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Undergraduate Engineers' Preference for a Range of Professional Roles

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Abstract

This paper reports on a personal preference test which aligns students to a range of professional roles based on their attitudes towards performing particular tasks. The 10-item test was administered to 109 first-year engineering students at TU Dublin, Ireland and 159 third-year engineering students at KU Leuven, Belgium in September of the 2018/19 academic year.

The test had two purposes:

- to align students to three professional engineering roles based on their preference for performing certain tasks;
- to allow students to reflect on an initially tacit model of professional roles.

In this paper only the first purpose is considered, followed by an evaluation of the reliability of the test.

Preliminary results indicate that the majority of students at TU Dublin and at KU Leuven wish to work in roles which involve the development of radically new products and services, while a much smaller proportion of students wish to work with product and process optimisation. The data also indicates that, in general, students have less favourable attitudes towards working in client-centred roles. These findings present a unique challenge for engineering educators and employers alike in Ireland and Belgium, as industries in these nations shift towards services and away from manufacture. So too do the skills requirements to work effectively in the modern engineering sector.

Keywords

Graduate engineers, professional skills, recruitment.

1. Introduction

Ireland has been the subject of scrutiny at European level with regard to some key indicators on the European Skills Index (*European Skills Index Technical report*, 2018). Ireland ranks 22nd out of the 28 EU member states for occupational skill mismatch, which is defined as a nation's ability in matching skills to the relevant job. In particular, engineering professionals and technicians were identified as a sector with a high degree of mismatch (*Skills challenges in Europe*, 2014).

The engineering sector in Ireland has enjoyed rapid growth over the past two decades, with employment levels in the science and engineering professions growing by 17% from 2005 to 2015, a figure which is set to continue to grow by another 13% by 2025 (*Researchers & engineers: skills opportunities and challenges*, 2016). With Ireland's manufacturing sector beginning to decline and employment in professional services seeing a steady rise, the skills requirements of engineering professionals are changing (*Ireland: Skill supply and demand up to 2025*, 2015) and the meaning of what it is to be an engineer is changing as well.

To address the growing concern over the skills mismatch in Europe, the Professional Roles & Employability of Future Engineers (PREFER) project was initiated in 2017 with three main objectives:

- to develop a model of professional roles to help engineering students navigate the job market;
- to develop tailored tests to allow students to reflect on their preferences towards working in these roles and on their strengths and weaknesses;
- to develop curriculum elements to help facilitate students' development of their professional skills.

As part of the PREFER project, a personal preference test was developed to help engineering students evaluate which type of *role*, rather than which *job,* they would most like to fulfil based on a self-assessment (Carthy, Bowe and Gaughan, 2018). This provided students with a compass to enable them to navigate the job market and identify roles which maximally utilise their skills and match with their personal preferences toward work.

The three roles of the PREFER model are the following:

- *Product leadership*, which involves developing new products and services for the company and its clients. Taking the example of the construction sector, this would include novel materials for reinforcing concrete and novel industrial processes for casting or the drilling of piles.
- *Operational excellence*, which focuses on monitoring and analysing production processes, optimising those processes in line with budgetary and time constraints, and coordinating scheduled maintenance of production machinery. Again taking the construction industry example these could be project coordinators, ensuring that a contract is delivered within budget and in a timely manner, and dealing with obstacles that may interfere with these deadlines.
- *Customer Intimacy*, this role centres on providing tailored solutions to clients and listening to their needs. These individuals are responsible for liaising between the firm or company and the client to ensure these needs are met, and to provide technical support to the client when required. These individuals are in particularly high demand in engineering consulting services where a strong emphasis is placed on client satisfaction.

The objective for this paper is to present the results of a pilot of the personal preference test and to establish which role – if any – was the preferred role for undergraduate engineering students to work in.

2. Methodology

Personal preference tests fall into the broad category of self-assessment measures. One method for operationalising a personal preference test is to look for a match between an individual's values, and the opportunities to fulfil these values. In general, these tests are known as value judgements. The advantages of this approach is that the test is easy to fill out and it requires little cognitive effort.

According to the Value-Expectancy Model (Fishbein and Ajzen, 2010), attitudes follow directly from beliefs about the attitude object. For example, Oscar's attitude towards learning maths is a direct result of Oscar's beliefs about the nature of maths. These beliefs could be formed by watching maths tutorials online, as a form of direct observation. They may be formed externally through other media such as accepting information from friends, maths lecturers or professional mathematicians, or they may be self-generated beliefs created through inference.

The way these behaviours can influence attitudes is outlined in the Value-Expectancy Model, which describes attitude formation and structure. The model suggests that attitude formation is autonomous and inevitable as new beliefs are formed about an object. So, an individual will have initial attitudes that are linked to an object, attitudes that slowly change as new beliefs are generated. This can be modelled symbolically as:

$$A \propto \sum b_i e_i \qquad \textbf{Eq.1}$$

The equation states that one's attitudes toward an object is the sum overall of all attributes of the object (Fishbein, M. and Ajzen, 1975). These attributes are composed of the strength of one's beliefs b_i about the attribute i and the evaluation of the attribute b_i relating to the object i. That is to say, the evaluation and strength of one's belief about an attribute contributes to an overall attitude towards an object. So, people will hold favourable attitudes toward an object for which they have associated an overall positive set of attributes to. This will be similar for negative attitudes for which the majority of the attributes associated with that object have subjectively been deemed negative.

A second way to operationalise a personal preference test is to look for an individual's preferred personal style. This is a measurement of an individual's dispositional interest, which reflects their preference for certain behaviours and the particular contexts in which those behaviours occur (Rounds, 1995). The evaluation of these dispositional interests are typically employed when dealing with individuals who are making career decisions (Su, Rounds and Armstrong, 2009).

Dispositional interest evaluation follows in the tradition of vocational psychology where the research focuses primarily on the development, validation and interpretation of interest assessments in order to tackle

issues relating to career development (Low and Rounds, 2006). Imagine a test to determine your favourite piece of fruit, one could simply ask *"what is your favourite piece of fruit?"*, but this question lacks any contextual specificity. Say for example an orange was your favourite fruit, what if the orange was over-ripened? To add more complexity to the problem, what if your second favourite fruit – a banana – is also presented to you and it is perfectly ripe … is the orange still your preference?

This form of testing has obvious value in that it does not simply examine what your favourite fruit is, but allows you to examine the boundaries of your preference and to develop a tacit rank-order of fruit preference. This type of test has been used in prior research into whether or not an individual was work or people oriented to a greater or lesser extent using an inventory style assessment (Harrison and Lubin, 1965). The test developed in this research can be seen as an extension of the work of Harrison and Lubin in that individuals are further separated into being more or less product, process or people oriented, and built on the measurement of *dispositional interests* rather than value judgement.

3. Methods

A test tool was developed by the authors in collaboration with HR professionals from the Human Capital Department at BDO, a large consultancy firm, to evaluate a student's fit to the three professional roles outlined in the PREFER project (Craps *et al*, 2017). This was achieved by separating the test into two parts. The first, which is the topic of discussion in this paper, was a personal preference test. The personal preference test asked participants to select the most and least preferred course of action from three possible activities.

An example drawn from the test is as follows. Together with two colleagues, you are preparing a new project. Which of the following roles would you prefer during this preparatory phase? The participant is then presented with three activities and asked to indicate their most preferred, and least preferred, course of action:

- Exploring technical reports to detect the latest developments in the field;
- Drafting the operational processes in order to reduce risk and maximise efficiency;
- Exploring the market in order to identify opportunities and setting up a marketing strategy.

This was initially a 10-item test with each response aligned to one of the three roles, developed by the PREFER development team in close collaboration with HR professionals from BDO. The test was administered on pen and paper. Participants were initially asked about their role preference and provided with a brief description of each professional role. The test was provided to 221 male and 39 female engineering first-year engineering students from TU Dublin, Ireland and third-year engineering students from KU Leuven, Belgium in the first semester of the 2018/19 academic year. Scores were assigned to each role with a theoretical maximum of 10 representing full preference for a particular role and a theoretical minimum of -10 representing full distaste for a particular role.

A six-item feedback questionnaire was added to gauge the user experience of the test. In the feedback questionnaire, the interpretability of the test in terms of the English language was evaluated along with students' need for feedback, the degree of interest in the presented cases and the length of the test. The test was administered in conjunction with a brief introduction to the research and was carried out with full ethics approval from the TU Dublin Research Ethics Committee (REC-17-112).

The test was subjected to face validation. A face validation procedure is a means of establishing if a test is fit for purpose by collecting expert opinions on the test items (Hardesty and Bearden, 2004). In this instance, the procedure involved structured interviews with five engineering academics who possessed industry experience from TU Dublin. A cross-section of engineers was selected, ranging from those who had worked with tangible products and services to those who work with more virtual products and services such as software applications and in consultancy. The items were read one by one and the participants were asked if they felt that each item was a realistic scenario for a graduate engineer to find themselves in. Their feedback was collated and used to fine-tune the first draft of the test.

A reliability analysis was carried out on the data collected from the pilot studies using Cronbach's test of internal consistency (Cronbach, 1955). The purpose of a reliability analysis is to see how the items on the test relate to one another and to establish how reliable a measurement is, in this instance how reliably it measures a participant's preference for a particular engineering role. For this analysis a "correct answer" for each item was assigned based on the participant's initial role-preference from a choice of the three roles followed by a short description. In other words, if a student initially chose *product leadership* as their preferred role, that participant could only score when their item response aligned to that initial preference.

The assumption for the purposes of this analysis was that the initial role-preference and the test itself measure the same thing and that students did not attach qualitatively different meanings to this initial question. The values obtained from the Cronbach's test will be discussed in detail in the results section.

4. Results

4.1 Reliability analysis

Each item had three values for Cronbach's alpha coefficient, one for each role it represented. The mean values for each role were α =.668 for the *product leadership* role, α = .427 for the *operational excellence* role and α = .545 for the customer intimacy role from a sample of n = 197 complete responses. The estimated acceptable value for a test of three roles with 10 items is .52±0.2 (Cortina, 1993) and so a lower bound of .32 was established as the minimum criteria for a reliable test in this instance.

Rather than focusing on the three values of alpha obtained from the initial analysis, the test values of alpha when a particular item was deleted were examined. *For Item 5* of the test, in the case of all three values of Cronbach's alpha obtained, the reliability of the test increased when that item was removed. The mean values for each role with *For Item 5* deleted were α = .686 for the *product leadership* role, α = .460 for the *operational excellence* role and α = .624 for the *customer intimacy* role.

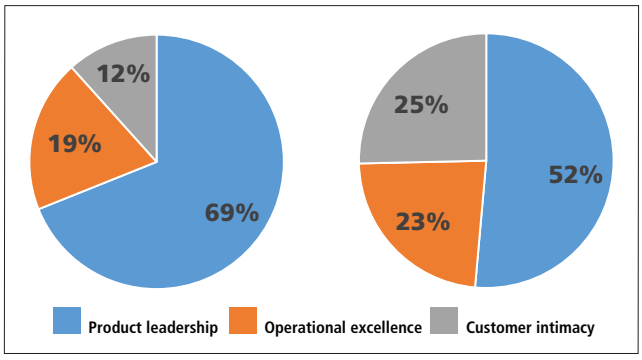

Figure 1: Comparison of initial role preference in TU Dublin and KU Leuven.

When one considers that this was a pilot study, these scores are promising and with a larger sample of the population and a revision of the test, the authors remain optimistic about the reliability of the test.

4.2 Personal preference test

The results of the initial question about role-preference (Figure 1) reveal some interesting findings about students' *prima facie* views of the roles from a sample of n = 268 responses. The results show a clear preference for product leadership roles, followed by customer intimacy and operational excellence. This preference is larger in TU Dublin, with 69% of participants indicating product leadership as a preference compared to 52% in KU Leuven.

This difference may be for a variety of reasons, including the participants' year of study. This finding might suggest that, with increasing age, engineering students' preferences become more diverse and less driven by a desire to develop radically new ideas. Another factor may be cultural. However, neither factor can be explained to any degree of certainty within the scope of this study.

A more detailed look at the data was undertaken by examining test scores. A theoretical range of 20 (±10) was established for each role as students were not only asked about their most preferred course of action on 10 items (+10), but also their least preferred course of action on those same 10 items (-10). Looking to the mean test scores from TU Dublin and KU Leuven, the mean score for product leadership was similar at 2.6 and 2.9 respectively, indicating modest preference for product-facing roles.

In stark contrast to these scores are the scores for operational excellence and customer intimacy roles, in particular in customer intimacy where there are modest negative views attributed to the role, with mean scores of -2.9 in both cases (Table 1).

It was important to establish if the data collected fit a normal distribution, as this opened up the possibility of using parametric statistics on the data, which provide a greater degree of certainly about findings than their non-parametric equivalent. A single sample Kolmogorov Smirnov test of normality revealed that the data was normally distributed in the above cases, except for the data collected from KU Leuven in the Operational Excellence role. Mean test scores are quoted in all cases. However, median values should be considered a more valid statistic than the mean value when discussing the results from the KU Leuven data on Operational excellence (Kvam and Vidakovic, 2007).

University	Role	N	Sig. Test of Normality	Mean	Standard Deviation
TU Dublin	Product leadership	114	.019	2.6	3.0
	Operational Excellence	114	.006	0.5	2.8
	Customer Intimacy	114	<.0005	-2.9	3.1
KU Leuven	Product leadership	159	<.0005	2.9	3.5
	Operational Excellence	159	.057	0.0	3.9
	Customer Intimacy	159	.003	-2.9	4.2

Table 1. Mean scores in each role on the Personal Preference Test.

From the box and whisker plots shown in Figure 2, the data suggests that overall students have a preference for working in product-facing roles, while students express a lower preference for working in customer-facing roles. This is in good agreement with the data collected about the students' initial role preferences. This means that, on average, students express a preference towards activities associated with the product leadership role, are neutral towards operations-focussed roles, and have a lack of preference for client-focused roles.

4.3 Feedback questionnaire

The personal preference test also included a number of feedback questions which served as a secondary means of validation for the test. This allowed evaluation in terms of whether both native and non-native English speakers could understand the language used in the test, and whether the test was perceived to be of value to the participants. The most important of these findings was that both native and non-native English-speaking students could understand the language used in the test.

More specifically, in TU Dublin 76% of the respondents either agreed or strongly agreed with the statement "I could easily understand the language" (Figure 3). Upon further examination, three out of four of these students stated that they were non-native English speakers and so the results from KU Leuven became pivotal in confirming the

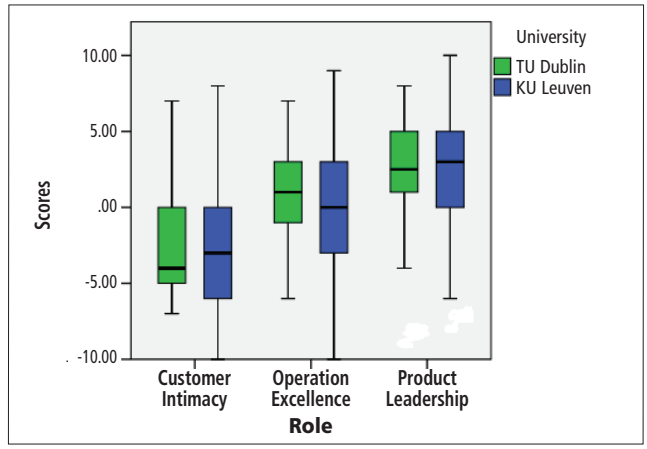

Figure 2: Box and whisker plots of scores by role, clustered by University.

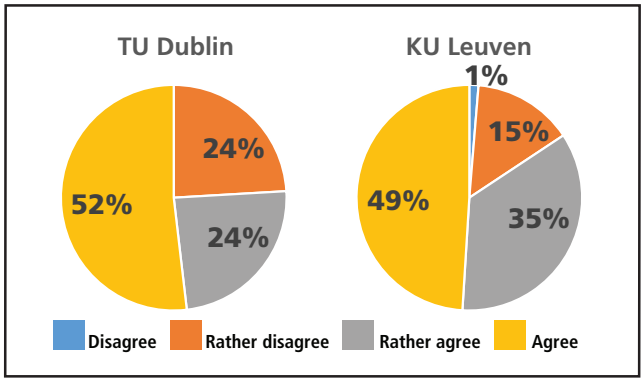

Figure 3. Comparison of responses to "I could easily understand the language".

usability of the test on a wider, non-native English-speaking cohort.

The results from KU Leuven indicated that 83% of the participants could understand the language used in the test. This was a promising result as both students of native and non-native English-speaking universities seemed to be able to understand the language used.

In addition to the language aspect, participants were also asked to rate the statement "I enjoyed filling out the questionnaire" (Question 4) and "I am curious about my results" (Question 5). Regarding the latter question, 26% either disagreed or strongly disagreed with the statement.

Although the majority of students were both curious about the result and enjoyed the experience, there was a reasonable proportion of students who did not. There are certainly grounds to conduct focus group discussions with the students who took part in order to get to the bottom of these results and collect recommendation for revisions before the final draft is delivered.

Twenty seven students spoiled their test data by completing the test incorrectly. In most cases this was the result of selecting more than one most-preferred response, or more than one least-preferred response. Upon analysis 94% of students agreed that the instructions were clear in Question 7 which stated "I found the instructions clear" which can only be described a spurious result in light of the rate of spoiled test data. Accordingly, a more detailed set of instructions is to be added to the beginning of the test to mitigate spoiled data.

5. Discussion

The authors believe that the data presents compelling evidence of engineering students' role-preferences being biased towards product-facing roles with implications for recruiters, in particular those companies and firms who seek client-focused graduates to work in consultancy. The test will be run again in TU Dublin with first-year engineering students in the 2019/20 academic year to establish if this pattern of role-preference is consistent over time. It will be followed by a retest of the original cohort of first-year students in the 2020/21 academic year to establish their role preferences change over the course of a two-year period.

6. Conclusions

The test will be revised in light of the results of the validation. In particular, *Item 5* will be altered, which will result in an increase in the mean value of Cronbach's alpha and provide a more reliable test of role preference. In addition, there is a case to extend the test beyond 10 items. There is a direct correlation between test length and reliability (Lord, Novick and Birnbaum, 1968), which is in some way implicit in that it adds granularity to a data set. The major disadvantage to adding items is that it increases test length, which currently is about ten minutes.

There is also a case for conducting a focus group discussion with students who have either taken the test or who are willing to review the test in an attempt to explain some of the negative experiences that test users expressed in the feedback questionnaire.

Currently, the data suggests that engineering students at both TU Dublin and KU Leuven have a strong preference to work in product-facing roles and a lack of preference for working in client-facing roles. This has serious implications for engineering recruiters, particularly those recruiting into consultancy, where a large amount of time is spent working with clients.

It also has wider implications for the field of engineering as a whole, as engineers spend as little as 7% of their time working on design and innovation, and 60% of their time managing projects and carrying out tests and inspections (Trevelyan and Williams, 2019). There certainly seems to be a mismatch emerging between what an engineer does and what undergraduate engineers would *like* to do.

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