma graduates with merit or distinction awards are eligible to apply for a further 2 years of study to obtain a degree level award with the normal classification system applied.

A national awards body the National Council for Educational Awards (NCEA) oversees the standards and levels of awards across the institute of technology sector and part of its role is to accredit course submissions from the institute of technology sector.

The institute of technology sector offers a large number of its courses using the NCEA Accumulation and Certification of Credits System (ACCS) to enable part time students, the majority of whom are in employment, to upgrade their skills and knowledge through self-paced part-time study.

Figure 2 shows the Certificate and Diploma graduate output from the institutes for the period 1972 to 1997. As we can see the total year-on-year output is increasing. However, this increase masks the fact that engineering output is reducing as fewer students choose to study this discipline.

If we examine the number of engineering graduates as a percentage of the total graduating from the sector we can see the downward trend in Fig. 3.

These figures cause concern within the institutes, within industry and should be a cause for concern within the engineering profession in general. In Ireland we need to structurally address the problem of insufficient students opting for careers in

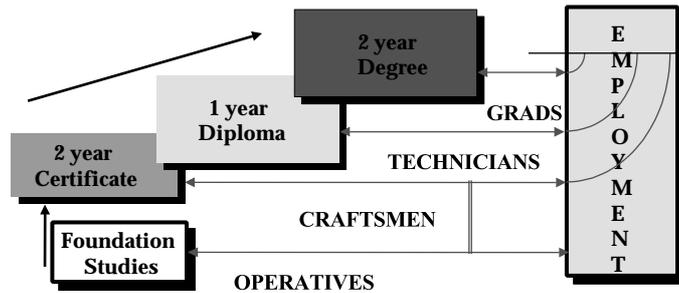


Fig. 1. The educational continuum.

ITT Cert\Dip Graduate Trends

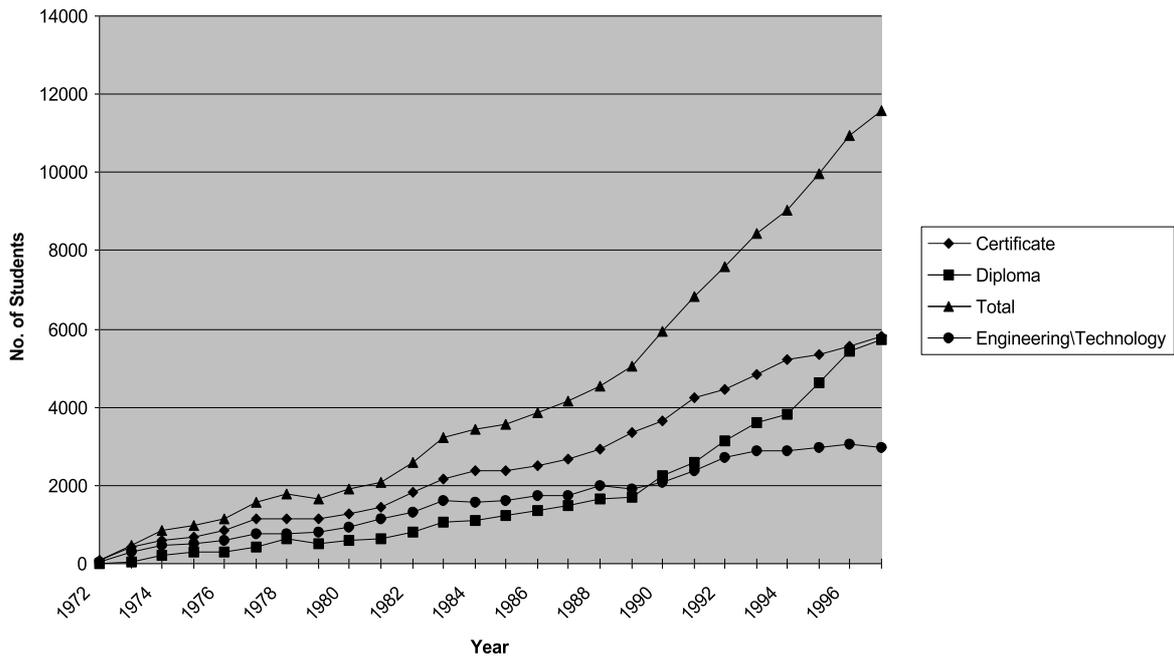


Fig. 2. Certificate and Diploma graduate output 1972–1997.

Eng\Tech Graduates as Percentage of Total

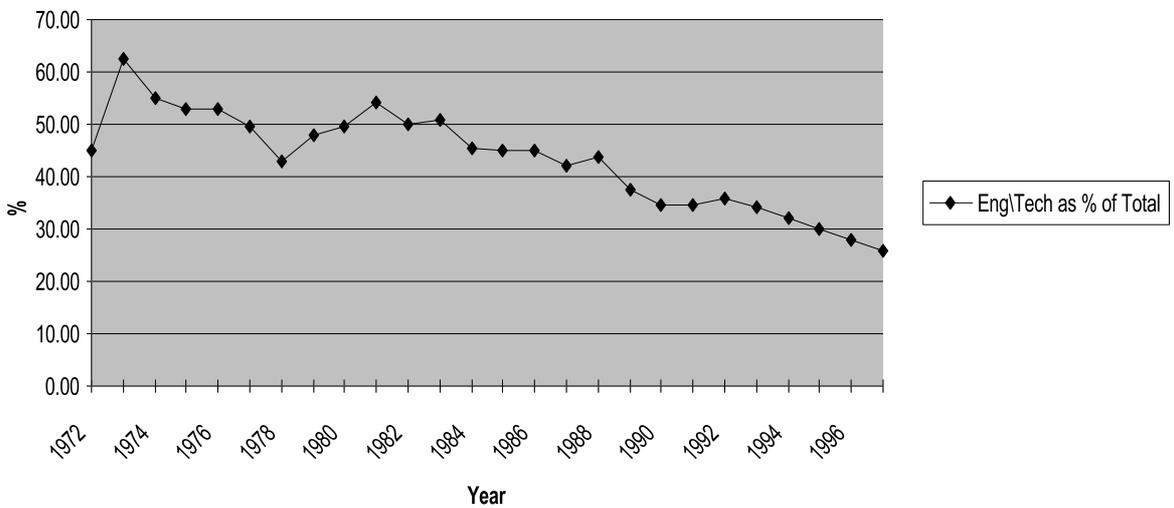


Fig. 3. Engineering/technology as percentage of total Cert/Dip graduate output.

engineering if we are secure the future competitiveness of the Irish economy. The author believes that this can only be achieved if all the educational stakeholders, government, educators, employers and the profession work together to develop a coherent, long-term solution to the problem.

If we took a sample of 100 students enrolling on a certificate course the following figures would represent the typical progression profile of the cohort:

- First year: 100
- Second year (Certificate): 65
- Third year (Diploma): 30
- Fourth year: 12
- Fifth year (B.Eng. Degree): 10

As can be seen from the figures the core business of the sector is in producing certificate and diploma graduates, although a minority of students do continue to degree level.

Using the NCEA's ACCS programme students may enrol for modules or complete courses and study at a pace that suits their occupational and social needs. This system recognises and responds to the need for lifelong learning and increasing numbers of the engineering workforce are now participating on the ACCS system.

In the school of Engineering at the Institute of Technology Tallaght in this academic year we have more ACCS students than full-time students. The figures are 414 full-time students and 548 ACCS students. We believe that the provision of learning to those at work will become an increasingly large element of our future activities as a school of engineering.

Research, development and consultancy are undertaken by the sector on a number of fronts and are regarded as very successful in terms of resources deployed versus tangible results achieved. The national Applied Research Programme (ARP) coordinated by Forbairt has helped a lot of indigenous firms access the resources of the institutes to help solve problems related to product development, process improvement, etc.

The sector has continued to develop innovative responses to the needs of society in general and industry in particular. Through its recent sectoral response to the well publicised skills shortage it has

evolved a further model for academia-industry course development that combines semesterised college attendance with structured industrial placement. The new Manufacturing Technology programme at certificate level was developed by a consortia of companies and colleges to provide industry with the technicians it so urgently requires.

Most observers agree that the institutes have served Ireland well and we look forward to building on our international reputation for producing marketable, adaptable and pragmatic graduates.

## COURSE DEVELOPMENT

Increasingly rapid technological and organisational change driven by competitive necessity is presenting those employed in the engineering profession today with an immense challenge. Academia is not immune to this challenge. As engineers working in academia we must recognise and respond to this challenge on a number of fronts. We must seek to secure our own professional development, we must seek to secure the quality and relevance of our teaching and courses and we must seek to emphasise the importance of lifelong learning to our students (and some colleagues!).

Dealing with the issue of course development first it is imperative that courses delivered to students reflect engineering reality and equip students with marketable skills, knowledge and understanding. At Tallaght we have developed a conceptual course development model that seeks to ensure the continuing relevance of our course programmes. This model is represented in Fig. 4.

The model reflects the needs of industry, academia and the individual student. It works as follows:

1. To develop a new course a course board (course design team) is formed comprised of engineering staff and industry representatives.
2. Discussions with the industry representatives on the course board and regional industry in general help us distil their generic technical or 'hard skill' needs and we try to integrate these needs into our course development via

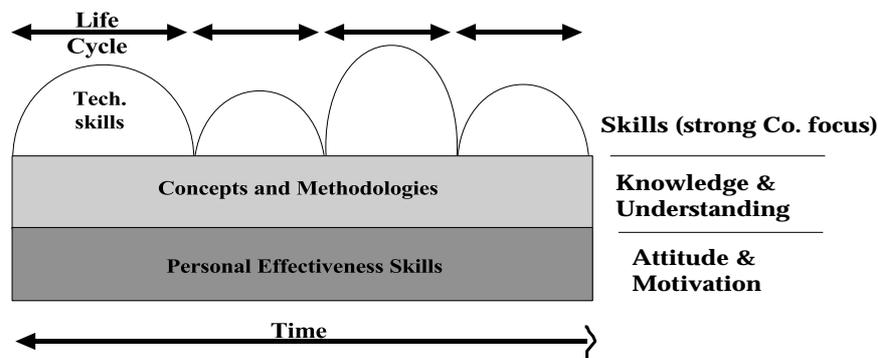


Fig. 4. Course development model.

laboratory and project work. Some of the 'soft skill' needs are reflected wholly or partially in actual course modules such as communications, or teamworking. This skills element is represented by the upper layer of the model in Fig. 4.

3. We then take the identified skills sets and embed them as elements of course modules designed to impart a broader and deeper knowledge and understanding of engineering concepts and methodologies. Care is taken to ensure we educate the student rather than train the student. The broadening and deepening is effected via lectures, tutorials, and computer-based learning reinforcement. This element is represented by the middle layer of the model.
4. The bottom layer of the model reflects our attempt to develop the individual students personal effectiveness in an area such as communications, time management and career development. This is effected via lectures, role playing exercises, industry visits and talks from guest lecturers from industry. Additionally, this element reflects our attempt to demonstrate that we are trying to equip students for a rewarding career in engineering not to pass milestone course exams.

To date this conceptual model has served us well and is used in tandem with other in-house course design methodologies to ensure a robust course design is achieved.

Each year a continuous improvement exercise is conducted on each course, feedback from lecturers, support staff, students and industry is analysed and used to fine-tune elements of the course. Every five years the course must be reaccredited by the NCEA and the continuous improvement activities ensure that the reaccreditation process is as painless as possible.

## CHALLENGES FOR THE FUTURE

### *Maintaining the relevance of courses*

If Irish academia is to positively respond to rapid technological and organisational change in industry, it needs access to financial resources on a scale not normally provided by the state funding agencies for teaching. The Institute of Technology sector must look to supplement state funding by forming strategic partnerships with industry.

An example of such a partnership is the collaboration between Tallaght School of Engineering, Hewlett-Packard and Intel for a Technician Development Centre. The School of Engineering via state funding provides a building that Hewlett-Packard and Intel have equipped with high-tech generic and company-specific equipment. All three collaborators pay the annual running costs of the facility.

The investment to date is £1.2M and results in full-time engineering students gaining access to state-of-the-art equipment and systems and company

personnel on the ACCS programme upgrading their qualifications via focused courses.

### *Maintaining the staff knowledge base*

The knowledge base and competencies of the staff are the critical asset of any institute. If an institute allows the knowledge base of its staff to depreciate it is undermining the well-being of itself as an organisation and more importantly the quality of education it can provide to its students.

Apart from the normal methods of staff development (research, conferences, training courses, etc.) there exists other possibilities for developing the organisational knowledge base and competencies. Some examples that provide win-win scenarios for both academia and industry are:

- academia-industry staff exchange (unidirectional or bidirectional);
- academic staff attending courses for industry (free of charge).

Academia in general, but schools and faculties of engineering in particular, must now look at how they can strategically and operationally respond to the challenges societal change will bring. Institutions and academics must now challenge some of their own long-held dogmas that have heretofore been used as arguments against any change in the academic status quo. Individuals or groups who continue to posit arguments on the basis of patent self-interest will not be tolerated in the emergent engineering world. Indeed they will no longer be tolerated by an emergent society that quite rightly will demand transparency, accountability and value for money from their servants in academia.

Third-level education as we know it today will undergo a sea change in the early years of the next millennium. The demand from learners to access JIT learning opportunities that are independent of time or place will undoubtedly increase the strategic importance of technology-enabled distance education to academia. Part-time education will one day surpass, in terms of student numbers, full-time education. We are seeing evidence of this within the engineering school at Tallaght. As technological change increases the half-life of a third level qualification will decrease. Our past graduates who are now in the labour pool will need to repeatedly access continuing education if they are to sustain their engineering careers and they will naturally turn to the universities and institutes of technology for help. How many will be in a position to credibly respond?

Ray Strata, President of Analogue Devices said recently: 'The rate at which individuals and organisations learn may be their only sustainable advantage, especially in knowledge-intensive industries.' I agree with the general thrust of his comment and in so doing recognise both the challenges and opportunities that it presents to academia in general, but institutes of technology in particular. His statement holds true for academia and the professions as well as industry.

If we look at the normally accepted personnel profile of an engineering organisation we see the typical pyramid model (Fig. 5). The model reflects the relative numbers and levels of engineering personnel employed within the organisation. At the 'top' are a number of engineers, in the 'middle' are a larger number of technicians and at the 'bottom' are a number of operatives. This model may also be used to define a market for those offering learning opportunities.

The universities have traditionally thought of the top tier as their exclusive market and have rarely deployed resources at the other levels. This is understandable given that they produce most graduate engineers and most, but by no means all, of the people at the top of the pyramid are graduate engineers. The Institutes of Technology on the other hand have tended to concentrate on the complete model, but predominantly on the two tiers that represent technicians and operatives. This again is understandable as the institutes of technology produce only a small number of graduate engineers, larger numbers of technicians and offer developmental opportunities to operatives through various enabling and certificate course programmes.

I believe that universities and institutes of technology ignore the lifelong learning market at their peril. If a university or an Institute of Technology is not a player generating income streams from this market, then unless they have found a very benevolent benefactor their only source of income will be from the state. A state that is increasingly reluctant to write blank cheques for academia.

An academic institution relying solely on state income for technological and resource development cannot possibly hope to invest in those very technologies that are driving the changes in the market where their graduates hope to find employment. In effect their graduate's ability to practise the application of engineering theory is undermined. Theory is undeniably necessary but without relevant application in a learning environment it runs the risk of sterility. Additionally, I know of few modern employers who have a large demand for theorists.

Employers are generally hiring people who can apply theory and who are conversant with the soft skills requirements of a modern organisation. An academic organisation that is not a player in this

market is in effect losing touch with the reality and needs of modern industry and is undermining the future industrial relevance of its graduates.

## ACADEMIA/INDUSTRY STRATEGIC PARTNERSHIPS

### *A way forward*

If Ireland is to sustain its economic and technological growth then it has got to adopt new paradigms for human resource development. Within the engineering arena as more sophisticated technology with shorter lifecycles permeates all areas of engineering activity, it will become almost impossible for the state alone, in the form of universities and institutes, to invest in the required educational infrastructure.

Students must have access to modern technology and systems if they are to realise the full value of the theory they have learnt and their personal learning potential. One way of addressing this problem is for academia to promote strategic partnerships with industry.

The partnerships can, if properly formed, help secure the physical and knowledge-based assets and skills of an institution while providing industry with the technologically competent manpower it requires. To start to look at such partnerships academia must approach industry with well researched and costed proposals that respond to industry's needs without compromising academic integrity or industrial timescales.

When speaking of industry and its needs, industry cannot be considered as homogeneous. For the purposes of this discussion I will define two broad types of need—those of multinational or 'large' industry and those of indigenous or 'small' industry. Colleges must modulate their strategies when dealing with these two industrial groupings. Additionally, they must modulate their strategies when dealing with different organisational cultures.

A strategic model for dealing with multinational industry might be represented as in Fig. 6.

Before approaching the organisation an institution must take time to research and understand the business drivers that shape the organisation and its activities. Only by doing this can an institution hope to open meaningful discussions with the company. The institution must feel comfortable using the *modes vocabularum* of the company.

The model is quite simple but reflects some key constituents of partnership formation with multinational or large organisations. Firstly, these organisations are usually characterised by having the finances and or personnel numbers to justify the partnership in the first place. Where they do not a 'cluster approach' may be adopted. I will describe this in more detail in a moment. Also, these organisations will usually have the commitment to a partnership once developed as they normally have a clearly defined HR development need.

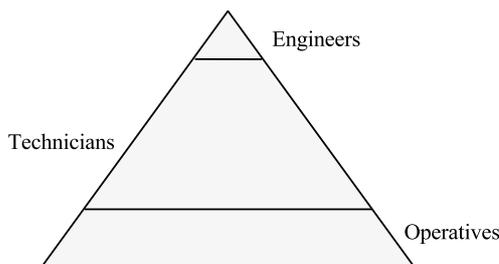


Fig. 5. Engineering personnel model.

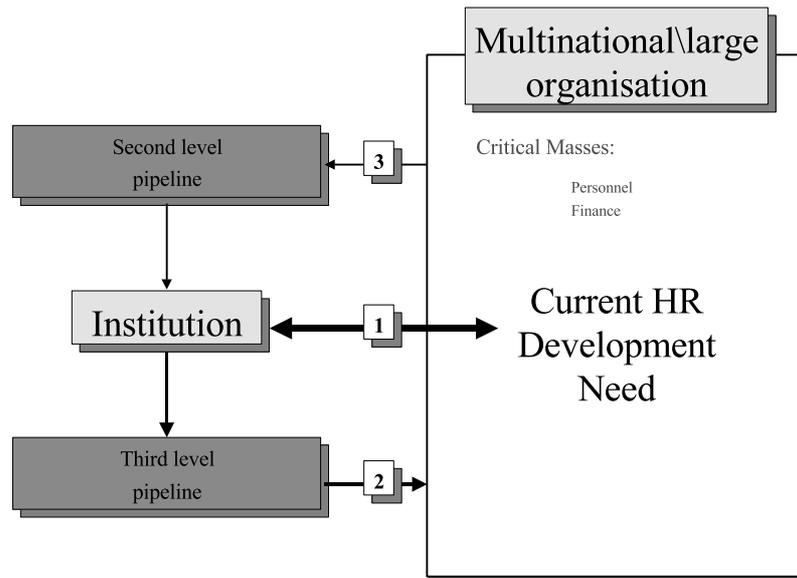


Fig. 6. Strategic partnership model.

The organisation's HR development needs are generally categorised as present, evolving and future. These are reflected in the diagram as 1, 2 and 3 respectively.

These needs can be identified and prioritised to a level where both parties have a clear understanding of the partnership requirements. During this phase the academic partner actively listens to the company's exposition of need.

Once the HR requirements have been clearly understood by both parties they can be said to have captured the 'design intent' for a course of study. The academic institution can then begin a course design process that reflects the design intent whilst clearly establishing the academic quality, level and integrity of the course. A diagrammatic representation of this approach can be seen in Fig. 7.

Once a prototype has been developed it can form the basis for further discussion between the partners. This discussion is driven by the academic partner, while the industrial partner must now actively listen to the academic partner as they explain the academic context within which the

course will be developed. At this phase the academic partner is in a position to describe curriculum, national/international accreditation requirements, examination and assessment requirements and where it applies any APEL content within the course.

It is important to state at this juncture that care must be taken to ensure that the structure of the courses and its content add value to the individual learner and not just the organisation. Institutes are not the training wings of specific organisations.

Contrary to the beliefs of some academics industry/academia interaction can offer a win-win scenario for both industry and academia. Win-win scenarios are created when collaborators seek to cooperate on the basis of actively listening to each other. By actively listening I mean that they each seek to understand the needs, drivers and constraints that each has to live with, and that they agree to develop learning and development models that reflect all these needs, drivers and constraints.

It takes time, patience and effort to develop strategic partnerships; however the potential

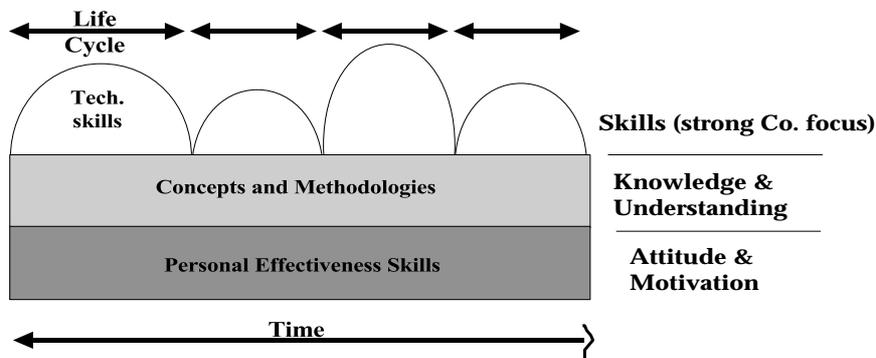


Fig. 7. Tallaght School of Engineering course development model.

benefits that flow from it are well worth the effort. Some of these benefits may be outlined as follows:

- development of focused curriculum;
- potential for equipment investment;
- faculty placement programmes;
- student placement programmes;
- industrially based student projects.

In my experience proactive rather than reactive interventions by colleges will provide the best strategies. This means that colleges must go out into their regions and seek to establish real links with the organisations that make up their regional economy. Colleges who continue to expect the organisations in their region to come to them will not really be players in the workforce development arena. We must market our services to industry in a focused manner using vocabularies that industry understands and values.

I would suggest that no one strategy will meet the requirements of all the organisations that a college interacts with. Rather a set of interdependent strategies will be required. In the institutes we are evolving such a set of strategies that will cater for large multinational organisations and Irish SMEs alike. I would now like to spend a few minutes to describe these interdependent strategies to you.

Irish SMEs normally have little or no resources to devote to joint development of engineering curriculum. They also individually lack critical masses of finance and personnel that are required to make a strategic partnership work. However, institutions can take time to identify groups of companies with generic education needs and

cluster these to make the required critical masses for strategic partnership.

Once a cluster has been formed the methodology used to meet their needs is the same as that used to respond to the needs of the multinational/large organisation.

These approaches are being used by a number of the institutes of technology to good effect in their regions.

At the Institute of Tallaght we have recently opened the Technician Development Centre (TDC) a £1m joint venture between ourselves Intel and Hewlett-Packard that allows engineering students at Tallaght to access state-of-the-art equipment and systems to apply their theoretical knowledge. Additionally, as a result of the collaboration we have recently received £250,000 private sector funding to purchase industry-standard electromechanical equipment. This venture is seen as just the start of our process of strengthening our relationships with industry.

## CLOSURE

I would like to conclude with the statement that the Institutes have been and will continue to be key players in the engineering arena within Ireland. They are well positioned to respond to the challenges of the twenty-first century and are not afraid, indeed they demand, to be judged on merit. They will no longer tolerate having their standing and future threatened by vested interests no matter who or what they are.

**Pat McLaughlin** is a graduate of Strathclyde University, Glasgow (1981) and the Queen's University of Belfast (1982). Worked for several years with Rover Group in Oxford on the development of the Rover 800 model. Joined Dublin Institute of Technology in 1986 lecturing in CAD/CAM and assisted in the establishment of their Advanced Manufacturing Technology facility. Appointed Head of School of Engineering and the new Institute of Technology in Tallaght in 1991. Current projects include the further development of the Technician Development Centre and in-company Accreditation of Prior Experiential Learning, APEL.