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Who, What, How? Tackling Skills Challenges: Future Relevance, Stakeholder Differences, And Teaching Hurdles

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WHO, WHAT, HOW? TACKLING SKILLS CHALLENGES: FUTURE RELEVANCE, STAKEHOLDER DIFFERENCES, AND TEACHING HURDLES: THE ENGINEERING SKILLS SIG WORLD CAFÉ

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ABSTRACT

The Engineering Skills Special Interest Group (SIG) ran a workshop on the current challenges in teaching engineering skills. This workshop employed the "world café" participatory method where attendees visited three tables for a structured discussion with a member of the SIG. Each table posed a different question: On the What? table we discussed which skills are most relevant for future practitioners. The Who? table focussed on the differences in the way that various professional skills are conceptualised by main stakeholders. Finally, at the How? table we discussed the facilitators and barriers in designing and delivering skills education. The outcome of the workshop presented here is a mapping of skills in terms of present and future importance to attendees and their countries, and a classification of stakeholders in terms of macro, meso, micro level when considering their influence over skill conceptualisation and realisation.

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1 INTRODUCTION

Our goal is to teach a diverse cohort of engineering students who will bring a variety of perspectives to the profession. This will result in more inclusive and creative engineering products, services, and solutions. We must teach a growing number of emerging technical competencies in areas like immersive technologies, digital twins, additive manufacturing, visual analytics, cyber security, AI, and systems complexity. Moreover, employers place increasing value upon professional skills which compels us to teach these too.

Accelerating our need to better teach professional skills is the emergence of a new technical competence – Artificial Intelligence. While this will significantly transform the way engineers design, optimise, and innovate solutions while applying their critical and analytical technical acumen, it also highlights the need for engineers to develop those people-centric skills which are less likely to be replaced with chatbots, solvers, and content generators. These skills include empathy, emotional intelligence, teamwork, interdisciplinary, lifelong learning, critical thinking, cultural awareness, ethical sensitivity, social responsibility, and the innovation and entrepreneurship mindset.

'Skills' are often interchangeably referred to as competencies, outcomes, and attributes. This can result in contradictory views as to what is meant by skill, how skills are taught and developed, and how students demonstrate proficiency; each engineering education stakeholder has their own definitions. Consequently, we hit several barriers when instructing students. These include unclear motivation, pedagogical shortfalls, institutional inertia, perceived lack of space in curricula, and fear of a negative response.

2 WORKSHOP DESIGN

This 1-hour workshop was hosted by members of the Engineering Skills SIG on 5/9/23 at the SEFI 2023 conference. There were twenty participants (Figure 1) who had the opportunity to discuss and learn about the current challenges we encounter to teach engineering skills. We ran the workshop using the "world cafe" participatory method to share knowledge, build relationships, and discuss current ideas. The room was split into three areas for groups of up to seven persons to informally discuss these questions with a member of the SIG. There were three consecutive 15-minute rounds of conversion so that attendees visited every area in the café, each focusing on one of these topics:

- **What**? We discussed which skills are most relevant for future practitioners because we maintain exhaustive skill inventories which might be considered unwieldy. For example, the EU EntreComp framework (Bacigalupo et al. 2016) has 15 competences along an 8-level progression model! Therefore, a key motivation was to consider ways to rationalise inventories and make them more comprehensible. To develop effective educational activities for mature students with limited resource, it might be imperative to define and agree on a few key skills required to develop early in a technical career.
- **Who**? We focussed on the differences in the way that various professional skills are conceptualised by main stakeholders: professional engineering institutions, engineering educators, employers, and students. Such differences can be problematic. For example, disparities in the way that educators and industry perceive a skill can result in ineffective teaching interventions which do not

develop graduates to the degree expected by employers (Meier, Williams, and Humphreys 2000). We discussed how such issues might be resolved. Participants were asked to give examples of skills mismatch and resolution strategies.

- **How**? We discussed the facilitators and barriers in designing and delivering skills education. These factors included designing an appropriate curriculum and its activities, educating students on the broad range of competencies, and assessment. For example, how can we solve the "reflection paradox" to satisfy the requirement for students to describe, evaluate, and develop their professional skill learning (Hermsen, Van Dommelen, and Hueso Espinosa 2022)? Since STEM students, in general, are more focused on technical issues, discussions were also directed towards how they can be motivated to improve their self-awareness, soft skills, and self-management skills to launch a successful career in the technology market.

Attendees left the workshop with insights into different understandings and meanings of skills and competencies, which professional skills that are valued by educators from different disciplines/countries, the differences in conceptualising skills by different stakeholders, facilitators, and barriers in designing and delivering skills education, and their capabilities to teach and assess professional skills. In this workshop paper we present results from the What and How table.

Fig. 1. Participants

3 RESULTS

3.1 Most important and unimportant skills

In the What? table, three groups successively contributed a piece of the puzzle; the first group mapped the most important technical (figure 2) and professional (figure 3) skills, defined by the SIG in 2021, drawn from the literature. Each member of the group selected the three most important engineering skills, motivating the selection and contextualizing with respect to the specific engineering field and country. The second piece of the puzzle was provided by the second group, to identify the least important engineering skills i.e., those that are perceived less relevant and crucial for engineers. Similarly, to the first group, each member selected the three least important skills, motivating and contextualizing the answer by specifying field and country. Finally, the third piece of the puzzle was about the future: each member of the third group was asked to predict the most relevant skills for the next ten years

and also suggest possible missing skills in the reference map in this forward-looking perspective.
There are several findings from the resultant mapping. Across all engineering fields, professional skills are becoming increasingly relevant, especially communication. Interdisciplinary, collaborative working and responsible action continue to increase in importance. Among the technical skills, systems thinking, and integration are identified as especially relevant, again independent of the engineering discipline. Technical skills in the area of augmented and virtual reality as well as data and cyber network security are considered relevant to computer science, and that the respective skills should not necessarily be taught in other engineering programmes. Interdisciplinary, collaborative work, and ethical and social responsibility emerged as critical professional skills for the future, similarly artificial intelligence was the most selected among the technical skills. It should be noted that the results should be further generalised, as the majority of data was collected from UK academics. Ways to establish a more diverse dataset should be considered including not only academic from a variety of fields but also students and industrial partners. This could potentially be done through a future SEFI online seminar. Or, as a starting point, by collecting data in the institutions of the SIG members. Once we identify more generally the skills required in the future a seminar should be organised for all relevant stakeholders.

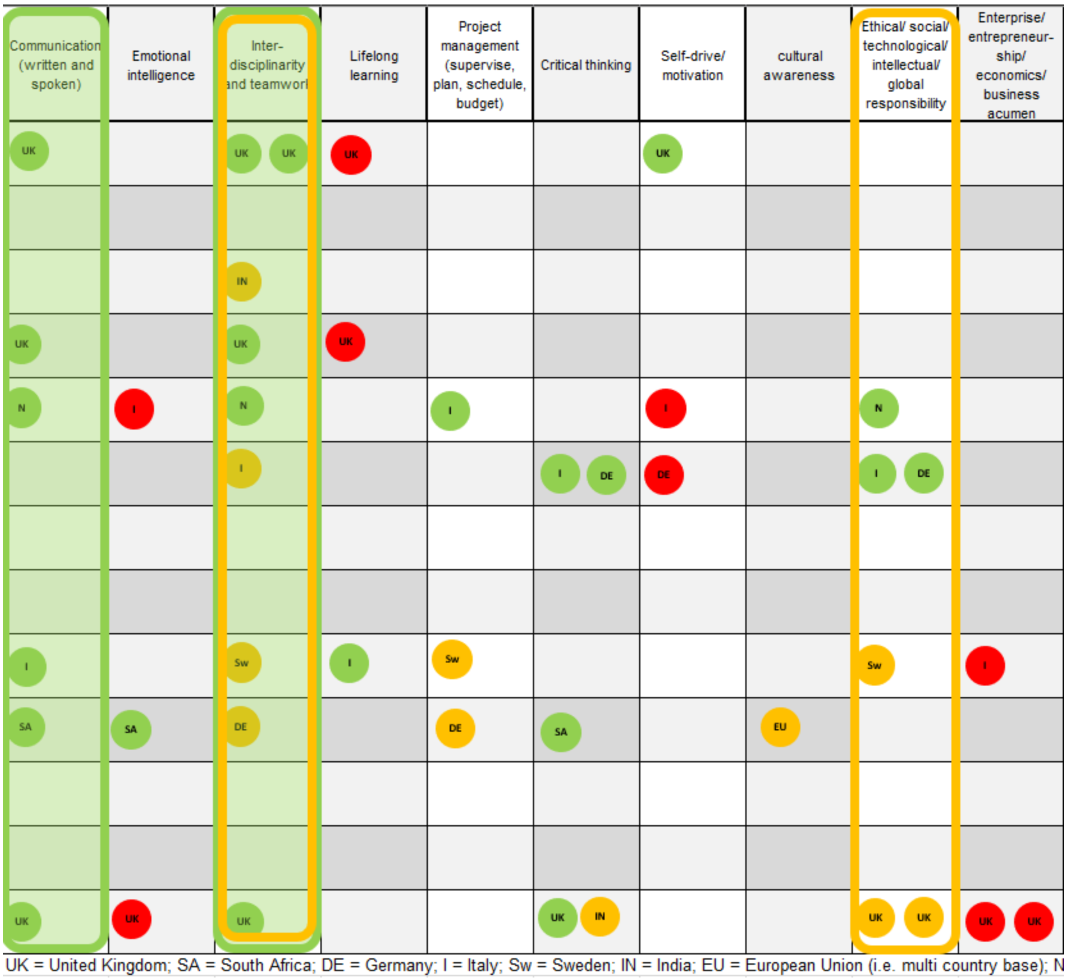

Fig. 2. Professional skill mapping to attendees/countries

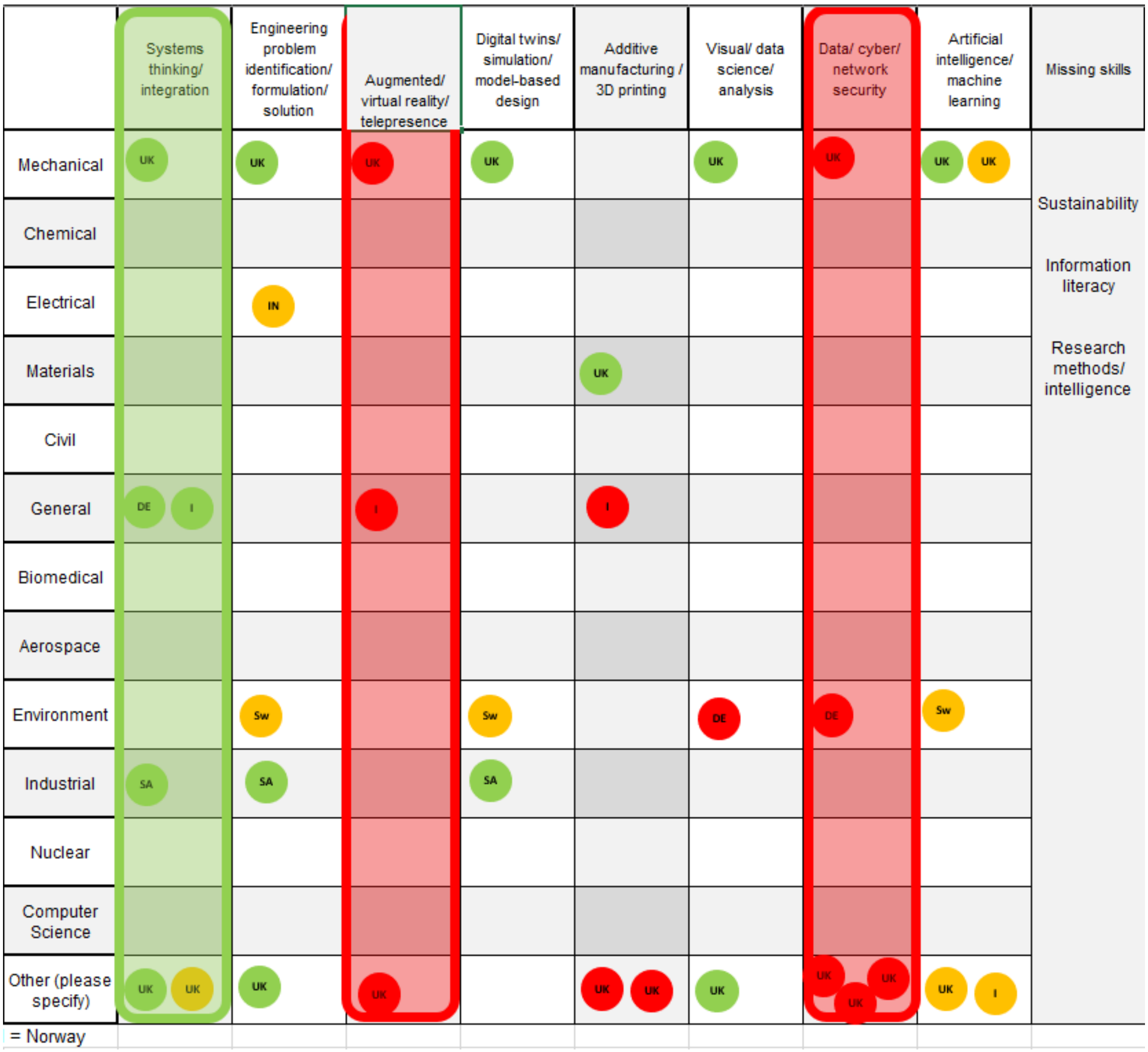

Fig. 3. Technical skill mapping to attendees/countries

3.2 Macro, Meso, and micro-level skill conceptualisation

At the Who? table, participants mapped the key stakeholders who influence the way in which skills are conceptualised within their own European context at a macro, meso and micro level. The stakeholder identified are:

- Macro: PEIs, accreditation bodies, government policy and strategy, skills reports, education strategy, international market forces, media.
- Meso: Institutional strategy, local industry and local government/regional strategy, students unions.
- Micro: module teams, students and student body, programme directors.

Key stakeholders were found to vary by context. For example, in Norway, union bodies are considered to play an influencing factor. In comparison, the government was considered as having limited influence in Spain. Similarly, the degree to which student financing and quality measures, and ranking systems influenced curriculum was seen to vary. In addition to this, the job market and industrial sectors varied between countries. Participants then considered how these stakeholders influence the conceptualisation, inclusion, and development of specific skills starting with examples of sustainability and communication. Participants referred to Lewin's force field analysis (Kuhn 1951), in which change processes are characterised as a state of imbalance between driving forces (e.g., new personnel, changing markets, recent technology) and restraining forces (e.g., individuals' fear of failure, organisational inertia). The influencing factors involved varied significantly between contexts and between the two skills considered. The 'trickle down' of influences at a meso level (e.g., strategy) to a micro level (e.g., teaching in the classroom) also appear to vary considerably depending on both national and institutional context. A summary of the key findings is given below:

Sustainability was impacted at the macro level.

- Sustainability is often part of government and/or institutional education strategy as well as accreditation criteria (and by implication industrial recommendations). In some cases, the strategy is not communicated or resourced, leading to surface level approaches being taken.
- There is increasing student pressure to include sustainability in the curriculum. Courses must remain relevant, and sustainability can be used as a marketing tool (Byrne 2023)
- Students and staff often conceptualise sustainability as including environmental aspects whilst neglecting societal and, to a lesser extent, economic aspects.
- Some academics may not want to teach sustainability in depth as it takes away from technical content. In contrast, some educators may increasingly focus on sustainability research, the findings of which may be embedded in modules.
- In some contexts, sustainability encompasses equality, diversity and inclusion (EDI), ethics, cultural awareness, and recognition of global and interdisciplinary imperatives. This increased recognition is influenced by evolving societal imperatives, including among universities themselves, and across corporate workplaces, which promote associated industry imperatives around graduate attributes.

Communication was thought to be influenced, at the meso and micro levels.

- Communication skills are consistently considered as lacking within skills reports. However, these reports lack depth.
- The difference in engineering education and what is required in practice, e.g., adaptability, communicating to those at different level, nuanced communication when embedded in a community with its own actors, each with their own experience frame and role within the hierarchical structure, community expectations and unwritten rules such as frequency of reply, need to write emails, notes, memos, meeting summaries.
- Educators may avoid teaching communications skills due to student resistance/feedback.
- Educators may prioritise technical over 'soft' skills.
- Educators may tend to focus of communication styles similar to those used within scientific journals.
- Concerns around quality and rigour of assessment may lead to educators failing to focus on informal communication such as email, memos, meeting notes.
- We cannot fully replicate communication in the classroom and assessment due to the complex need to communicate with multiple people across expansive network, and the situated nature of communication in the workplace.

Participants said the exercise was useful in identifying the many factors that influence engineering student skill development. The method has potential for use as a comparative tool and will form the basis of future work within the SIG.

4 SUMMARY

By definition, the continual evolution of the engineering skill set will always be an active topic. This workshop created an opportunity for educators, through a structured discussion, to appreciate the different priorities given to skills, and to recognise the various stakeholders who influence the skills agenda. There was a high level of agreement about the relevant importance of emerging professional and technical skills, as well as an increased awareness of how different skills depend on a different subset of stakeholders. Future SIG work will consider how to bring this "what, who, and how" structured approach to a wider audience.

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