ENHANCING (FUTURE) STUDENTS' SENSE OF BELONGING TO INCREASE DIVERSITY AND INCLUSION IN ENGINEERING

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ABSTRACT

The shortage of engineering talent leads to a loss in economic output. This shortage-combat has to be fought on several fronts, one of them is attracting and retaining more currently underrepresented students. This paper discusses the need to improve a sense of belonging and to increase professional awareness, or the understanding of the different roles an engineer can take on, in order to increase diversity in engineering. Based on an extensive literature review an overview is given of previous research on this topic from an interdisciplinary perspective.

Research has shown that professional identity development has high impact on persistence and study success. Although identity development is a hot topic in engineering education research, several studies indicate that engineering students still have difficulties in grasping what it is to be an engineer and often fall back upon the rather stereotypical, harsh technological, male image. However, research also shows that it is important for students to know what to expect and value in order to develop feelings of belonging or fit. The former European project PREFER has developed promising tools in this regard. However, these tools have not been tested regarding inclusiveness.

The paper also outlines the next steps that will be taken by the authors as part of an interdisciplinary project URGENT to increase attractiveness and retention of underrepresented groups in engineering education. This URGENT project proceeds on the outcomes of the PREFER project and will focus on the attraction and retention of female students and students with a migration background.

1   INTRODUCTION

In this rapidly changing world, facing many global challenges, engineers play a crucial role. However, the demand for engineers has never been greater [1], [2]. To decrease the engineering shortage, education and industry should focus on a relatively large but unexploited talent pool that lack the opportunities necessary to prepare for engineering careers [3].

The project URGENT (UnderRepresented Groups in Engineering Technology) that was launched at KU Leuven (Belgium) aims to improve motivation and persistence for female students and students with a migration background in engineering education. Research conducted in an earlier European project PREFER (Professional Roles and Employability for Future EngineeRs) indicated that different groups might have different role preferences [4], [5] and that professional awareness (the knowledge and understanding of different engineering roles) is important in making career choices [6].

The objectives of the URGENT project are threefold. First, the project aims to increase insight into the constraints to recruitment and retention in terms of cultural or gender expectations and stereotypes. Are the initial beliefs and predispositions on engineering the same for male and female students and for students without and with a migration background? Second, possible differences in interest and motivation between the different student groups will be investigated using the recently developed PREFER

tests [7], [8]. These tests were designed to initiate and stimulate reflection among engineering students about their professional identity. In order to be able to implement them in an inclusive learning environment, the tests will be evaluated on gender and cultural inclusivity and validity. Final, the third objective builds on the insights from the first two objectives and aims to develop and pilot a number of interventions in secondary schools and in university to break through the stereotypical perspectives on engineering.

In order to realise the URGENT objectives, a well-balanced interdisciplinary consortium was built involving partners from university, secondary education and industry in Belgium. Research expertise in engineering education, sociology and social psychology are brought into the project. The project is actively supported by university's central offices of Communication and Recruitment, Diversity, and Career Guidance. Also, different secondary schools, companies and STEM organisations engaged in the project, as well as ie-net, the Belgian engineering federation.

This paper reports on a literature review that laid important foundations for the project. First, the context of this study is described, emphasizing the need to increase the representation of different groups in engineering (education) (Section 2). Section 3 presents theoretical insights from sociology and social psychology regarding the importance of a sense of belonging to the engineering field. Section 4 brings the perspectives from engineering education research, in particular on professional identity development. Final, the paper concludes with a summary presenting the next steps of the URGENT project.

2   BACKGROUND

2.1 Different hurdles for different groups

The characteristics of a target group determines what actions a university should take to attract and retain different groups. For example, in 2021-2022, female students made up half of the first-year students at KU Leuven[2] but only 18,9% of the students who enrolled in a Bachelor's programme in Engineering Sciences is female and even less in the Bachelor's programme in Engineering Technology (10,2%) [9]. However, their retention is better compared to male first-year bachelor's students [10].

Engineering students with a migration background also face a recruitment problem. If we look again to KU Leuven, they make only 8,4% of the first year students in Engineering Technology (and 13,1% in Engineering Sciences) [9]. However, by a large extent, this can be explained by their underrepresentation in the higher tracks in secondary education that prepare for the engineering programmes. Since students with a migration background, on average, show lower retention at university than the students without [11], engineering faculties should try to improve the retention of this group of engineering students.

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[2] KU Leuven is a comprehensive university, offering a broad range of programmes in Humanities and Social Sciences, in Biomedical Sciences, and in Sciences, Engineering and Technology.

This shows that universities should remove different barriers to increase the representation of different groups in engineering, such as barriers during recruitment for female students and hurdles during their studies for students with a migration background leading to lower retention. Removing these barriers will increase the representation of diverse groups in engineering, which will be beneficial for industry and the society at large [12].

2.2 Different groups for a smarter industry and a prosperous society

Increasing diversity in engineering, like the representation of female engineering students and students with a migration background, has never been more important. When businesses truly embrace diversity and inclusion, they create a powerful team that is unbeatable together [13] and outperform homogenous groups on complex tasks. These "diversity bonuses" include improved problem solving, increased innovation, and more accurate predictions, all leading to better results [12].Today, more effort is needed in this regard as stated by Hilary Leevers, Engineering UK chief executive [14]: "Workforce diversity improves innovation, creativity, productivity, resilience and market insight and the engineering workforce could and should be much more diverse." Also, SEFI and ASEE, the European and American Societies for Engineering Education, recognize that higher education should find better ways to retain and support individuals who are commonly underrepresented [15]. Historically, the demographic of practicing engineers has not reflected societal heterogeneity.

The recruitment of more female students and the retention of students with a migration background will improve the diversity of these groups in the community of professional engineers. This will make the industry smarter and society more prosperous. The next question is: how? Making a choice for a (future) career is a complex process, in particular when one does not feel that they belong to or fit in a (professional) group. In the next section, we look for theories and insights, in particular from the perspective from social psychology and sociology.

3   FEELING A SENSE OF BELONGING

3.1 What do I expect?

Young people's educational decision-making is a complex process, and many approaches have been taken to understand it in the STEM field (for an overview, see e.g., [16]). One key approach is the expectancy-value model of achievement-related choices [17]. The underlying premise of this theory is that choice, persistence and performance can be explained by individuals' beliefs about how well they will perform in a particular activity ('Will I do well and succeed?') and the subjective values they attach to the activity (e.g., 'Do I like this?', 'Is it useful?', 'Does it fit with what is important to me or others around me?'). Both expectation of success and subjective value predict career choices [18]. These beliefs are a result of gender and cultural socialization.

3.2 What do I value?

Although young women and people with migration backgrounds may have equal formal access to higher education, informal constraints in terms of cultural or gender expectations and stereotypes still restrict access for certain groups. For example, stereotypes about women's mathematics capacities and about ethnic minorities' intellectual capacities can reduce their expectation for success [19]. Importantly, expecting to succeed is not enough to choose a field, the subjective value is key too. Due to gender and cultural socialization, women and ethnic minorities often attach less value to engineering. For example, in STEM fields, characteristics such as brilliance and independence, being self-focused and agentic traits are strongly valued [20]. Additionally, the STEM fields are much less associated with communal characteristics (working with and helping others [21]). Although these characteristics in itself seem neutral, they are stereotypically associated more with the majority groups, and subtly exclude minority groups, such as, in the male dominated STEM fields, women and ethnic minorities [19] (also called 'majority group defaults' [22]). Brilliance and agentic traits are much less associated with women and ethnic minorities [23], [24], and communal characteristics are typically valued more by women and ethnic minorities [21], [25]. As a consequence, these minority groups tend to feel less sense of belonging in these fields and they tend to be less interested in fields such as engineering [26]. Within engineering, women also tend to be less likely than men to value technological leadership but more likely to value social consciousness [27]. The intersection of the two target groups is studied by Phalet et al. [28]. They discovered that women with a migration background in Belgium show the same relative educational advantage as the women without a migration background: they are more inclined than men to start university and to stay on.

3.3 What do I want to become?

The role of subjective value in career choices has also become stronger with increases in economic prosperity in many Western countries and having more alternatives to choose from [26]. As put by Yalcinkaya and Adams ([29], p. 363): "Our review of cultural-ecological variation in STEM gender gaps suggests that freedom from financial or relation-maintenance concerns and freedom to pursue personal dreams may [actually] insidiously constrain women, who seem otherwise liberated, to conform to particular stereotypes about gender and academic pursuit." In our rich western societies, we value the idea of free choice. The question 'Who do I want to be?' becomes more and more important during the process of choosing [26]. As a consequence, the concept of professional identity development has become increasingly relevant, and this concept needs more empirical attention. Identity development is a particularly important part of young people's lives. For students it is not only a question about what they want to study, but also of who they wish to become, i.e. of constructing an attractive identity, or an ideal possible self [30], [31]. Moreover, study choice is not an isolated event but a continuing process, also after entering higher education.

4   REFLECTING ON THE ENGINEERING IDENTITY

Research about professional identity and value creation within the field of engineering is hot [32]. The incentives to focus on this specific topic within the engineering community are numerous. The professional possibilities of engineers are diverse but that makes it also vague for students. Students are not aware that they should reflect about the ideal match, resulting in a possible mismatch [33], [34].

4.1 Knowing what to expect or value: the importance of professional awareness

Engineering students who choose a discipline through a deep exploration of the field and who believe the choice matches their interests, skills and prior experiences, are more likely to have positive beliefs about their competencies in engineering and the value of an engineering discipline [35]. The importance of professional awareness (knowing and understanding different engineering roles) and career exploration was confirmed in a recent study: engineering students who showed more career exploration and a better understanding of the possible future engineering roles were more confident that they would fit their future role [6], young graduates perceived also a higher job satisfaction [36].

4.2 Knowing what to become: the PREFER instruments

To aid students in getting a grip on the variety of engineering jobs, Craps et al. [37] developed a competency based professional role model describing three roles that early career engineers can take on when entering the labour market. These roles, independent of discipline, are product leadership (focusing on radical innovation and research and development), operational excellence (focusing on product or process optimisation and increasing efficiency) and customer intimacy (focusing on tailored solutions for particular customers). This PREFER model is a unique reflective instrument that offers a compact view of engineering practice in the early stage of the career in a flexible manner. The model was validated with both education and industry stakeholders, and 13 expert panels including engineers and HR representatives identified the professional competencies that industry requires to be successful in these roles [37]. Based upon the PREFER model, two innovative tests were developed: PREFER Explore is a personal preference test, aiming to inform students about the three professional roles and their personal preference for one (or two, three) of them [7], [38]. PREFER Match is a situational judgment test, aiming to trigger a process of reflection on students' drives by measuring to what extent engineering students are able to judge professional situations [8], [39].

4.3 Breaking through stereotypes: the interventions

Recent findings from a large-scale review of interventions focusing on identity development consistently point to an increased representation of minority students in STEM in the US [40]. This encourages us that it will also work in Belgium and, by large, in Europe. However, it is important that the instruments that are used in these interventions are validated by the different target groups, and not only by the majority

'white, male' students. Quoting from Morelock's systematic literature review [32, p. 1255]: "The interventions – with their focus on more engineering experiences or more professional ones – may help change individuals' perceptions of the field, but none ask students to connect their beliefs, values, or other aspects of identity to engineering."

The PREFER tools seem promising instruments to fill this gap. The extent to which these PREFER tests counteract a sense of belonging in and fit with the field, experienced by females and students with a migration background, was not yet examined. However, a small exploratory study with a limited group of students (N=67) suggested that the customer-related role in which competencies such as empathy and creativity are essential, was more attractive to female students than to male students [5], although the university traditionally focuses on the product leadership and operational excellence roles in engineering programmes. Similar indications were observed in a comparative study on role preferences in Belgium and Ireland [4]. In her study on gender-troubled engineering identities, Faulkner [41, p. 351] concludes that "engineering as a profession must find ways to foreground and celebrate heterogeneous understandings of engineering and heterogeneous engineering identities". Such a broader view of what engineering is, and what one can do with engineering, benefits all [future] students trying to find a good fit.

5   SUMMARY

Increasing diversity in engineering has never been more important. In order to choose and to stay within a field it is key to feel like you belong and like the field fits with your sense of self [40], [42]. However, in engineering these are lower for women and people with a migration background because of the stereotypes of the field and majority group defaults (characteristics that seem neutral but are associated more with majority groups) that fit less with these groups' sense of self. An important objective of the URGENT project is to collect empirical evidence within the field of engineering for the majority group defaults (aim 1).

The PREFER tools seem valuable instruments to break through the stereotypical thinking of engineering and increase a sense of belonging in and fit with the engineering field. However, the extent to what these tests counteract this sense of belonging or fit by female students and students with a migration background has not yet been examined. This will also be an objective of the URGENT project (aim 2). If the tests are validated with different groups of engineering students, they can serve as instruments to set up different interventions. These interventions are set up to examine the effects of broadening the view on the field of engineering and of helping (potential) students see the different professional roles they could take in engineering (aim 3).

It is expected that this will help a broader group of students (including women and ethnic minorities) to feel a sense of belonging in and fit with the field, aiding their professional identity development and increasing both their recruitment and retention.

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