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Learn And Work: A Hybrid Educational Model For Engineering Education

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LEARN AND WORK, A HYBRID EDUCATION MODEL FOR ENGINEERING EDUCATION

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ABSTRACT

Traditional models of education are undergoing significant change in recent times due to evolving graduate attributes, shaped in no small part by the changing demands of modern industrial practices. Technology is one of the key elements of the factory of the future. Advances in manufacturing and digital technologies facilitate automation and offer significant benefits in a variety of areas.
Academic programmes that feature industrial work placement have long been a feature of engineering education in TU Dublin. The BSc in Process Instrumentation and Automation is a three-year programme that goes further in that it evenly balances on-campus instruction with work placement. The programme was specifically devised in response to industry feedback that had identified significant skills shortages in the areas of industrial instrumentation and automation. It is a hybrid between the apprenticeship model of education (www.apprenticeship.ie) and the traditional engineering degree model and directly addresses industry's immediate need for experienced graduates.
Participation in the programme is sponsored by Irish Medtech Skillnet, a learning network for companies in the medical technology and engineering sector that responds to the training needs of that sector.
This is one step in the lifelong learning path of a modern graduate.

This paper will provide a detailed critical review of the ‘learn and work’ model; strengths, challenges and opportunities offered by this mode of engineering education.

1 INTRODUCTION

1.1 Background

Process instrumentation and automation technicians are employed in large chemical, pharmaceutical/biopharmaceutical, food processing, oil and gas, waste-to-energy conversion facilities and manufacturing plants. Their principal roles cover installation, maintenance, and calibration of measuring instruments. This role is key in that it provides the technical support that is essential to a high-tech manufacturing process. These technicians require training that is specific to automation processes across a range of industries. This paper provides a critical review of the Level 7 (www.qqi.ie) Process Instrumentation and Automation (‘learn and work’) Programme; the graduates of which, work as qualified instrumentation and automation technicians. The programme was specifically devised in response to industry feedback, with pre-programme validation confirming significant skills shortages in the areas of instrumentation and automation (EGFSN 2013).

This programme is a hybrid model, lying somewhere between the apprenticeship model and a traditional engineering degree programme, in that it evenly balances academic modules with work-placement. Apprenticeship is a programme of structured education and training that formally combines and alternates learning in the workplace with learning in an education or training centre. The employer pays the apprentice for the full duration of the apprenticeship, and it typically leads to a level 6 qualification. Currently in Ireland there is a backlog in the apprenticeship sector, leading to long qualifying times for apprentices. This ‘learn-and-work’ model ensures completion of this BSc programme within a fixed 3-year period.

It is well documented that work-based learning programmes make valuable contribution to the third-level educational experience (Sheridan and Linehan 2011). Studies have indicated the advantages of integrated work placement in benefiting students with different skills, for whom the inductive pedagogy (from experience to theory) is more efficient than the classical deductive one (Rouvrais and Remaud and Saveuse 2020).

2 PROGRAMME STRUCTURE

The programme is structured over three academic years and runs through the summer, the students earn 180 ECTS credits in total, 60 per academic year. First year students spend their first 2 semesters studying taught modules in the university and then spend the summer in work placement. Students on year two and three spend their first semester on campus and their second semesters and summers in work placement. See details in Figure 1. This structure has evolved over the course of delivery of the programme in response to industry and student feedback, with more focus now in first year on academic modules and in fully preparing the student for work placement.

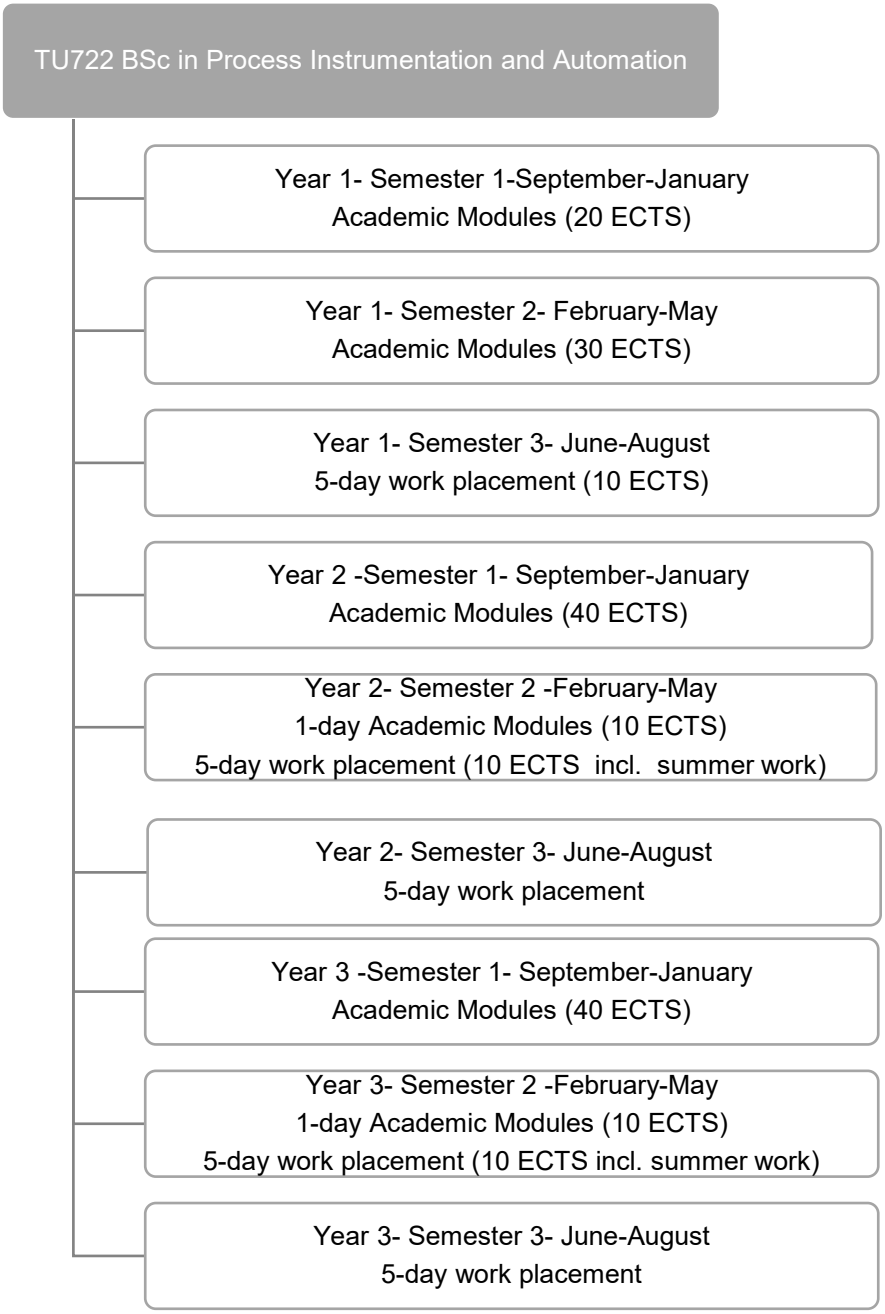

Fig. 1: Structure of the Programme

Typically, the 5-day week academic blocks comprise about 24 hours/week in the university. This is broken down into $^{2}/_{3}$ lab work and $^{1}/_{3}$ lectures. This balance of classroom learning, and practice-based lab work suits the learning style of the students on the programme. In addition to this, students have laboratory reports/case studies to complete or self-directed learning to carry out, to consolidate learning.

3 STUDENT RECRUITMENT TO THE PROGRAMME

Since 2020, students are recruited through the CAO (Central applications office) (www.cao.ie). The Central Applications Office processes applications for undergraduate courses in Irish Higher Education Institutions (HEIs). Decisions on admissions to undergraduate courses are made by the HEIs who instruct the CAO to

make offers to successful candidates. CAO points are calculated based on student's grades in state examinations. The Irish school programme on which the points are based is known as the Leaving Certificate. Points are calculated based on 6 subjects, with maximum points of 625 achievable.
Prospective candidates must also meet several other minimum entry requirements as detailed in Table 1. The required points for admission to this programme are a combination of the CAO points in addition to a combination score from interview and aptitude test. This year, 2023 the entry requirements were simplified, as they were perceived to be a deterrent to students applying for the course. As a result, requirement numbers 4 and 6 (Table 1) were removed. The effect of removal of these additional requirements will be evaluated in September 2023, when applicant numbers are reviewed.

Table 1: Minimum Entry Requirements

No	Entry Criterion	Minimum requirements	Notes
1	Leaving certificate/CAO points	5 subjects pass (40%) to include a minimum grade of O6/H7 in both Mathematics and either English or Irish	H7:30-39% at Higher Level
			O6:40-49% at Ordinary Level
2	Aptitude Test	Minimum score of 42/100	Combined score of 110/200
3	Interview	Minimum score of 50/100	
4	Ishihara colour vision test 24 Plate Edition	Pass	Criterion removed for 2023/24 entry
5	Submission of a Résumé	Submitted prior to interview	
6	Submission of 2 written references	Submitted prior to interview	Criterion removed for 2023/24 entry

Recruitment has proven to be challenging and labour intensive. Despite extensive engagement activities such as apprenticeship fairs, school visits, taster sessions for schools and engagement with FET (Further Education and Training) centres (www.fet.ie), numbers of applicants remain low. Perceived reasons for the low numbers of applicants are detailed in Table 2.

Table 2: Perceived barriers to recruitment to the programme

1	New and unfamiliar programme of study	Word of mouth is beginning to positively influence numbers of students applying to the programme as more graduates from the programme enter the workplace.
2	NFQ (www.nfq.ie) Level of the programme offering	Perception among CAO applicants that Level 8 is a more attractive choice.
3	Marketing issue	Rebranding of the programme title may be required to include the word "engineering" or removing the reference to "learn and work": this is currently under discussion.
4	Additional entry requirements	The additional entry criteria: aptitude test and interview may be a deterrent to potential students who may be busy with Leaving Certificate studies.

Current students participate in recruitment events and have shown themselves to be excellent role models for the programme. Industry partners assist with the recruitment of new students to the programme by promoting it at school events and

sometimes they themselves propose students for the programme.

3.1 Entry Criterion-CAO points

To date there has been a large variation in the CAO points achieved by the student recruits as seen in Figure 2. These range from 152 to 523.Even with this large variation in Leaving Certificate results, students from all base levels are successfully completing the programme. The mixed levels in the classes may have the effect of raising the standard of those students who entered on lower points (<400).

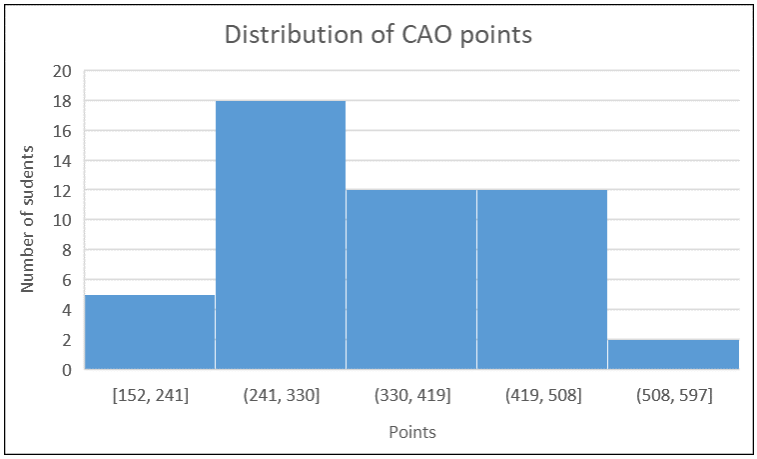

Fig. 2: Distribution of CAO points

3.2 Entry Criterion-Aptitude Test

Prospective students are invited to take an aptitude test prior to being called for interview. Aptitude tests are proctored and are hosted online by a third-party company. The test consists of 28 questions that are taken over 45 minutes and is based on four main question areas; abstract reasoning, numerical ability, analytical ability, and data analysis.
The aptitude tests have yielded some valuable trend information to date, for example lower scores in the abstract reasoning section of the test seem to correlate with those students who struggle more with the academic content of the programme.

3.3 Entry Criterion-Interview

This is a key step in the selection process; students in traditional engineering courses have the benefit of at least 3 years in university in which to gain confidence and maturity before embarking on work experience, whereas these students need to be work-ready at the end of their first year. The interview provides the opportunity to assess whether the student would be a suitable fit for the programme. The format of the interview is usually via an online meeting with 3/4 staff members. The candidate is asked to discuss various details on their résumé, particularly in relation to subjects studied and interests. The level of research and preparation that the student has carried out is often a good indicator of the level of interest that the student has in this programme. Practical details such as mode of transport to work placement as well as general demeanour and attitude are also considered. Prospective students have an opportunity to ask questions and are therefore more informed around what to expect. They are also inclined to do some research on the programme in preparation for interview and this leads them to making a more informed career choice. This year to date, 2023, approximately one quarter of the candidates interviewed had heard about the course through word of mouth. This is an encouraging figure, as more students graduate into well paying, satisfying employment this will enhance the reputation of the course. The interview process provides valuable additional

information, such as how the candidates heard about the course or why they chose it.

4 WORK PLACEMENT REVIEW

Research has shown that the inclusion of work placement in the curriculum can strengthen university–industry collaboration and can help to shape engineering curricula based on feedback from students and industry partners (Carbone et al. 2020). At the programme's inception, a range of potential industry partners were invited to meet with academic staff to discuss the structure and content of the programme. Feedback indicated that placements of length 6 months or longer were deemed to be more useful from an industry perspective.

Studies also show that work-based experience results in higher post-graduation starting salaries and enhance the likelihood of securing a job offer prior to graduation. These results are borne out in this programme with most students securing a job offer prior to graduation. However, some studies show that an improvement in academic results are only marginal (Purdie et al. 2013). Future review of the programme will examine the grade progression of students on the programme to assess the effects of work placement on their overall academic performance. Informally, the positive academic progression of many students is evident as they mature through the programme. Work-placement enables students to learn how an organisation functions and how their work can contribute (Vaezi-Nejad 2009). As there are limits to scale for work related internships or placements, other forms such as field trips and site visits are common in engineering curricula. These have been shown to expand students' perceptions of their career work and identity (Carbone et al. 2020). Few programmes offer work placement opportunities to match this one in duration so the benefits such as an “increase in agency and a contextualised learning experience” are likely to be higher (Purdie et al. 2013). Studies also show that work placement has a “positive impact on students’ self-efficacy, and in articulating their skills and strengths” (Edwards 2014).

Industry placement periods are significantly long and so lead to deeper learning and immersion in the everyday work that is carried out in a manufacturing facility. This is differentiated from a short-term placement that may be more superficial in nature and allows for greater integration of the student into the engineering team from the first year on the programme.

5 WORK PLACEMENT ARRANGEMENTS

One member of the programme team acts as the work placement co-ordinator and all communication with the industry partners are directed through them. Industry partners were initially recruited through the programme team’s professional contacts and these industry partners also went on to recruit other companies on behalf of the programme. The partners work with the programme team on an annual basis taking one or two students from each year on the programme. In a small number of cases, students have secured work placement themselves, this typically happens in third year when students have more experience. Students have successfully approached companies directly using LinkedIn and email.

Industry partners were involved in pre-programme validation and are regularly consulted on the efficacy of the course delivery.

Regular contact is maintained with the industry partner at the start, middle and end of the placement for each student. Pre Covid-19 this was achieved through visits

from the placement co-ordinator, but increasingly this is achieved through online meetings and phone calls.

5.1 Industry recruitment of students from within the programme

Matching students with industry for work-placement is achieved through a round of interviews with the industry partners. These interviews typically take place in December /January and the industry partners often deliver a presentation outlining what they do, to the student group. The work placement co-ordinator then provides the industry partner with a selection of résumés that allows them to shortlist candidates and call them for interview. The co-ordinator endeavours to place students in work that is geographically suited to the student and consideration is given to whether the student has access to their own car. Interviews take place either online or in person, at the university or on-site and are arranged directly between the student and industry partner. Ideally, offers to students are made through the programme co-ordinator. Students will, in general, remain with the same placement company for each of the three years of the programme.
In a small number of cases, it can be difficult to place a student, where they do not meet the employer's expectations at interview. This has generally been shown to be related to poor student communication skills. In this instance the programme team may rely on the goodwill of an industry partner to provide a placement opportunity. Consequently it has been found that work-placement enhances that student's skills and progression opportunities.
Studies on the primary motivation of the employer for becoming involved with programmes such as this one, include social duty, the opportunity of training students in company needs and as a source of fresh staff recruitment. Studies also show that less rated motivators were improving the company's position within the sector, benefitting from university services, and saving time in recruitment (Ferrández-Berrueco and Sánchez-Tarazaga 2021).
Future work on this programme will seek to identify the motivating factors of the employer but informal discussion with employers highlights the skills shortage as the primary motivator.

5.2 Preparing for work placement

First year students are prepared for work placement in several ways. Academic modules incorporate critical skills such as effective communication, technical report writing, presentation skills, résumé and interview preparation, software proficiency skills, concept generation, group dynamics and teamwork and basic project management skills.
Prior to going on their first placement, informal information sessions are facilitated in the university to enable first years to learn from the experience of those students who have already participated on work placement with a particular company. These sessions are also designed to allay any apprehension that first year students may have. Students complete an industry induction on their first day and then in general they work as part of a team where they effectively shadow qualified technician(s) on site. Students also undergo extensive in-house training while on placement. Future review of the programme will involve student surveys to assess the student experience.

5.3 Assessment and challenges

There is consensus on the limits to scale of work placement activities and this programme is no different in that respect (Carbone et al. 2020). However, the rewards that are borne out in solid employment offers at the end of the programme for each student warrants the time and effort that is expended in the organisation of the work placements. Most students have secured an offer of employment with their placement company before they complete the programme.

Assessment of work placement activities generates much discussion and has been widely studied. Monthly logbooks, industry supervisors report and student final report and presentation are used to assess work placement. Logbooks are graded using a rubric based on the module learning outcomes. Weekly entries encourage students to detail what they have been working on and have learned that week. An evaluation section prompts self-reflection in terms of progress made and in identifying areas for improvement. Logbooks allow the student to record learnings and methods of work for future reference and this practical knowledge enhances understanding of key concepts. It provides the academic staff with valuable insights into the development of each student on an ongoing basis. Employer feedback is garnered through an MS form, a Likert scale is used to assess student performance in 15 key areas. Employers are also prompted for general feedback. The Covid-19 pandemic caused some additional difficulties during 2020/2021, most students were allowed to continue or to work from home. A small number of industry partners opted out of taking a student during that time. This was addressed by condensing the work-based learning modules into two 3-month terms on an exceptional basis.

There are occasional operational challenges, for example when offers of work placement are made directly from the industry partner to the students (without consultation with the work placement co-ordinator). This can sometimes cause issues; where a student has already been committed to another placement company by the placement co-ordinator. On rare occasions, students may request a change of placement mid-programme where they feel they are not gaining as much experience as they would like or for other reasons. This is accommodated where possible. There is a fine line to tread to maintain a good relationship between all parties. This is one of the main challenges for the work placement co-ordinator.

6 RESULTS

The most significant challenge faced by the programme team is attracting students to the programme. The perceived barriers to recruitment are under consideration and are being addressed on an ongoing basis by a more proactive recruitment drive and a considered review of the admission criteria. The candidate-selection process is very resource intensive in terms of time and university personnel.

All graduates of the programme are in full employment. Feedback from Industry partners cite typical starting salaries of €37,000-€47,000 being achieved. Career progression is fast-moving with students earning upwards of €50,000 after two years. This compares very favourably with similar programmes, for example a graduate engineer who has spent 4 years in university can expect to earn €36,000 (Engineers Ireland Salary Survey 2023).

Retention rates on this programme are higher than similar level 7 engineering programmes. To date the average completion rate on the programme of 84.7%

(Table 3) compares very favourably with national overall completion rates of 60% in other level 7 engineering programmes (Pigott and Frawley 2019).

Table 3: Student Completion Rates

Intake Year	Number students started	Number complete/ on-target to complete	Number student losses	Completion rate %
2018	10	9	1	90
2019	15	13	2	86.7
2020	9	7	2	77.8
2021	12	10	2	83.3
2022	14	12	2	85.7
Total	60	51	9	
Average				84.7

These high completion rates are at odds with the findings of Higher Education in general where ”There is a strong positive correlation between the proportion that enter with up to 400 Leaving Certificate points and the non-completion rate, indicating that lower points are associated with higher non-completion rates.” 96% of those students who do not complete their level 7 engineering programmes have <400 CAO points (Pigott and Frawley 2019). It has been shown that there are “relatively high rates of non-completion in the computing and engineering, manufacturing and construction fields of study, particularly at levels 6 and 7” (Pigott and Frawley 2019). The recruitment process is believed to contribute to the higher retention rates being achieved. In addition to this, small class sizes (<16 students) allow for more individual attention and facilitate practice-based learning. Unlike other comparable Level 7 engineering courses where large class sizes can sometimes lead to anonymity and dissociation, smaller numbers can have a stabilizing effect and problems can be identified and addressed more quickly. The practical mode of delivery is beneficial in that students remain engaged through hands-on practice-based learning. Work placement blocks allow the students to put their learnings into practice, this appears to lead to greater engagement in the academic material. Studies also show that work-based learning benefits the student in a “variety of other ways, particularly reduction in anxiety, increases in agency and confidence” (Purdie et al. 2013) which may also contribute to the higher retention rates.

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