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SUSTAINABLE DEVELOPMENT AND THE SDGS: REVEALING ENGINEERING ACADEMICS, STUDENTS AND EMPLOYER VIEWPOINTS

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THE IDENTIFICATION OF FUTURE PROFESSIONAL SKILLS FOR THE GRADUATE STRUCTURAL ENGINEER AND THE CO-CREATION OF THEIR DEFINITIONS.

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ABSTRACT

Employers recognise that the future is changing and as such the structural engineer's role is changing along with the skill set required. The skills gap has been acknowledged yet there is no consensus on which skills are most important for these engineers. This research presents the outcome of a project which proposes future professional skills needs for the structural engineer and the co-creation of their

definitions. A review of the most recent relevant literature alongside chartership requirements of the Institution of Structural Engineers (IStructE) and Engineers Ireland (EI), as well as consideration of three seminal consultation and analysis reports on the future skills in the sector, led to the identification of 7 skills. These are the traditional, though evolving skills related to communication, technical ability, management and engineering practice as well as emerging skills related to sustainability, technology and digitisation and society. It is accepted, however, that there may be different conceptions of each term, therefore, the presented research describes the co-creation of definitions for each of these skills with undergraduate structural engineering students. The work describes how focus groups were used to engage students in a conversation around the meaning and importance of each skill resulting in specific action orientated definitions for each skill. These definitions will then be used in the next phases of the project which engage the same students in a reflective e-portfolio exercise and structural engineering educators in a review of the programme outcomes in relation to such skills.

1 INTRODUCTION

Third level institutes are increasingly concerned with ensuring that their students develop attributes which will better equip them for the world of work, but also as members of society [1]. This paper presents the methodology and findings from the first work package of a project which aims to “design our structural engineering programme so that students can develop skills which will enable them to become exemplary structural engineers with a focus on the future of our planet and it’s people.” This work package aims to firstly identify these skills and then co-create their definitions with undergraduate students.

A narrow field of literature was targeted due to the aims of the project being focused on Ireland specifically and professional structural engineering skills as students move to chartership beyond graduation. The identification of skills needed for the structural engineering graduate began with the two Irish bodies which offer chartership in Ireland; the Institution of Structural Engineers (IStructE) and Engineers Ireland (EI). Chartership is essentially a professional registered title, and the requirements for achieving it are different for each body. Under Irish law certain engineering work is reserved for EI chartered engineers. The application process is based on the submission of evidence of learning and experience particularly related to 5 competencies. The IStructE require graduates to undertake a programme of Initial Professional Development (IPD) which is then followed by an interview and intensive examination. The IStructE IPD programme outlines ‘core objectives’ that applicants for chartered membership must achieve. These competencies and core objectives for chartership were examined alongside engineering academic literature. This built on the previous work by some of the authors who synthesised two systematic reviews of worldwide literature on the topic, [2] identifying communication, teamwork and interpersonal skills as the top most referenced skills in recent literature, followed closely by core technical skills and business acumen. Aspects of

each of these skills also need to be evidenced as competencies when applying for Engineers Ireland chartership [3] or core objectives for IStructE chartership [4]. The terminology varies between the sources, therefore“Core Technical Skills”, “Communication”, “Management” and “Engineering Practice” were chosen as the terms to describe the key skills required.

The second area of focus is on the future of the construction industry and emerging needs of the sector. Primarily, relevant aspects of three sources were used, again due to the specific focus on Ireland; The Expert Group on Future Skills Report on the Built Environment [5], Engineering 2020 [6] and KPMG’s 2020 analysis of the construction sector [7]. These were scrutinised alongside the recent proposed changes in Engineers Ireland Accreditation programme outcomes [3] and the new TU Dublin Strategic Plan [9], the university at which the authors carried out the research. These formed the core focus of our study. Looking to the future allowed us to identify several areas of future change which may not have previously been prioritised in structural engineering programme designs nor included in graduate attribute models. They are summarised as:

- Modular, off-site or prefabricated construction/manufacturing [5, 7, 8]
- Environment and Sustainability and/or related SDGs [5-7, 9]
- Diversity and inclusion [3, 6, 9]
- Technological advancements including collaboration techniques (BIM) and digitisation [6, 7, 9]
- Engineering as a business / Commercial Awareness [3, 5, 6]
- Increasing regulation inc. GDPR and other new or tightened standards [3, 7]
- Ethical and societal responsibilities and/or related SDGs [3, 6, 9]

These emerging skills were clustered into “Technology & Digitisation”,“Sustainability” and “Societal” skills for the purpose of this study.

Having examined the literature surrounding specific requirements for structural engineers in Ireland, a synthesis of the requirements can be described as: Technical Skills (including Core Technical Skills and Technology and Digitisation), Non-technical skills (including Communication, Management and Engineering Practice) and Attitudes (including Sustainability and Society) [10]. The seven clusters are identified in Figure 1 which also shows the key themes emerging from each literature group.

Despite describing how the clusters of skills emerged, the authors recognise that there may be different perceptions of each term and any research work which discusses or tests these skills should provide descriptions to reduce the risk of a misunderstanding [2]. This research study takes this concept one step further by not providing definitions created by the authors, but by co-creating the definitions with third year structural engineering students using small focus groups as detailed below. These same students will use these definitions in a later part of the project.

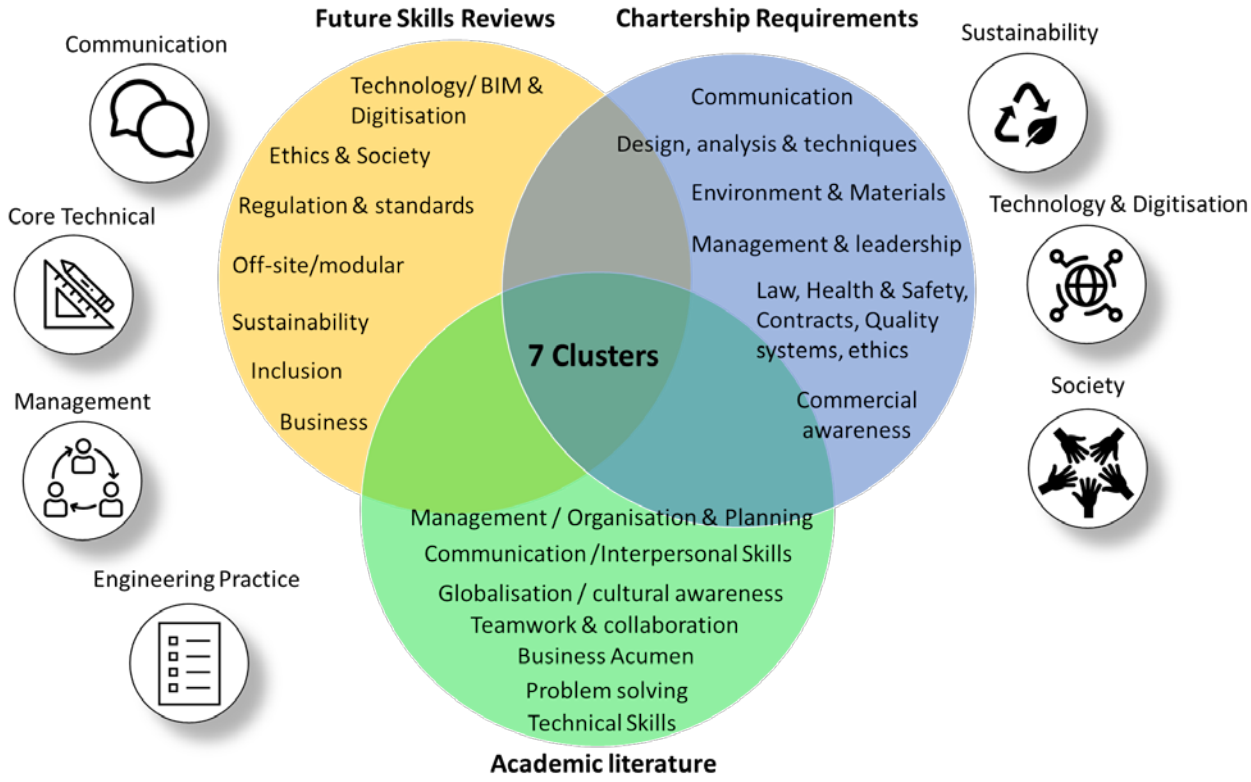

Figure 1: Clustering of Skills emerging from the literature

2 METHODOLOGY

Co-creation has been described by Ryan and Tilbury [11] as a pedagogical idea that emphasises learner empowerment, engaging learners in constructing and questioning knowledge and learning. For this study, the students engaged in co-creation in the curriculum as described by Bovill and Woolmer [12]. In order to attain broad definitions and potential new skills that may have been overlooked by the researchers and for the sake of rigour in the qualitative data collected, the researchers chose to adopt a focus group methodology to generate deep discussion on the skills, their definitions and any missing aspects.

The aim was to co-create definitions for the identified 7 skills clusters, and produce ‘action lists’ for each cluster. These lists were generated for two reasons. Firstly, because action learning aligns with the overall ethos and long term goals of the project which will include the introduction of new activities within the programme to strengthen skill development. Secondly, ‘learning outcomes’ within module design and re-design are defined by action terms that are measurable and observable. This format and wording will be familiar and easily interpreted by educational staff during the next phases of the project.

2.1 Sample identification

The sample of students for the study was drawn from current third year structural engineering students at TU Dublin. This is a four year programme which is accredited by Engineers Ireland as meeting the education standard (with further learning) for chartership. The rationale for selecting these students is that they have a better range of educational experiences when compared with first or second year students and so they are best equipped to define the skills that are presented to them. We also hope to assist them in developing their portfolio of skills development in this year and also in final year.

2.2 Ethical Approval

As the research work involved human participants, ethical approval was required for the focus groups. Focus group participants received written information about the objectives of the focus group study, confidentiality of data collected and the possibility of withdrawal. Following the researchers provision of the rationale and outline of the study, students were provided with an ethical consent form seeking their permission to use the data collected for this research. The audio from discussions with students was also recorded to enable checking and clarification at a later date as required. Participants provided written consent before the focus groups began and ethical approval was granted by the TU Dublin Research Ethics and Integrity Committee [Ref: REC-20-77].

2.3 Focus group

A request for research participants was emailed to the third year structural engineering class group and all volunteers who had signed the ethical approval form were accepted. The procedure guidelines used by the researchers was agreed with the research team before the session and the focus groups were carried out remotely using Microsoft Teams. After introducing the researchers, the project and the aims of the focus groups, the students were provided only with the titles of the seven skill clusters; “Communication”, “Core Technical”, “management” and so on.

Taking each skill in turn, students were prompted initially to consider each skill individually and then discuss in the group what that skill meant to them. As this was a co-creation exercise, the co-creation took place in real time by recording, discussing and agreeing the definitions of each skill presented using a Powerpoint slide to work through the process and record the outcome. After the focus group, the two researchers involved in the focus group, met to review and refine the definitions, based on the outcomes of the discussions and the audio recording. This included correcting grammar and syntax. The definitions were also reviewed by the remaining research team to check for clarity. These exercises helped add validity to the outcomes. The definitions were then compiled into a table of skills and definitions.

3 RESULTS

Definitions and action lists for each skills cluster are presented in Table 1.

Table 1: Definitions of Skills co-created with Third Year Structural Engineering Students

Core Technical
Definition: The skilled structural engineer of the future has a strong grounding in mathematics and science within structural engineering. This includes the fundamental principles of structural engineering, material behaviour, engineering equations and problem solving. Action List: • The ability to design and analyse a structure or parts of a structure • The ability to use appropriate equations and methods to solve a problem • The ability to recognise, understand and use structural engineering terminology and definitions
Engineering Practice
Definition: The skilled structural engineer of the future understands and follows the protocols, processes, rules and regulations of practicing within this field. Action List: • The ability to identify and follow the required standards and codes • The ability to describe and recognise the design stages in a project • The ability to perform a cost-benefit analysis in comparing options during initial design • The ability to recognise roles and responsibilities within a team • The ability to follow good practice and protocols in design and on-site engineering including health and safety, Universal Design, and Environmental impact statements
Communication
Definition: The skilled structural engineer of the future can effectively exchange information through a variety of diverse means and with diverse groups in various settings and circumstances. Action List: • The ability to present information in a clear and understandable form • The ability to communicate through a variety of online formats including video conferences, emails, or messaging services • The ability to present to a group • The ability to write in a clear, well-structured and understandable manner, cognisant of spelling, grammar and syntax • The ability to share, understand and record information in a meeting setting including minute-taking
Management
Definition: The skilled structural engineer of the future can manage themselves and others in keeping on track towards an end goal. Action List: • The ability to delegate responsibilities within a project or task • The ability to display leadership • The ability to motivate a team towards a goal • The ability to plan a project, it's tasks and deliverables • The ability to record progress and keep themselves and the team on schedule • The ability to prioritise tasks within a larger project or subject

Table 1(cont.): Definitions of Skills co-created with Third Year Structural Engineering Students

Technology and Digitisation
Definition: The skilled structural engineer of the future is able to learn and use new technologies and digital advancements in analysis, testing, communication and collaboration. Action List: • The ability to translate 2D drawings to 3D models and images • The ability to use online resources for self-directed learning • The ability to use up to date software for structural design • The ability to use hand calculations to check software output • The ability to use automated testing equipment and data recording devices in a laboratory setting • The ability to interpret output from software and data recording devices • The ability to convert between metric and other international systems
Sustainability
Definition: The skilled structural engineer of the future has a working knowledge of the impact of design choices on sustainability and targets the reduction of impact on the planet and its natural resources. Action List: • The ability to compare design choices in terms of sustainability • The ability to reduce material usage through design • The ability to design for longevity • The understanding of the relative green credentials when choosing between materials or structural products • The ability to do examine the environmental impact of a structure • The ability to list locally available structural materials and products
Societal
Definition: The skilled structural engineer of the future has an understanding of how they can impact society directly or indirectly, and makes efforts to give back to the community, understanding the inseparability of structure or structural engineering practices and people and place. Action List: • The ability to engage with a community for the betterment of structural engineering or a structure • The ability to research and reduce the negative impact of a structure on a locality, including the local community, local services, traffic, and local businesses • The ability to be ethical in daily engineering practice

3.1 Discussion and Conclusions

Several disparities were identified between the commonly understood definitions of terms in academic and professional writings and the interpretation by the students. One example of this is the complete omission of any discussion on Building information Modelling (BIM) within “Technology and Digitisation” when compared to its almost exclusive presentation under this heading in the Future Skills report [5]. The students are taught BIM in several modules throughout the programme and are therefore very familiar with it. This brought to light the importance of using terminology which relates concepts to specific skills and module titles.

The skill that students struggled most to define and produce action lists for was “Societal”. They needed to be encouraged to think about their future role within the engineering profession and larger society many years into the future. It is interesting to note that this reflects initial findings of other aspects of the project, whereby societal skills were identified as being the most poorly represented within individual modules.

The co-create approach was found to produce results which could not have been identified through literature examination alone. The findings were very specific to the cohort and within the context of the programme being examined. This serves the purpose of this project well as the intention is to consider the existing programme design and introduce changes where needed. The approach would need to be adopted across several institutions in order to gain results that could be combined and generalised across all structural engineering programmes. As an exercise in itself, the co-creation process facilitated students to reflect on their own experiences and abilities, which is a requirement within the chartership process for both the IStructE and EI. Students were engaged and lively throughout and all requested a copy of the results and to be kept informed.

The next stage of this research involves a full programme review in order to examine areas where the skills presented here can be integrated. During this step, the staff at the school will reflect on their own modules and rank the extent to which each skill is represented. Staff are also provided with the opportunity to detail how they would define each skill cluster. Our aim is to engage our students in a programme which sets a sound foundation not only for their academic training, but orientating their views towards the skills they will need in the immediate future as a graduate and their long term career as an **exemplary structural engineer** with a focus on the **future of our planet and it’s people.**

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