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RECRUITMENT AND RETENTION: THE ROLE OF THE PUBLIC IMAGE OF ENGINEERING

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ABSTRACT
This paper presents findings of three surveys conducted with first year students in the Faculty of Engineering in the Dublin Institute of Technology. It focuses on their motivation for studying engineering and the people who influenced the decision to do engineering. It shows there are gaps in the students' knowledge of their programmes and also between their expectations and their experience of their course. Some proposed areas of action are identified to increase both recruitment and retention. It is argued that projecting an image of engineering as a creative activity would help in addressing recruitment and retention issues.

INTRODUCTION
The popularity of higher education engineering courses in Ireland is falling. First preference applications fell in both 2006 and 2007. This is part of a trend which has seen first preference applications fall by 18% between 2000 and 2005. There is evidence that students with high levels of ability are not choosing engineering [1, 2]. There is also a failure to attract women. An analysis of acceptances on Honours Degree programmes in 2006 shows that engineering, with 80% males, is only one of three disciplines where males are still in the majority [3].

The Dublin Institute of Technology (DIT) is the largest engineering educator in the state. Since 2003 the faculty has conducted an annual survey of first year full-time students. The survey seeks to discover why students study engineering and who influences that decision.

This paper will profile the faculty before providing details of the recruitment survey. Findings of the surveys are presented in relation to student motivation for studying engineering and key influencers on their decision. Students' knowledge of their course prior to entry is also examined. The paper concludes by examining key themes that emerge from the research and argues that an emphasis on engineering as a creative activity may be required to increase the numbers of engineering graduates. This paper focuses narrowly on key findings of the research in order to support this argument. More detail, including a full set of tables, can be found in [4].

THE FACULTY OF ENGINEERING AT DIT
The Faculty of Engineering at DIT is a multi-disciplinary faculty comprising five schools: School of Civil and Building Services Engineering; School of Control Systems and Electrical Engineering; School of Electronic and Communications Engineering; School of Manufacturing Engineering; School of Mechanical and Transport Engineering. The research reported here covers students from 19 full-time programmes. These programmes are both level 8 honours degree programmes, of

four years duration, leading to professional qualifications and usually referred to as Bachelors of Engineering (BE), and level 7 ordinary degree programmes, of three years duration, leading to technician qualifications and known as Bachelors of Engineering Technology (BEngTech). There is one remaining certificate/diploma programme in electronics and computer systems.

A Common First Year (DT 025) is run for students wishing to take BEs in mechanical, manufacturing, structural or building services engineering. There is a requirement to have achieved honours mathematics in the Leaving Certificate (LC) to gain entry to BE programmes. For students who do not get honours mathematics, but who are otherwise qualified, the faculty provides access to the Preliminary Engineering (PE) programme as a gateway to BEs.

There are two Bachelor of Science programmes in the faculty, in product design and transport management. The former was jointly developed with the Faculty of Applied Arts and the Faculty of Business and combines the principles of engineering with design, innovation, business and marketing (see Table 1 for a full list of programmes).

Entry to DIT programmes, in common with all higher education institutes in the Republic of Ireland, is through the CAO. Candidates for courses apply to the CAO indicating their preferences both at Level 8, honours degrees, and Level 7, ordinary degree, diplomas and certificates. Places are allocated on the basis of grades achieved in the LC with points being allocated for different grades. There are different entry routes for mature and international students.

The faculty operates a ladder system, which facilitates progression through all course levels. Students who have successfully completed a BEngTech and reached certain grade thresholds may gain entry to the third year of relevant BE programmes.

RECRUITMENT SURVEY

The Faculty commenced collecting data from first year entrants in 2003. This was in the context of a growing concern about recruitment and a concern to evaluate the faculty's recruitment activities. The survey was repeated in 2004 and 2005 with modifications being made in each year. This paper relies mainly on the data from 2004 and 2005 as it is most compatible and was analysed using the statistical programme for social sciences (SPSS). Data from 2003 is provided where it is comparable.

The data is collected from students in October and November of the year in which they commence studying at DIT using an online questionnaire through Web Course Tools (WebCT). Based on mid September acceptances the faculty recruits in the order of 650 students per year although the number of acceptances in 2004 was 747. In each year approximately two thirds of students have completed the survey. Table 1 provides the details of the programmes for which respondents were registered and shows that each course is represented in the final group of respondents. The varying and changing number of respondents from some programmes mainly reflects the numbers registered for each programme.

To supplement the survey data, student records are also analysed. Each year the CAO provides DIT with data on all those who accept places. This includes data such as their secondary school address, LC results, their CAO points and their CAO preference of the course for which they are registered. There are limitations in both data sets which restrict the extent of the analysis. The responses from year to year have been consistently similar and are sufficiently robust to constitute a serious contribution on the issues surrounding the best strategies for attracting students to engineering. Given the small number of women in the faculty comparisons based on gender should be seen as indicative rather than conclusive.

Programme	***2005***	***2004***	***2003***
Common First Year Engineering (Bolton Street)	93	104	111
BSc Transport Technology	9	17	21
BE Electrical and Electronic Engineering	17	12	10
BE Computer Engineering	7	7	9
BSc Product Design	23	50	21
BEngTech Engineering Systems Maintenance	14	9	13
BEngTech Manutronics Automation	27	22	14
BEngTech Civil Engineering	34	37	37
BEngTech Building Services Engineering	29	34	25
BEngTech Mechanical Engineering	49	26	24
BEngTech Automotive Management and Technology	23	32	13
BEngTech Electronics and Communications Engineering	13	15	24
BEngTech Electrical and Control Engineering	14	23	33
BTech Electrical Services Engineering	19	39	19
Cert/Diploma Electronic and Computer Systems Engineering	24	20	25
Preliminary Engineering	49	31	41
Total	444	478	440

Table 1: Survey respondents by programme

Respondent Profiles

Respondents were predominantly school-leavers and male. The proportion of school leavers was 93% and 87% in 2003 and 2004 and 92% in 2005. The proportion of mature or international students has never exceeded 6%.

The number of women respondents has averaged 9% over the three years. These women were concentrated in a small number of programmes. Women join the faculty either to do civil/structural engineering or product design. The product design programme has had a significant impact on the number of women in the faculty with 37% of students being female. The success of the programme in attracting women to the faculty lends support to Beraud's argument for the role of interdisciplinarity in attracting women to engineering [6].

An examination of student records for the full cohort from each year highlights a worrying trend in that the average ability as measured by CAO points is falling. Between 2004 and 2005 the average points in the faculty fell by 13 points. Between

2003 and 2005 average points fell for 9 of the 16 programmes listed in Table 1. The fall is most acute for level 7 programmes.

In summary the faculty is drawing on a very narrow base from which to recruit students: male school leavers. Average ability on entry is in decline. This may be impacting on our capacity to retain students. Data compiled by the DIT retention office shows that retention rates are lowest for technician programmes.

KEY FINDINGS

Tables 2 and 3 set out key findings from the research:

Reason for studying engineering	***2005 (%)***	***2004(%)***	***2003(%)***
I was always interested in how things work	38	41	52
I am interested in designing things	34	31	28
Engineering is a good career	28	34	29
I want to build things	25	24	30
Engineers are well paid	19	15	15
I liked engineering at school	15	15	13
I like maths and physics	15	11	14
I like working with computers	10	9	Not Asked
Engineering qualification will allow me to travel	8	8	9
My family is involved in engineering	4	6	8
Other	5	5	5

Table 2: Reasons for choosing engineering (Top 2 Choices)

Person	***2005(%)***	***2004(%)***
Parent	38	36
Career Guidance Counsellor (CGC)	28	23
An Engineer	23	20
Other Family Member	22	21
A Current Student of DIT	14	7
Engineering Teacher	12	14
Maths Teacher	10	10
Science Teacher	10	7
An Ex-student of DIT	9	9
Other Teacher	8	6
A member of Staff at DIT	5	5

Table 3: Strong positive influence on decision to study engineering

A key aim of the surveys was to determine the reasons why DIT students choose to study engineering and who influenced them. Students were presented with a list of statements. While in 2003 they were asked to rank the statements, in 2004 and 2005 they were requested to rank their top five reasons. Table 2 presents the statements and the proportion who gave them a ranking of one or two.

Students were also presented with a list of people and asked to indicate the strength of their influence on their decision to do engineering. Table 3 presents the list and the proportion who said the individual had a strong positive influence on their decision. Key issues arising from this data will now be examined.

The Importance of Intrinsic Motivation

The most popular reason in each year was *'I was always interested in how things work'*. Taking the average across the three years this was followed by '*I am interested in designing things'*, '*Engineering is a good career'* and then by *'I want to build things'*. It is evident that DIT students were primarily attracted to engineering by intrinsic features of engineering and their desire to understand, build and design. While similar trends were found when level 8 students were compared with the other students, there was a slightly greater emphasis on the career aspects of engineering by the students not taking level 8 programmes and a greater emphasis on design and *'liking maths and science'* by level 8 students.

At all levels students had a very practical orientation with similar proportions saying *'I liked engineering at school'* and they wanted to '*build things'* or find out '*how things work'*. This practical orientation is underlined by responses to a question asking why they specifically came to DIT. While the data is not presented here in detail the responses were again consistent across the years. In all years the most popular response was that *'DIT has a good reputation for engineering'*. This though was followed by *'DIT courses are more practical and applied'*. This response received support across the programmes offered at different levels. Indeed in 2005, 57% of the Common First Year students gave this response a first or second preference.

These findings support the outcomes of research by the American IEEE in which student respondents indicated that their primary reason for doing engineering was that they *'wanted to invent, build or design things'* [7]. These kinds of findings reinforce evidence that suggest that 'the single most influential desire' which guides the choice of a career is the desire 'to work in an area that is personally satisfying and fulfilling' [8]. These findings also seem to support research which argues that early year students tend to have a 'sensing mode of perceiving' which emphasises the concrete, practical and the immediate. Such students tend to learn better using a practice-to-theory approach rather than the more traditional theory-to-practice route [9].

The Role of Engineering at Second Level

It can be seen that on average 14% said they did engineering because they liked mathematics and physics, while 16% said they did it because they liked engineering at school. While, according to student records, all of the students who enter the faculty following the LC have studied mathematics and half have studied physics, only a minority of the full cohort of students had studied engineering for the LC. Of these students, who took the survey in 2004 or 2005, two thirds of them ranked the statement *'I liked engineering at school'* first or second. It is noteworthy that of those who did engineering over 80% said their engineering teacher had a positive influence on their decision to do engineering in college.

What this suggests is that the experience of doing engineering at secondary school is a positive one and an efficient route in directing students to higher education engineering courses. This is particularly the case for mechanical and transport courses especially at technician level. It is a also a factor for those pursuing professional degree qualifications. One fifth of Common First Year entrants rated this answer as first or second while only one quarter of entrants to this programme had studied engineering.

By way of contrast it can be argued that an interest in mathematics and physics is not a primary motivator in directing students into engineering. Further only 10% said their mathematics teacher had a positive influence on their decision to do engineering.

Gender Differences

As already stated the number of women in the faculty is small making comparison with males difficult. It is also the case that most women are studying on honours degree programmes particularly the BSc in Product Design. Bearing this in mind some differences between males and females can be noted. Women were more likely to say they did engineering because of an interest in *design* or they *liked maths and science.* They were less likely to say they wanted to *build things* or they *liked engineering at school*. Like other Irish female school leavers the female respondents were less concerned with career and pay issues than males [10].

While the difference in the emphasis on *'designing things'* can be explained by the nature of the product design programme, it is perhaps indicative of a different emphasis that needs to be placed in promoting engineering to women. The product design course is the only one that includes the word design in its title. Research elsewhere suggests that this title conveys a more artistic impression of the product design process [11]. This may make it more attractive to women. In 2005 one third of the women entrants to the faculty had studied art and design for the LC compared to only 13% of males.

Their *'like of mathematics and physics'* seems to be more important in directing them towards engineering than it is for males. This is in line with findings elsewhere. [12][13]. Liking engineering at school is less important because of the tiny number of women who did engineering: five in 2004 and two in 2005.

Family involvement in engineering was slightly more important for women. This again is in line with evidence elsewhere [12]. Females were more likely to say that parents or other family members had a positive influence on their decision to do engineering. Looking at the group of students in the Common First Year and Preliminary Engineering in 2005 it was found that while 75% of the women said they had a relative who was an engineer only 35% of males did so.

The Importance of Parents

It can be seen from Table 3 that the key influencers were parents, CGCs, engineers and family members. The importance of parents and family members can be linked to the number of students who had engineers in their family (in 2005 over one fifth had a relative who had studied engineering at DIT). But it is the case that only a minority of families have engineers within them. A significant number of respondents said their families were influential even in the absence of an engineer. If parents are influential then it is important that colleges pay attention to parents understanding of engineering. In 2005 Engineers Ireland held focus groups with the public and students to discuss their perception of engineering. One of the findings, in common with findings elsewhere [12] was that: 'The perceptions of most students and parents were negatively influenced by poor knowledge of the breadth of engineering applications and the low contact with engineers' [1].

ARE STUDENTS PREPARED?

Respondents were asked to state whether they *'had a clear understanding of what their course was about before they came to DIT.'* In 2004 and 2005 over 40% said no. This is in the context of 80% of 2005 entrants studying on a programme that was either their first or second CAO preference. It might therefore be expected that they would have high levels of knowledge about their courses. The lack of knowledge is worrying in that poor preparation for higher education has been identified as a cause of early withdrawal [5].

Another factor that that affects retention is the gap between 'students' expectations and their experience on their courses' [5]. Although the surveys were conducted in the very early months of their programmes some evidence emerged that students were having some difficulties. Respondents were asked *'What is the most important thing you need to know before coming to DIT to do engineering'*. While not all students responded, open ended responses were obtained from 459 students in 2004 and 2005 combined. While these responses ranged over a wide number of issues three key themes emerged. First, students wanted more detail about their programmes before they start. Second, over one fifth made reference to the mathematical and scientific content of their programmes and seemed surprised by the extent of it. The third key set of responses referred to the long class contact hours or the difficulty of the programme.

The second set of responses supports much anecdotal evidence in the faculty that students expect to do more real engineering in first year. Despite the reputation of DIT for having a 'hands on' approach to engineering, most of first year modules focus on the mathematical and scientific foundations of engineering. It seems to be the case that 'students expect practicality and find abstraction' [14]. This is not conducive to helping those with a 'sensing mode of perceiving' survive in engineering.

CONCLUSION: LINKING RECRUITMENT AND RETENTION

The evidence presented above has identified the key reasons why students choose to study engineering at DIT. It has been shown that there were gaps in students' knowledge of their programmes before they start studying and that some were surprised by the mathematical and scientific content and the level of difficulty. It was also seen that DIT is recruiting from a very narrow base and that overall ability levels on entry are falling.

How can this information be used to improve recruitment? Can it help in addressing retention issues? There is a general concern about rates of attrition in engineering programmes particularly among first years [5]. Data from the DIT Retention Office shows attrition rates for first year are falling but are still higher than for all years of engineering. Attrition rates are highest on programmes not leading to honours degrees. These are the programmes for which entry points have fallen most.

The findings presented here suggest that action in a number of areas offers potential to improve recruitment and retention [4]. Two are dealt with here.

Firstly, students should be given the opportunity to experience engineering in secondary school. It is clear from the data that many students who take engineering in secondary school achieve high grades and say their experience influences their decision to do engineering. It is also clear that more students would take the subject if it was made available to them [10]. Department of Education and Science data for 2003/04 shows that only 43% of schools provide the subject. Only one of 156 girls schools do so. There is also a difficulty in combining engineering and science subjects [5] making it harder for students who are studying engineering in school to acquire expertise in science. An analysis of the LC subjects taken by the 2004 intake into the Common First Year and PE shows that only 23% had taken engineering *and* a science subject, mainly physics.

In light of this information, there is a need to explore how greater access to engineering could be achieved by, for example, students taking the subject in neighbouring schools. Consideration should also be given to providing transition year modules in engineering. This would help in overcoming the lack of knowledge about engineering. But this should not lead to on overly narrow view whereby engineering is seen as purely a ‘hands on’ activity.

This leads to the second area. It has been seen that there are serious gaps in parents’ and students understanding of engineering. This means that the engineering profession and academic institutions need to consider the image of engineering. Are they contributing to an informed public image of engineering which enables parents to understand that this is a career that will allow their children to make a meaningful contribution to society and be fulfilled? Further, are they generating a public image that young people themselves can understand?

This is an issue that needs to be addressed by the entire engineering community and not just by individual, and competing, institutions. As indicated above an emphasis on the creative role of engineering will help in attracting more females to the profession. The idea of creative engineering has been adopted by Engineers Ireland as the basis for projecting a new image for engineering:

> Engineering needs to be perceived as innovative, proactive, and challenging, where the opportunities to use one’s creative abilities are manifold. We need to make sure that our target audiences feel excited and inspired by the prospects of working in engineering, and confident that they will be admired and respected for their contribution to societal development [15].

This conception of engineering is useful in that will help to address an overly mathematical and scientific image of engineering [12, 13] without suggesting that engineering is just ‘hands-on’ activity. It will also help in addressing some of the issues raised in the research.

Firstly it has been seen that students, especially females, are motivated by intrinsic features of engineering. Career and pay issues are not the primary motivators. In this context emphasis needs to be placed on the '*other* rewards in advertising engineering as a career' [8 emphases in original].

Secondly, in the context of falling mathematics standards amongst school leavers a focus on engineering as 'doing math and science' excludes a large pool of 'potential engineers who have not yet being motivated to develop their math and science skills, and who don't realise that they have abilities that make them well suited to be engineers' [13]. The survey findings show that an interest in mathematics and science is not a primary motivator in choosing engineering. It can also be noted in this context that when asked what attracted them to DIT one third of students not taking level 8 programmes gave a first or second preference to the response: *'The DIT ladder system will allow me to transfer to a higher course when I finish my current course'*. Many students value the ladder system in DIT which allows them to enter at technician level or onto PE and progress to professional programmes when they have attained the requisite standard in mathematics and science. An emphasis on attributes other then proficiency in mathematics may make some believe that engineering is for them.

Thirdly, and perhaps most importantly from the perspective of teaching, an emphasis on engineering as a creative activity may force institutions to consider 'how can the creative challenge that is seen to be an important element of engineering be retained in the training of engineers' [8]. Edward has criticised the overly mathematical approach to the early education of engineers which makes engineering appear 'unexciting, abstract and frankly, tediously arduous'. He argues for an approach that would introduce more innovative work early in courses and 'engage and excite students' [14]. He echoes Wulfs's call 'to make the creative part of engineering more evident early on'. There is no reason, Wulf says, 'to deny engineering students the opportunity to tackle some creative problem solving until they have survived the initiation of two years of math and science.' [16] Such an approach would engage with the main reasons why DIT students do engineering and help bridge the gap between their expectations and their programme of study which undoubtedly contributes to retention problems.

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