Research design and preliminary findings from the EUniWell MASOEE project on teaching skills to disadvantaged cohorts

Chung, Sarah[a] Cooke, Neil[a] Cottle, Daniel[a]

University of Birmingham, UK[a]

Corresponding Author's Email: SJC653@student.bham.ac.uk

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ABSTRACT

The ERASMUS+ European University of Wellbeing alliance (EUniWell) has seed-funded the project "Maximising Academic and Social Outcomes in Engineering Education" (MASOEE). This initiative explores how to better teach non-technical skills with the aim of ensuring the success of students from disadvantaged backgrounds in their professional lives, making a significant contribution to societal wellbeing. It can be argued that because engineering jobs are relatively well-paid, engineering education might be considered a force for social mobility if universities reduce attainment gaps between marginalised and mainstream cohorts. To this end, we are sharing best practice for professional, business and sustainability skill teaching between the engineering faculties at the Universities of Florence (Italy), Birmingham (UK), and Linnaeus (Sweden), whilst appreciably contrasting how their disadvantaged cohorts are profiled and supported. In this paper we provide an overview of the project and present some preliminary results comparing students self-rated skills levels and engineering identity against an objective measure of disadvantage – the number of parents who attended university. We discuss our research method with emphases on methodological and contextual reflexivity. This enables us to select our procedures and acknowledge the study setting, and to offer readers insights to help them assess its transferability.

INTRODUCTION

Research on engineer identity is growing (Casper *et al.*, 2021), with Euan et al. (2023, p. 116) arguing that there is a move away from a "content-centric models of what the students should know towards capability-centric models of what graduates should be able to do". Engineering has a distinct cultural identity that revolves around developing skills to solve problems through the development of products, processes, or services, with some noting that both skills and cultural identity are forged during learning (Hughes *et al.*, 2021). Although Alarcón et al. (2023) found that ethical skills were often learned implicitly during project work, there is a strong argument that non-technical skills such as ethics are more effectively learned through more explicit instruction (McHenry and Krishnan, 2022). The question that arises therefore is how to strike the balance between developing technical skills and other professional skills which allow the students to develop a more holistic identity (Hughes *et al.*, 2021). A common opinion in the literature is that non-technical skills are considered important, yet it is still an active research topic how to teach them; their assessment is more subjective, and they have a social-science orientation - for example, skills in the areas of enterprise, communication and sustainability have foundations in business, psychology, and geography respectively. Accordingly, less confident teaching of these competencies carries a risk of negative student experience. It can be reasoned that this issue might be heightened in disadvantaged cohorts making it important to identify these students and offer appropriate support (Andrews, Clark and Knowles, 2019). Key objective indicators of disadvantage are to be found in a student's socio-economic background. This includes factors such as whereabout they grew up, whether they were a recipient of financial support for school meals, and their parents' or guardians' prior education or occupation.

This article proceeds as follows. A literature review focussing on disadvantaged students is followed by the study aims and corresponding research questions including a discussion on engineering skills and identity. We then describe our methodological approach, then finish with some preliminary results and insights from our student survey on identity and skills.

DISADVANTAGE

It is widely reported that there is a link between disadvantaged students and academic achievement (Agasisti and Longobardi, 2014; APPG, 2017). However, despite there being substantial research addressing this issue across higher education, little is specific to engineering. Moreover, the engineering education-specific research is mostly quantitative. (Lundy-Wagner 2013, p. 6) argues that for educators to make a difference and reduce the potential impact of Socio-Economic Status (SES), they should have a sound understanding of what it entails. Accordingly, our research adopts a mixed method, with the qualitative aspect allowing a deeper understanding of disadvantage.

Identifying and measuring disadvantage in the UK, Sweden, and Italy

In the UK, measuring disadvantage can be difficult, with some universities adopting proxy measures to make contextual offers to degree courses which consider SES as well as academic performance. For example, there are several ways to identify SES students in UK such as Free School Meals (FSM), parental level of education, home postcode (POLAR), and the proportion of first-generation graduates obtaining professional level employment (The Sutton Trust, 2015, 2021; Jerrim, 2021). However, with some of these factors there is the possibility of bias because of self-reporting (Jerrim, 2021). Within this research we adopt both FSM and parental education as determiners of disadvantage within the UK, and whilst we acknowledge that biases exist, we believe that it is less likely to impact our findings because the respondents are not offered anything for their responses. UK research identifies family income as having a direct impact on educational achievement, with the gap beginning early in childhood and growing with time, culminating in GCSE grades that were 20-30% below non-FSM students and impacting on the subjects they chose and career aspirations they held (APPG, 2017). This is reflected in the Universities and Social Mobility: Summary Report (The Sutton Trust, 2021), which explores subjects and social mobility within cohorts from the mid-2000s, ranking engineering as 6th for social mobility. Lundy-Wagner (2013) suggests that the field of engineering is viewed from two perspectives – as a field inundated by students with professional, possibly STEM-based parents, or as a field that provides an opportunity for disadvantaged students to pursue a career that is relatively stable and well paid.

Italy adopts a similar approach to the UK, with several studies acknowledging families' use of free school canteens, the links between socioeconomically disadvantaged students and those with both cultural and linguistically diverse backgrounds, and the level of parental education (Agasisti and Longobardi, 2014; Agasisti, Soncin and Valenti, 2016; Gross, Francesconi and Agostini, 2021). Those from a disadvantaged background appear to have less family support and grow up in an area that has fewer resources (Agasisti, Soncin and Valenti, 2016).

In Sweden, Hällsten and Thaning (2018) identify social background, in particular the level of parental education, occupation, and income and wealth in their research on educational success. They note that the level of parental education is one of the strongest predictors of negative attainment and that engineering mostly attracts children of parents who are economically affluent.

Disadvantage and engineering identity

The effect of exposure to the field of engineering via contact with engineers, peers, and even parents is considered an important factor in not only making the initial decision to study engineering, but also in the development of a student's professional identity, as well as potentially increasing their overall persistence (Kutnick *et al.*, 2018; Lakin *et al.*, 2020; Hughes *et al.*, 2021; Wint, 2023). Additionally, it is suggested that students from a disadvantaged background whose parents are unable to use their own experiences to help them to successfully attend college have weaker academic profiles and lower expectations (Lundy-Wagner, 2013, p. 2). Given the impact that disadvantaged status has on educational achievement, future careers, and potential future earnings, we believe it is important to explore how this impact on identity development can be challenged, and what may impede it.

Interventions to overcome disadvantage

To better support disadvantaged students, we need to overcome factors such as our unconscious bias, ill-suited recruitment practices and application processes, and the lack of social and cultural networks (APPG, 2017). Furthermore, unpaid internships and work experience opportunities obtained through known networks, are both considered key barriers to those who are socioeconomically disadvantaged and who may lack social and cultural network access. The Institute of Chartered Accountants in England and Wales (ICAEW) report argues that students, especially those from disadvantaged backgrounds, lack certain skills expected within the workplace, such as communication, resilience, innovation and commercial awareness. They argue that aspirations should be raised through access to mentoring and the development of these 'soft skills', with greater encouragement for students to take part in extracurricular activities. In addition to these challenges, it is acknowledged that "Higher education is a key driver of social mobility in this country" (The Sutton Trust, 2021, p. 1), with the report further highlighting that in comparison to the 22% of graduates from a disadvantaged background (based on FSM eligibility) who achieve the highest earnings after graduating, only 6% of non-graduates from a disadvantaged background reached the same level of earnings.

AIMS AND RESEARCH QUESTIONS

This project investigates the differences in teaching practice between partners with an intention to support transfer of best-practice and support disadvantaged cohorts in developing engineering skills and identity. The study also considers how engineering education is balanced between professional skills and technical abilities.

Traditionally, technical competence, which produces a 'traditional technologist', has been the mainstay of engineering culture (Berge, Silfver and Danielsson, 2019). However, more recently there is a move away from the narrow focus of technical competency, towards a more contemporary focus of incorporating three specific skills sets: innovation, enterprise, and creativity; communication collaboration and networking; and social, environment, and technical responsibility. These skills sets promote the development of three new identities: ‘Self-made engineer’, ‘Contemporary technologist’, and ‘responsible engineer’.

‘Social-technical’ dualism (Faulkner, 2007), can lead to a ‘hidden curriculum’ (Tormey *et al.*, 2015) if reinforced through both the design and delivery of the curriculum; engineering educators may not take full responsibility for teaching these skills as they are considered outside of the core discipline. To understand both staff and student attitudes to teaching and learning these skills, as well as to identify how the hidden curriculum manifests within each MASOEE partner, the following research questions are proposed:

1. What are the similarities and differences between engineering partners, their student bodies, teaching, programme structures, and institution culture?
2. How are the skills currently taught and embedded in programmes? What are student attitudes to learning these? How do we currently define and measure social outcomes?
3. Which innovative approaches can we employ to better teach these skills that deliver better social and academic outcomes?

RESEARCH DESIGN

Philosophical approach (ontology and epistemology)

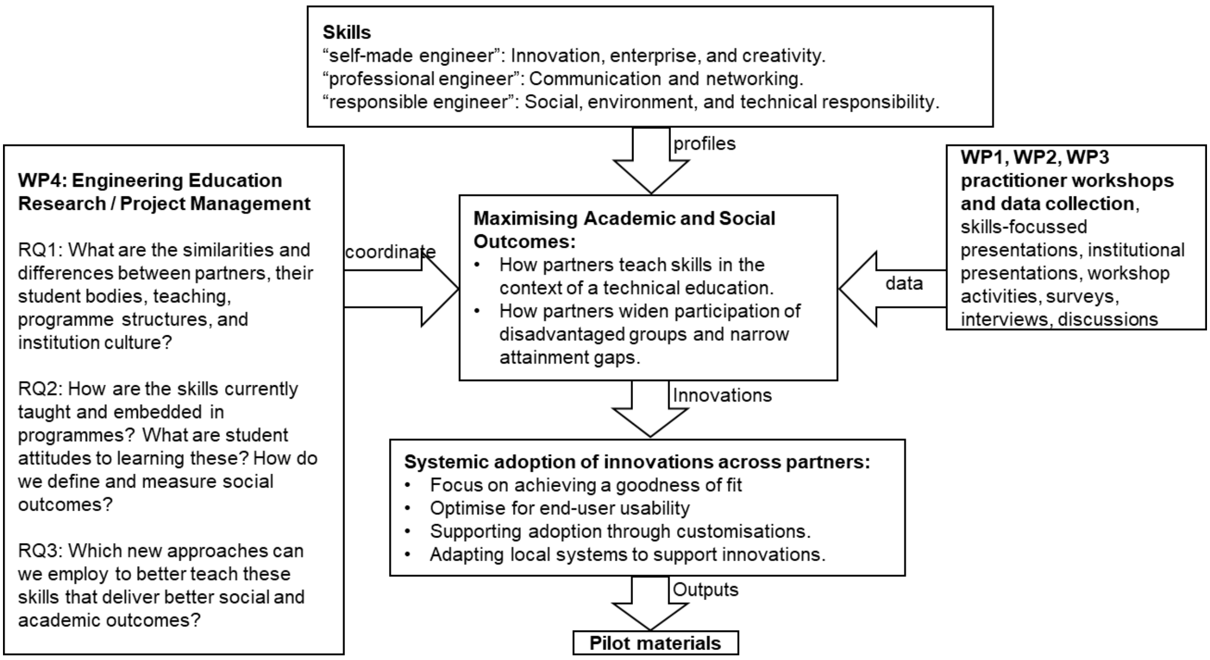
Exploring not only what elements of professional skills are being taught but also why these are considered best practice, would suggest that rather than searching for a single truth, we are looking for multiple realities. As such, the research is based within the remit of constructivism (Scotland, 2012; Lowndes, Marsh and Stoker, 2018; Berryman, 2019). Acknowledging the ontological position of this research is important as it allows all who read it to understand how the researchers have viewed the nature of research and subsequently how it has been applied within the study (Kivunja and Kuyini, 2017).

In order to be robust, research with an interpretive aspect must be reflexive. Part of this reflexivity is to be transparent in terms of epistemological stance, ensuring that our choices are explicit to those who read the study, which allows a better understanding of the research design (Moon and Blackman, 2014; Waring, 2017; Creswell and Creswell, 2018). As this research is exploring participants' lived experiences – their opinions of professional skills learning and teaching - it would suggest an interpretive epistemology is most suitable.

Project Structure

Figure 1 provides a visual overview of the project and how it is compartmentalised. Each component contributes to creating a thorough understanding of how professional skills are taught within partner universities, in addition to how each partner is developing wider participation of disadvantaged students with the intention of narrowing possible attainment gaps. There are four 'Work Packages' (WP1, WP2, WP3, and WP4) that form the basis of the project. Data collection, practitioner workshops, and establishing data collection opportunities are based within WP1, WP2, and WP3. The final work package, WP4, is designed to enable the research team to co-ordinate overall engineering education research approaches, research questions, and provide more general project management oversight.

Figure 1 Project Workflow



Mapping Identity to Skills

Establishing an engineer identity, which is how engineers view themselves professionally, is an essential process for students beginning their engineering career (Young, Dawes and Senadji, 2023). Young, Dawes and Senadji (2023) expand on this further by explaining that establishing an identity not only allows a student to establish themselves within an appropriate engineering community but also exposes them to the inherent values associated with the discipline. Understanding professional identity has also been linked to persistence within both an engineer's education and career, overall motivation, and decision making in terms of careers and development (Berge, Silfver and Danielsson, 2019; Emmett, Springer and Huang-Saad, 2020; Young, Dawes and Senadji, 2023). However, exploring the concept of identity can be difficult as it is influenced by a number of factors such as field discipline specific knowledge (internal) as well as field-based interactions with peers and both academic and industry-based professionals (external) (Casper *et al.*, 2021). Additionally, personal and social factors can potentially also impact perceived identity, making it somewhat subjective given the personalised nature of the influences (Emmett, Springer and Huang-Saad, 2020; Young, Dawes and Senadji, 2023). Therefore, it was essential that all partners shared a common definition when discussing the skills sets, with the research team deciding to employ existing skill inventories and taxonomies. These were then mapped to the four engineering cultures (Table 1) defined by Berge, Silfver and Danielsson (2019). Understanding how engineer identities are formed is essential in helping engineering educators to meet the needs of their students (Emmett, Springer and Huang-Saad, 2020).

Table 1. Engineering identities mapped to MASOEE skill map

Engineering identity as defined by (Berge, Silfver, and Danielsson 2019)	**MASOEE skill mappings to frameworks**
Traditional technologist	Science and maths, design, analysis, engineering tools and methods.
Self-made engineer	WP1 Entrepreneurship: Innovation, enterprise & creativity Entercomp (Bacigalupo et al. 2016)
Contemporary technologist	WP2 Solving complex challenges: Communication & networking. WEF 21st Century Skills (Soffel 2016)
Responsible (Ethical) engineer	WP3: Sustainability competence: Technical, social & environment responsibility. EU GreenComp (Bianchi, Pisiotis, and Cabrera Giraldez 2022)

Mixed methods

When compared to a single method approach, it is the diverse nature of mixed methods that results in higher quality research enabling a deeper understanding of the advantages and disadvantages of each singular paradigm, allowing the research team to devise strategies by combining and employing methods that best suit their needs (Johnson and Turner, 2003; Johnson and Onwuegbuzie, 2004). However, it is important when adopting a mixed method approach, to establish how one component of a mixed method project interacts with other aspects (Denscombe, 2017). To help understand how this mixed method research has been structured, the research questions were broken down into each method used to help answer it, whilst also acknowledging whether it was qualitative or quantitative (Table 2).

Table 2. Methods identified to answer research questions

Documentation (Qualitative)	**Student Survey (Quantitative/ Qualitative)**	**Interviews (Qualitative)**	**Focus Groups (Qualitative)**	**Case Studies (Qualitative)**
University college/school websites (RQ1/2): Teaching, Programme structures, Institution culture, How skills are taught, acess to scholarships (identifying support for disadvantaged)	Demographic (RQ2): Disadvantaged (e.g. Sutton Trust, UK), Free school meals, first in family to go to university, postcode. Similarities and differences (RQ1): Engineering partners, Student bodies, teaching, Programme structures	Attitudes (RQ2): Student attitudes to learning these skills Approaches (RQ3): Which new approaches to better teach these skills to deliver better social and academic outcomes.	Approaches (RQ3): Which new approaches can we employ to better teach these skills that deliver better social and academic outcomes.	Similarities and Differences (RQ1): How skills are taught Similarities and Differences (RQ1): How skills gaps are partners closed Approaches (RQ3): transfer best practice.

Survey

The survey provides an overview of current professional skills teaching practises, comparisons and contrasts between partner universities, and demographic data (current year of study, foundation/pre year, discipline, university, country of birth, secondary school attended country, measure of disadvantaged status). Furthermore, it allows exploration of how disadvantaged status was monitored within each partner country via responses from students within each partner institution. Although there is some crossover in terms of how each partner monitored disadvantaged status, there are some differences (Table 3).

Table 3. Measurement of disadvantaged students in the four partner countries

Measure of disadvantage	UK	SWEDEN	ITALY	FRANCE
Free School Meals (FSM) at secondary school	✓			
Home postcode	✓		✓	
Parents attended university	✓	✓	✓	
First Language		✓	✓	
Government Scholarship			✓	✓
Paid employment whilst studying				✓

Given the project is trying to reach students in multiple European universities, an online survey collection is most suitable.

All MASOEE partners are actively conducting the student survey within their own institution (Table 2). To increase accessibility to the survey, it was translated into Swedish and Italian. We intend the survey to capture quantitative demographic information, in addition to qualitative aspects such as attitudes to the teaching of 'professional' skills, and students self-identified ratings of their abilities within certain skills, outlined in Table 1.

Documentation, interviews, and focus groups

Documents, interviews, and focus groups are part of the qualitative aspect of this research and are designed to build on information shared within the survey, as well as explore the approaches used and student attitudes towards them. To guide the process of interviews and focus groups, interview, and focus group schedules or protocols, are developed. Document analysis allows the research team to explore modules offered within each institution, utilising a curriculum grid developed by the team to gather this information. The grid allows each partner to enter information on modules that were running at each institution.

Case study documentation: best practice adoption across partners

A case study explores phenomena through detailed research into a case or set of cases, which enables researchers to gather rich data (Baxter and Jack, 2008; Hamilton and Corbett-Whittier, 2013; Denscombe, 2017; Thomas, 2017; Priya, 2021). However, for a case study to be effective, there must be an acknowledgment of the two interconnected, but equal, parts – the subject and object (Thomas, 2017). This research acknowledges the importance of both parts and posits that our subject is Enterprise/ Communications/Sustainability modules within the four partner Universities, with the object being the exemplary use of innovative pedagogical approaches in engineering education.

- This research is a 'key case study' that adopts an explanatory/descriptive approach (Yin, 2014; Thomas, 2017). MASOEE partners could then share case studies, enabling the exchange of best practice.

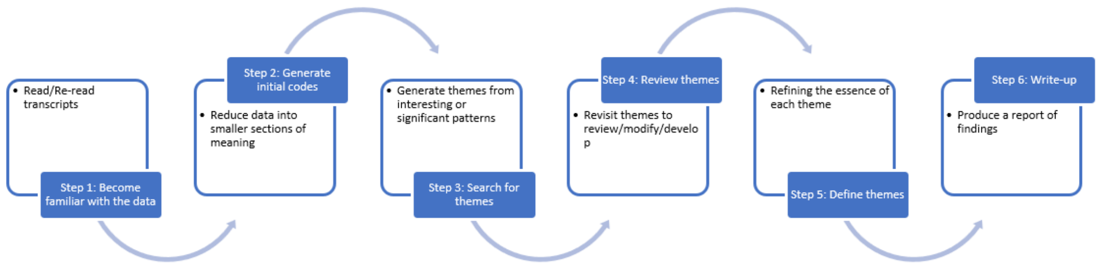
The case studies are organised based on the literature on the diffusion of innovations, more specifically the propagation paradigm (Froyd *et al.*, 2017), which allows a more legitimate adoption by each partner because it focusses on maximising the efficacy and fit to each individual institution, which are key characteristics of the propagation paradigm. However, consultation with partners to determine how to modify an invention at a partner institute is essential. Innovations identified should be distinguished by usability to allow generalisation to different settings, rather than strong data, with case studies promoting adoption within each partner institute.

Analysis

Unlike Quantitative research which provides an overview of what is happening within a phenomenon, qualitative research enables researchers to gather a "richer, deeper understanding of the meanings…" within a specific phenomenon (Castleberry and Nolen, 2018, p. 808). The most common approach to analysing qualitative data, and one which is utilised within this research, is Thematic Analysis (TA).

It is the intention of this research team to adopt a reflexive approach to thematic analysis, acknowledging that whilst we are not constrained by specific procedures (Braun and Clarke, 2019), the TA for this research will follow the six main steps (Figure 1) as outlined by Braun and Clarke (2006; Maguire and Delahunt, 2017).

Figure 1. Six phases of Thematic Analysis based on Braun and Clarke (2006)



Whilst qualitative data is analysed with the intention of finding a deeper, richer meaning behind participants views, quantitative data is analysed to measure and verify information, which in terms of this project includes aspects such as module types, approaches to teaching, and certain demographic information that allows us to explore disadvantage status within each partner institution. The quantitative data within this research is based upon an initial survey distributed to students within all four partner institutions.

Sampling

A purposive sample was considered most beneficial (Sharma, 2017; Campbell *et al.*, 2020; Andrade, 2021) as it would allow us to reach survey respondents who meet a specific criterion whose views and experiences would address the aims and objectives of this study. To receive the survey, the recipient had to be a current engineering student based at either the University of Birmingham, University of Florence, or Linnaeus University.

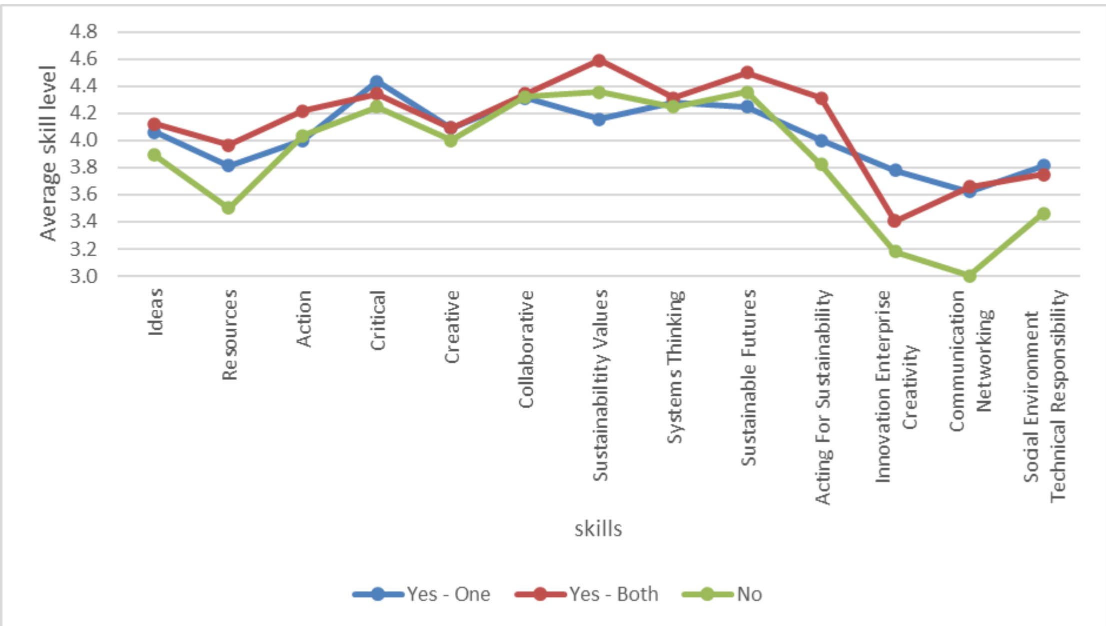
It was deemed necessary to adopt a different sampling approach for interviews and focus groups, with 'volunteer' or 'self-selection' sampling used to recruit participants (Sharma, 2017) via a self-selection option at the end of the initial survey or through directly approach students known to meet the specified criteria.

PRELIMINARY RESULTS

Self-rating of skill levels compared to parental education

Initial results from the student survey across all universities is presented in Figure 2. The average self-evaluation of skill level for 13 skills is compared for subsets of respondents who have either no, one, or two parents who attended university: a key measure of disadvantage. The findings reveal that students with no parents who attended university score themselves, on average, lower for seven of the 13 skills. Likewise, students with two university-attended parents have higher skill ratings in ten out of the 13 skills. This supports the hypothesis that this objective measure of disadvantage correlates with skill level, albeit with the skill level self-reported. Finally, students with only one university-attending parent reveal no clear pattern, scoring highest for three skills and lowest for two, suggesting that the effect is greatest when either none or both parents attended university. Of particular interest is the largest differences between no-parents university and both-parents university is in communication and networking, suggesting that this skill could be prioritised over others when considering interventions in the curriculum to address disadvantages arising from familial education attainment.

Figure 2 Self-evaluation of MASOEE skill mappings against parents' university background (n=186)

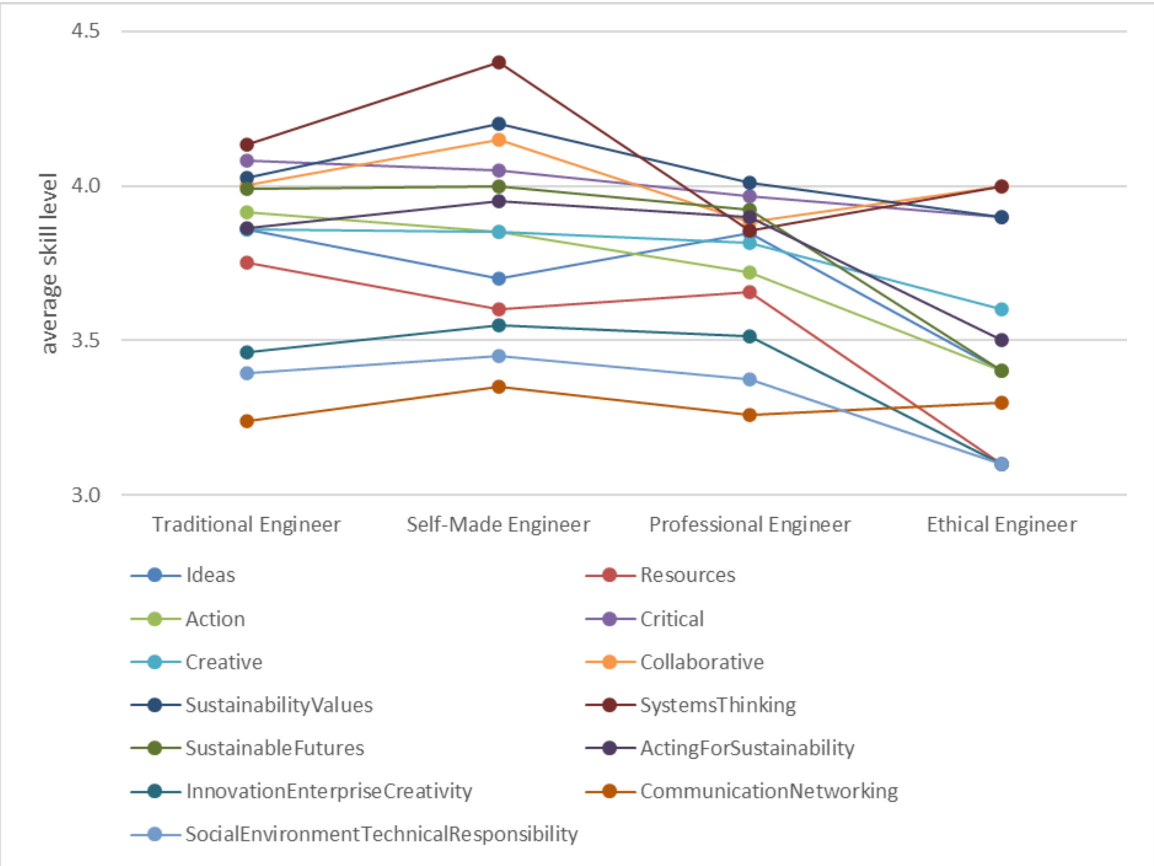


Self-rating of skill levels compared to engineering identity

While not directly considering disadvantage, another preliminary finding from the survey is to compare a student's highest self-identified engineering identity against how they rate themselves for each of the 13 skills; the skill inventories associated with each of the 4 engineering identities in Table 1 have many similar and arguably overlapping skills e.g. collaboration and communication/networking might be considered a skill for enterprising engineers, professional engineers, and responsible/ethical engineers.

The results (Figure 3) support this argument with many similarities in the rank of the skills for each of the 4 identities. Each column represents an identity, with relatively few lines overlapping in the graph between columns signifying there are only a few changes in rank. For example, communication and networking skills scored lowest by all students other than those who identified themselves as a responsible/ethical engineer. Likewise, only students who rated themselves as professional engineers do not score systems thinking as their highest rated skill. Notwithstanding the limited dataset (n=186), these minor differences suggest it is more important to focus on specific identifiable skills when considering interventions to address disadvantage, rather than broad notions of identity.

Figure 3 Self-evaluation of MASOEE skill mappings against engineer identity (n=186)



DISCUSSION

Our research relies on the use of an online survey for initial data collection and purposeful sampling of focus groups to better understand how skills are learned. We attempted to ensure that the design of the survey was easy to both understand and complete by testing multiple online survey platforms and conducting a pilot survey. However, because we rely of student's self-ratings, we acknowledge that it is possible that inaccuracies or misunderstandings could potentially still occur in relation to student's comprehension of what the skills are. Furthermore, our preliminary findings can be strengthened by further statistical analysis of survey data and incorporating the findings from focus groups and individual interviews currently underway.

CONCLUSIONS & RECOMMENDATIONS

There are clear systems to ensure the quality of engineering degrees is assured. However, it is important to acknowledge the diverse cultural contexts within engineering education. These include institutional differences across Europe and their student profiles of disadvantage. The research design and preliminary findings we have presented here are examples of how this acknowledgement can be achieved.

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