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ENGINEERING STUDENTS' PREFERRED ROLES: ARE THEY STABLE, ARE THERE GENDER DIFFERENCES?

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ABSTRACT

Being able to situate oneself in an engineering role is a developmental process. Students may initially have idealized perceptions of a professional role and over time, they make this role more congruent with their own values and goals [1]. In light of this, Higher Education Institutions are being challenged to offer learning experiences and career exploration activities to enable students to clarify their interests, values and competencies in relation to a professional role [2]. This study compared the professional role preferences of more than 700 engineering students at TU Dublin (Ireland) and KU Leuven (Belgium). Professional role preference was measured with PREFER Explore, a personal preference test for engineers. The test aligns students to three professional roles for early career engineers: Product leadership (focus on radical innovation), Operational excellence (focus on process optimization) and Customer intimacy (focus on tailored solutions and customer satisfaction). A comparison was drawn between the role preference of first year students at TU Dublin and KU Leuven to establish if there were significant differences in preference across both universities. The results suggest that the role preference of engineering students does not shift from first to third year. There is also evidence that the PREFER Explore is sensitive to gender differences, with female students showing a greater preference for customer intimacy than males and males showing a greater preference for operational excellence than females at TU Dublin. The data have a number of implications for the labor market in Ireland and Belgium.

1. INTRODUCTION

Several studies showed that first-year engineering students lack clear views of their professional future and have rather vague ideas about engineering [3,4]. A 2018 study in KU Leuven (Belgium) and TU Delft (The Netherlands) indicated that first year students in both universities seemed to be most attracted to roles that involved product innovation [5]. However, in reality, only a small proportion of engineers are directly involved in technological innovation [6,7].

Being able to situate oneself in an engineering role is a developmental process. Students may initially have idealized perceptions of a professional role and over time, they make this role more congruent with their own values and goals [8]. In light of this, higher education institutions are being challenged to offer learning experiences and career exploration activities to enable students to clarify their interests, values and competencies in relation to a professional role [2]. Earlier studies have demonstrated that a better understanding of one's professional future and engineering identity not only has positive consequences for student learning and study choices [9,10], but also increases employability and job satisfaction [11,12]. This study sets out to explore the role preference of engineering students at TU Dublin and KU Leuven in order to address three research questions:

1) How does the role preference of engineering students at KU Leuven and TU Dublin compare?
2) Are there differences in role preference of first year engineering students based on gender?
3) Does year of study have any influence over this preference, or are the preferences stable?

2. BACKGROUND

2.1 Professional Role Model for Future Engineers (PREFER-model)

The PREFER-model was developed to enhance engineering students' reflection about their future selves. The model wanted to offer very concrete opportunities to grasp particular aspects of the complex and varying careers that an engineer can pursue that transcend the engineering discipline. The model represents three professional roles independent of discipline: Product leadership (focus on radical innovation & research and development); Operational excellence (focus on process optimization & increasing efficiency); Customer intimacy (focus on tailored solutions for specific clients). The roles specifically focus on early career engineers and are flexible in use since several roles can be combined in one job. The model has been thoroughly validated with both industry stakeholders and engineering students [13,14]. For each of the roles, essential non-technical competencies have been identified in close collaboration with industry [15].

Based on the PREFER-model, two tests were developed allowing students to explore their personal preference and to receive feedback on their role alignment and competencies. In this study, the PREFER Explore test was used to investigate role preference [16,17]. A further description of PREFER explore is provided in the method section.

2.2 The nature of interest

Interest is not a self-sufficient concept, it requires material, a subject matter and conditions on which an individual can operate, effort on the part of the individual and that the individual possesses some traits and tendencies that can be assessed [18]. So a researcher must consider the modality of the assessment of this interest and the nature of the interest as well. Interest can take on two forms, either *situational interest*, which is a snapshot of an individual's interests at a given time that can change based on their experiences, or *individual interest* which is relatively stable over time and has a tendency not to change with experience [19]. This highlights a question as to whether or not PREFER-Explore is a situational interest assessment or an individual interest assessment, which the authors will attempt to address during the discussion of the results.

2.3 Gender differences in vocational interest

The magnitude and variability of gender differences in individual preference was examined in great detail by Su, Rounds and Armstrong [20] who suggest that men and women differ in their preference for things and people, with women favoring people and men favoring things. Carrying out a meta-analysis of 503,188 responses to 47 interest evaluations, this gender difference in People-Thing orientation was found to be significant, with a large effect size ($d = 0.93$). While Su, Rounds and Armstrong concede that the application of some item development strategies can reduce gender differences, they suggest that interest may play a crucial role in occupational choices in STEM fields. This phenomenon was also investigated in an engineering specific context in a recent article by Bairaktarova and Pilotte [21]. In their study of 339 practicing engineers and engineering students, they found significant gender differences in both people and thing orientation in both practicing engineers and students.

3. METHODS

3.1 Data collection

In total the test was administered to 755 students, resulting in data from 624 males and 131 females being collected. A summary of the datasets is presented in table 3.1. All data collection was carried out with the full approval of the TU Dublin research ethics committee (REC 17-112) and the KU Leuven ethics committee (G- 2019 10 1792)

respectively. The engineering discipline of the sample of students is provided in table 3.2, with first year students in both universities enrolled in a common entry route.

Table 3.1 Summary of data sets form TU Dublin & KU Leuven

University	Gender	N	Year of study	Year of collection	Collection method	Response type
TU Dublin	Female	12	1	2018	Pen and paper	Voluntary
	Male	98				
TU Dublin	Female	22	1	2019	Pen and paper	Voluntary
	Male	79				
KU Leuven	Female	27	3	2018	Pen and paper	Voluntary
	Male	127				
KU Leuven	Female	70	1	2019	Online platform	Obligatory
	Male	320				
Totals	**Female**	**131**				
	Male	**624**				
Grand Total		**755**				

Table 3.2 Engineering discipline of sample

Engineering discipline	N	%
Engineering (common entry)	596	79%
(Bio)Chemical Engineering	25	3%
Electronics-ICT Engineering	42	6%
Mechanical Engineering	81	11%
Structural Engineering	10	1%
BLANK	1	0%
Grand total	**755**	**100%**

This data allows a study using data from both universities to establish a comparative study of first years and the potential gender differences in the role preferences of first year students and moreover a cross sectional study in KU Leuven to evaluate if role preference was stable over time .

3.2 Instrument
The test instrument used in this research was PREFER-Explore [22] a 10 item personal preference test that aligns individuals to 3 professional roles based on their vocational interests. Product leadership, Operational Excellence and Customer Intimacy. Participants are provided with several questions, for example: You participate in an event that is aimed at stimulating knowledge sharing in your professional area. You can choose between different kinds of sessions. What sessions would you prefer the least and the most?

- Information meet ups and networking sessions with engineers from within your field

- Presentations on best practices to increase efficiency of production and delivery of services in your professional area

- Presentations discussing the state-of-the-art in your field of expertise

A maximum score of 10 and a minimum of -10 is assigned to each role, giving a theoretical range of 20. When students indicate a response is their least preferred, it deducts 1 point from that role and *vice versa* when they indicate it is their preferred role.

The test has been shown to be a reliable test for evaluating preference in each of the three roles with modest inter-item correlations and Cronbach's Alpha Coefficients ranging between .460 and .686 [17]. The items of PREFER-Explore are available at via the instructors test account on www.fet.kuleuven.be/prefer.

3.3 Data analysis

All data from each role were checked for normality to establish if the data were normally distributable or distribution free. A comparison was drawn between first year students in KU Leuven and in TU Dublin to establish if differences in role preference were observed across universities. As the sample sizes for first year students were different, homogeneity of variance was not assumed for the t test, this was confirmed with a Levene's F test. The null hypothesis H_{0a} was that there would be no difference in the sample means and an alternative hypothesis was promoted by the researchers that significant differences would be observed H_{1a}

Data collected from first year students were analyzed to establish if there were differences in role preference by gender using independent samples t-tests to compare the scores of male and female students in each of the three roles at both Universities. As the sample sizes for male and female students were different at each university, homogeneity of variance was not assumed for the t test, this was confirmed with a Levene's F test. The purpose of selecting first years for this analysis was to determine if there were differences in role preference by gender on entry to University. The null hypothesis was that no significant differences exist between the two cohorts H_{0b} and an alternative hypothesis was promoted by the researchers that significant differences in the sample means would be observed H_{1b} in each role. The purpose of this analysis was to determine if PREFER-Explore was sensitive to gender differences.

Using an independent samples t-test, the distribution of scores for each role were compared between first and third years students at KU Leuven to establish if they were significantly different from one another and to establish an effect size. As the sample sizes for first and third year students were different, homogeneity of variance was not assumed for the t test, this was confirmed with a Levene's F test. The null hypothesis H_{0c} was that there would be no difference in the sample means and an alternative hypothesis was promoted by the researchers that significant differences would be observed H_{1c}. The purpose of the analysis was to determine if the preferences of the students were stable over time.

4. RESULTS

4.1 Role preference by university

As highlighted in table 4.1, a strong preference for product leadership was observed in both universities, while operational excellence remains in a neutral position, followed by a lack of preference for customer intimacy based on mean scores.

Table 4.1. Independent samples t-test of scores from KU Leuven and TU Dublin

Role	University	N	Mean	Std. Dev	t	df	Sig. (2-tailed)	Cohens d
Product Leadership	KU Leuven	363	3.19	3.165	2.1	401	0.036*	0.185386
	TU Dublin	198	2.6	3.2				
Operational Excellence	KU Leuven	363	-0.06	3.788	-0.873	427	0.383	-0.07625
	TU Dublin	198	0.22	3.552				
Customer Intimacy	KU Leuven	363	-3.12	3.758	-1.272	411	0.204	-0.11017
	TU Dublin	198	-2.71	3.685				

*$\alpha = .05$

It can be noted that first year students in KU Leuven hold a stronger preference for product leadership roles on average when compared with first year students in TU Dublin. Upon further examination, the difference in mean scores for product leadership were found to be significant, with a small effect size (.19), while no significant differences in the mean scores from the other two roles were observed across the two universities.

4.2 Role preference by gender

The analysis carried out on the sample of first year engineering students to determine gender differences in vocational interest revealed differential results in both universities. In TU Dublin no difference existed between female-male preferences for product leadership. For operational excellence and customer intimacy however, significant differences in female-male sample means were observed at a confidence interval of 95%. A subsequent examination of Cohen's d revealed a small effect size in both cases, with female students having stronger preference for customer intimacy than males and males having stronger preference for operational excellence than females. In KU Leuven, no significant gender differences were observed in the three roles.

Table 4.2 Independent samples t-test of gender differences in preference in TU Dublin

Role	Gender	N	Mean	Std. Dev	t	df	Sig. (2-tailed)	Cohen's d
Product Leadership	Female	35	2.66	3.067	0.129	52	0.898	0.025
	Male	163	2.58	3.237				
Operational Excellence	Female	35	-1.03	2.895	-2.674	59	0.01*	-0.459
	Male	163	0.48	3.63				
Customer Intimacy	Female	35	-1.46	3.551	2.282	51	0.027*	0.421
	Male	163	-2.98	3.668				

$\alpha = .05$

Table 4.3 Independent samples t-test of gender differences in preference in KU Leuven

Role	Gender	N	Mean	Std. Dev	t	df	Sig. (2-tailed)	Cohen's d
Product Leadership	Female	68	2.91	3.398	-0.753	95	0.453	-0.088
	Male	295	3.25	3.112				
Operational Excellence	Female	68	-0.38	3.579	-0.804	106	0.423	0.069
	Male	295	0.01	3.836				
Customer Intimacy	Female	68	-2.53	3.846	1.422	98	0.158	-0.031
	Male	295	-3.26	3.73				

α = .05

4.3 Role preference by year of study

The analysis of the differences in role preference based on year of study at KU Leuven suggest that there are no significant differences between the role preference of first year students and third year students at a 95% confidence interval.

Table 4.4 Independent samples t-test of differences in scores by year of study

Role	Year	N	Mean	Std. Dev	t	df	Sig. (2-tailed)	Cohen's d
Product Leadership	First Year	294	3.25	3.117	1.237	216	0.217	0.135
	Third Year	128	2.8	3.532				
Operational Excellence	First Year	294	0.03	3.832	-0.657	238	0.512	-0.069
	Third Year	128	0.3	3.899				
Customer Intimacy	First Year	294	-3.28	3.724	-0.444	215	0.657	-0.047
	Third Year	128	-3.09	4.254				

*α = .05

5. DISCUSSION

The results of the comparison of role preference in KU Leuven and TU Dublin suggests that first year students, by and large, have similar preferences for each of the three professional roles, with the exception of Product Leadership, where the preference is significantly higher in KU Leuven than in TU Dublin, with a small effect size (.19). The reasons for this could be numerous, one possible explanation is that the economic activity of engineers in Belgium places a stronger emphasis on manufacture than Ireland, manufacture implies the production of a tangible product and may explain the greater degree of preference for such a role.

The results of the analysis of differences in mean scores by year of study reveal that students' role preference is rather stable. That would tentatively suggest that PREFER-Explore is an *individual* interest assessment as opposed to a *situational* interest assessment, as the results seem to be stable by year of study. Of course, the finding of this study are based on cross sectional data and so changes in preference could not be

tracked. Previous research in Belgium suggests that role preference is not stable over time [14], however the sample sizes was low (n = 67) and the data were also cross sectional. On the basis of both the Belgian study and the study reported here, the author's hypothesis is that PREFER-Explore is in fact a *situational interest* assessment. To address this, a longitudinal study using PREFER-Explore would need to take place that tracked students' role preference over time. It would also be interesting to investigate whether students have clear preferences for a combination of roles. Earlier research with Masters students indicated that, when combining roles, up to 40% of the students expressed a preference, either as a single role or combination of roles, for customer intimacy [14].

The results of the analysis of gender differences in the mean scores on PREFER-Explore reveal differences in preference between male and female students in operational excellence and customer intimacy at TU Dublin. This would suggest that the test is sensitive, at least to some degree, to the female *people-orientation* discussed in the literature. The test did not detect gender differences in preference for product leadership however, this is contradictory to evidence in literature which suggests that male students are more *thing-oriented*. There are two explanatory factors, one is that the product leadership subscale is simply not sensitive to these differences and the second is that students who have selected engineering as their field of study are already predisposed to be *thing-oriented*, regardless of their gender. This latter factor is far less likely however, as confirmed by previous research into engineering students' people and thing orientation [20,21]. This first point, about the sensitivity of the test to gender differences is punctuated in the KU Leuven data, where students showed no difference in role preference based on gender in any of three roles, with a clear preference for product leadership being demonstrated from the data.

6. CONCLUSIONS

Nye et al [23] expected that interest would predict performance where that interest directly related to an occupation. In their study, which evaluated 60 years of interest research, the samples of students and those who were employed illustrated moderate correlations with performance criteria and persistence at work and in school highlighting the benefits of interest assessment in predicting job success. In addition, they discuss the added benefit of providing interest profiles rather than interest levels stating that in predicting performance in a particular occupation or major should involve considering the interest profile in that particular context. Learning the knowledge and skills required to understand topics where there are less well-developed interests is a difficult task. Students are less motivated to work on developing knowledge about these topics. Their ability to make enquiries about these topics is also limited, questions tend to be procedural, unless they set a goal to learn about it. Most adults can set goals and utilize motivational strategies from other content domains in order to master content in less well developed interests, and they can learn to do so [24]. It is an imperative then, that students can frame the topics of study in their programme within a professional role, to enable them to develop motivational strategies to succeed in topics where they lack an intrinsic motivation to succeed.

In addition, and in response to previous work by the authors on role preference in different universities, a comparison was drawn between the interests of first year engineering students at KU Leuven and TU Dublin to evaluate if there were differences in role preference across these universities. As noted in previous research, there is a strong lack of preference for customer intimacy roles and a strong preference for product leadership

roles. Despite female students having a stronger preference for customer intimacy, the mean scores on this subscale still range from -1.46 to -3.26. With approximately 3.5 standard deviations from the mean score on this role, even positive scores for customer intimacy are relatively small compared to the other two roles. This presents a number of challenges in Ireland and Belgium, as traditional manufacturing begins to decline and jobs in professional services continue to grow [25,26] the role of an engineer in industry is changing. There are two key issues, the main issue being that if we concede that engineering is as much about people as it is about product and process, a question is raised about how we can attract talent to engineering that focuses on the former of these roles as well as the latter two. There is a second, paradoxical issue, in that female students at TU Dublin have a stronger preference for customer intimacy roles than males, roles which are becoming more and more important to the industry, yet females remain consistently underrepresented in traditional engineering disciplines. The authors argue that in light of this research, now more than ever, initiatives seeking to secure the STEM pipeline are essential to ensure we avoid vertical skill mismatch in the field.

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