Addressing Challenges Of The Sdgs: Stakeholder Perspectives On Skills Required By Engineering Students On The Island Of Ireland

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ADDRESSING CHALLENGES OF THE SDGS: STAKEHOLDER PERSPECTIVES ON SKILLS REQUIRED BY ENGINEERING STUDENTS ON THE ISLAND OF IRELAND (RESEARCH PAPER)

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ABSTRACT

Living sustainably on a shared island poses both challenges and opportunities for engineers of the future. Whilst at a European level, the professional skills that engineers will need to achieve Sustainable Development Goals (SDGs) have been identified, less has been written on how these skills should be contextualised for a national, regional and/or local level. This research paper considers the specific professional skills required for engineers on the island of Ireland. It examines differing perspectives of stakeholders, comparing and contrasting views according to local context (Northern Ireland (NI), Ireland).

A professional skills survey was designed, drawing on previous research which had identified 53 competences in six sets (Fundamental Technical Skills, Application Skills, Outward Facing – People Orientated Skills, Inward Facing – Ways of Thinking, World View, Character and Ethical Orientation). The survey was completed by 235 academics, students and engineering employers (ranging from SMEs to large multinationals) on the island of Ireland in 2022. Analysis highlighted interesting similarities and differences in stakeholder perspectives between the two jurisdictions. Whilst awareness of SDGs was markedly higher in Ireland compared to NI, average importance ratings for many competences were generally similar in both jurisdictions.

These findings have improved engineering educators' understanding of the stakeholder perceptions including how those vary by location. Such improved understanding, including regional insights, should help to inform engineering curriculum development at tertiary level and ensure that engineering graduates are equipped with the appropriate skill set to contribute solutions to the big global challenges of our day.

1 INTRODUCTION

1.1 Geographic Context: One Island, Two Jurisdictions

Life on a shared island, in particular the island of Ireland (comprising Ireland and Northern Ireland), presents both challenges and opportunities, including within the realms of sustainable development. Whilst Ireland is one of 27 member states of the European Union (EU) (an economic and political union), Northern Ireland (NI) is a constituent country of the United Kingdom, which is no longer a member of the EU. Operating within two jurisdictions (each of which has its own governance arrangements and legal frameworks, as well as professional engineering institutions), engineers of the future will be tasked with addressing problems that are indifferent to such boundaries.

Considering the pipeline of future engineers, it is important to note some key differences in typical pathways to university. In both jurisdictions, education is compulsory up to 16 years old. In Ireland, students wishing to enter the university system take the Leaving Certificate State examination at the end of the senior cycle (aged 17 or 18). They typically take seven Leaving Certificate subjects which must include English, Mathematics and Irish. Places on university courses are allocated according to a points system (top six subjects scored for each student). In NI, at the end of compulsory education (16 years), students take GCSE examinations, usually in eight subjects including English and Mathematics. Those who continue in education study for a further two years, either for A-levels (typically three (sometimes four) subjects, graded by letter, and all considered in university admission process) or vocational courses, in schools or further education colleges. Thus NI students entering university will have a more focused in-depth subject range compared to students from Ireland with a broader range of subjects.

The professional skills that engineers will need to achieve Sustainable Development Goals (SDGs) have been identified at a European level (Beagon et al, 2022). However, contextualising these to a smaller scale (national, regional and/or local level) is the focus of this paper. It explores stakeholder perspectives on the specific professional skills required for engineers on the island of Ireland, within the context of achieving the SDGs. It examines the extent to which these perspectives vary according to local context (NI and Ireland).

1.2 Literature Review

Previous research studies undertaken into the generic skills that engineers require have been generally conducted at a national or international level (Passow and Passow 2017; Male et al. 2011; Kovesi and Csizmadia 2016; Colman and Willmott 2016). Seminal work on skills requirements for sustainable development in particular highlighted a range of competences that are needed for a sustainable future (Wiek et al. 2011; de Haan 2010; Rieckmann 2012). More recent work as part of an Erasmus+ project (A-STEP 2030) focused more directly on competence requirements specifically for engineers in order to work towards achieving the SDGs (Beagon et al, 2022). The study used focus groups with engineering employers, engineering academics and engineering students in four European countries to collect and synthesise their views on the key competences required. The findings highlighted 53 separate competences presented in six main categories (Fundamental Technical Skills, Application Skills, Outward Facing – People Orientated Skills, Inward Facing – Ways of Thinking, World View, Character and

Ethical Orientation). The research also identified that there was a lack of agreement on which competences should be prioritised.

The UNESCO (2017) report "Education for Sustainable Development Goals: Learning Objectives" provides a framework for educators to enhance their curriculum, offering students an opportunity to develop the much-needed skills required of the future. However, it is not surprising that educators could feel overwhelmed faced with a list of 53 competences and hence, contextually relevant priorities for a local context could prove useful in focusing educational initiatives in individual Universities.

2 METHODOLOGY

2.1 Context for the Research

This research was conducted as part of a Higher Education Authority (HEA) funded project entitled PROFESS 12. One of the project aims was to design and test an innovative Summer School to help students develop skills to solve SDG 12. A survey was circulated as a pre-cursor to the design of the Summer School to ascertain appropriate teaching activities according to the localised and prioritised skill set requirements of survey respondents on the island of Ireland.

2.2 Approach

A professional skills survey, developed using MS Forms, was based on previous research (Beagon et al, 2022) which identified (at a European level) the skills engineers need to meet the SDGs. Ethical approval for the survey was granted by the Research Ethics and Integrity Committee in TU Dublin (REIC-21-74); the survey was piloted prior to launch in November 2022. The survey requested information on respondent profile capturing characteristics such as category (academic / employer (including sector and size) / student (including year)) and demography (gender, age, region). The first question seeking stakeholder perceptions investigated awareness of the SDGs using a 5-point Likert scale. Further questions sought ratings on importance, preparedness of engineering students and graduates and then priorities for teaching in reference to the 53 competences identified in six competence sets (Beagon et al, 2022). An open text response was provided for additional feedback (if any). Invitations to complete the survey were issued (primarily via email) to:

- **students** in TU Dublin and Ulster University (UU)
- **academics** in the research team's personal networks (wider than TU Dublin and UU)
- **engineering employers** in the research team's personal networks and through professional institutions (such as Engineers Ireland (EI) and Institution of Structural Engineers (IStructE)).

This paper describes the findings in relation to awareness of SDGs and the importance of the competences only. Analysis of survey responses by region has been undertaken. It does not differentiate by gender, category (employer, educator, student) nor by size of employer though we recognise that views are likely to differ within some, if not all, sub-groups. This could form the basis of further analysis.

3 FINDINGS

3.1 Profile of respondents

There were 235 respondents to the survey from the island of Ireland; around twice as many men as women responded (overall and within the two jurisdictions). Just over one third of responses were from NI, with the majority from Ireland. Overall, more than half of responses were from students (129, 54.9%) with similar proportions from academics (54, 23.0%) and employers (52, 22.1%) respectively. A small number of responses (n=7) from elsewhere were excluded from this analysis.

3.2 Awareness of SDGs

The first question gauged **awareness of the SDGs** on a 5-point Likert scale. Average scores are shown in Table 1.

Table 1. Awareness of SDG
(5 – Extremely Aware to 1 – Not at all Aware)

	NI	Ireland	All Island
Number of respondents	88	147	235
% of respondents	37.4%	62.6%	100%
Awareness of SDGs (average score)	2.7	3.5	3.2

Overall, whilst the average level of awareness was **3.2** (*somewhat* to *moderately aware*), unpacking this reveals marked differences. The level of awareness in Ireland, 3.5 (between *somewhat* and *moderately aware),* is considerably higher than awareness in NI of 2.7 (closer to *somewhat aware*).

3.3 Importance of Competences

For 53 competences in six Competence Sets, respondents rated **importance** on a 5-point Likert scale, with 5 being very important and 1 not important. For reference, the competences included in each set are (Beagon et al. 2022):
- **1 Fundamental Technical Skills** (Mathematics Skills, Digital Skills, Economic Skills, Research Skills, Technical Skills);
- **2 Application Skills** (Multidisciplinary Skills, Problem Solving, Design Skills, Interpretation Skills, Conceptual understanding, Resources optimisation, Innovation, Entrepreneurship, Decision Making Skills, Learning to Learn, Project Management, Organisation Skills, Problematisation (to consider or treat as a problem));
- **3 Outward Facing – People Orientated Skills** (Intercultural Skills, Collaboration, Leadership, Conflict Management, Negotiation, Communication, Respecting Diversity, Teamwork);
- **4 Inward Facing – Ways of Thinking** (Critical Thinking, Life Cycle Thinking, Holistic Thinking, Systems Thinking, Creativity, Analytical Thinking, Stress Management, Time Management, Self-Reflection, Multi-perspective Thinking);
- **5 World View** (Global Awareness, Social Responsibility, Challenging the status quo, Sustainability Awareness, Environmental Awareness, General Knowledge, Lifelong Learning);

- **6 Character and Ethical Orientation** (Respect for others, Open Mindedness, Agility, Adaptability, Curiosity, Empathy, Emotional Intelligence, Perseverance/Grit, Ethical Conscience, Personal Engagement).

All 53 competences are rated as being of at least some importance: average ratings for all are **at least 3.0**. The **five most important competences** overall are: Problem Solving, Communication, Teamwork, Respect for Others and Critical Thinking. All have similar ratings, between 4.56 and 4.74.

Disaggregating results by region yields broadly similar findings. The **top five most important competences** overall are also top five in NI and Ireland, although there is slight variation in rank order and average importance. Problem Solving, rated 4.75, is the most important competence in NI, whilst Communication (also 4.75) is highest in Ireland, as shown in Table 2.

Table 2. Average Importance Ratings by Competence and Jurisdiction
(5-Extremely Important to 1-Not at all important)

Rank	Northern Ireland	Ireland	All Island
	Top 5 most important – average importance		
1	Problem Solving, 4.75	Communication, 4.75	Problem Solving, 4.74
2	Respect for Others, 4.64	Problem Solving, 4.73	Communication, 4.68
3	Communication, 4.57	Teamwork, 4.69	Teamwork, 4.64
4	Teamwork, 4.56	Critical Thinking, 4.61	Respect for Others, 4.60
5	Critical Thinking, 4.48	Respect for Others, 4.59	Critical Thinking, 4.56
	Bottom 6 least important – average importance		
48	Intercultural Skills, 3.82 **Negotiation, 3.82**	Intercultural Skills, 3.96	Challenging the status quo, 3.93
49	n/a	**Agility, 3.95**	Intercultural Skills, 3.91
50	Challenging the status quo, 3.80	Holistic Thinking, 3.78	General Knowledge, 3.82
51	Economic Skills, 3.72	General Knowledge, 3.76	Holistic Thinking, 3.74
52	Holistic Thinking, 3.67	Economic Skills, 3.74	Economic Skills, 3.73
53	Entrepreneurship, 3.47	Entrepreneurship, 3.22	Entrepreneurship, 3.31

The **range of average importance ratings** (all respondents on the island of Ireland) is **1.43**. Both lowest (Entrepreneurship, 3.31) and highest (Problem Solving, 4.74) competences are in Competence Set 2. However, the Entrepreneurship rating is an outlier: the next nearest competence has an average importance rating some 0.42 points higher (Economic Skills, 3.73). Excluding the outlier reduces the range to **1.01**. Thus, average importance ratings for all competences are closely grouped. Average importance ratings of competences are fairly tightly grouped, as shown by considering the **range** of ratings (excluding Entrepreneurship, the outlier):

- **1.08 in NI**: from 3.67 (Holistic Thinking) to 4.75 (Problem Solving);

- **1.01 in Ireland**: from 3.74 (Economic Skills) to 4.75 (Communication).

Entrepreneurship, the least important competence in both jurisdictions, is rated somewhat lower in Ireland (3.22) than in NI (3.47). Three other competences (Economic Skills, Holistic Thinking, Intercultural Skills) also appear in the bottom six in both jurisdictions; rank order and average importance vary slightly.

Turning to Competence Sets, examining average importance ratings along with lowest and highest average importance ratings reveals more about similarities and differences between the two jurisdictions. In fact, they demonstrate a lot of similarity as shown in Table 3.

All six Competence Sets have average importance ratings above 4.0 highlighting a substantial degree of importance ascribed to all. In NI ratings range from 4.07 (Competence Set 5) to 4.25 (Competence Set 6); in Ireland from 4.14 (Competence Set 2) to 4.26 (Competence Set 6). In five Competence Sets, the average importance rating is marginally higher (though by no more than 0.14) in Ireland than in NI, the exception is Competence Set 1 (0.03 higher rating in NI).

In four of six Competence Sets, the same competences are rated lowest and highest in both jurisdictions, though ratings differ slightly. However, in Competence Set 3, two competences tie for lowest rating in NI: Intercultural Skills and Negotiation Skills, whereas only the former appears as Ireland's lowest rated competence. Furthermore, the lowest rated competences in Competence Set 5 differ as do ratings: Challenging the Status Quo (3.80) in NI and General Knowledge (3.76) in Ireland. In Table 3, competences in red font illustrate differences between NI and Ireland, showing those rated lowest in one but not in the other.

Table 3. Importance Ratings by Competence Set and Jurisdiction
(5-Extremely Important to 1-Not at all important)

Competence Set (Number of Competences)	Northern Ireland Average score per set Lowest and highest rated individual competence	Ireland Average score per set Lowest and highest rated individual competence
1 Fundamental Technical Skills (5)	Average (4.21) Economic Skills (3.72) Technical Skills (4.45)	Average (4.18) Economic Skills (3.74) Technical Skills (4.45)
2 Application Skills (13)	Average (4.09) Entrepreneurship (3.47) Problem Solving (4.75)	Average (4.14) Entrepreneurship (3.22) Problem Solving (4.73)
3 Outward Facing – People Orientated Skills (8)	Average (4.17) {Intercultural Skills (3.82) {Negotiation (3.82) Communication (4.57)	Average (4.30) Intercultural Skills (3.96) Communication (4.75)
4 Inward Facing – Ways of Thinking (10)	Average (4.10) Holistic Thinking (3.67) Critical Thinking (4.48)	Average (4.20) Holistic Thinking (3.78) Critical Thinking (4.61)
5 World View (7)	Average (4.07) Challenging the status quo (3.80) {Sustainability Awareness (4.34) {Environmental Awareness (4.34)	Average (4.21) General Knowledge (3.76) {Sustainability Awareness (4.54) {Environmental Awareness (4.54)
6 Character and Ethical Orientation (10)	Average (4.25) Agility (3.93) Respect for Others (4.64)	Average (4.26) Agility (3.95) Respect for Others (4.59)

For the majority of competences (39 of 53), average importance ratings for Ireland are higher than for NI: the opposite is true for the other 14. However, whilst there are some differences between average importance ratings (and corresponding ranking) for competences in NI and Ireland, these are typically quite small (largest magnitude difference is 0.32).

4   SUMMARY AND ACKNOWLEDGMENTS

There are moderately high **levels of awareness of SDGs** amongst respondents, with an average rating overall of 3.2; awareness is markedly higher amongst respondents in Ireland compared to NI. The impact of this finding indicates that there is scope to raise awareness further, particularly in NI and this can be immediately addressed in the design of engineering programmes.

All competences are rated as being of at least some importance with **average importance ratings** above 3 (out of 5) though there is considerable variation across the 53 competences. It is worth noting that the **five most important competences** are the same overall and within each jurisdiction, which suggests that amongst survey respondents in both jurisdictions there are similar perceptions on competences required of engineers.

Disaggregating results into the two jurisdictions shows that whilst some differences exist, these are generally small. Competences are typically rated at similar levels though respondents from Ireland tend to rate importance marginally higher than those from NI: this is the case for 39 of 53 competences. This translates into similarities at Competence Set level. The similarity in ranking of importance of the competences is perhaps surprising to some extent given some differences in the two jurisdictions (for example: public policy, economic and social context, education systems, etc.) as well as in awareness of SDGs (highlighted in this paper). However, the cross-border mobility that currently exists (for education, employment, trade, etc.) together with the global nature of SDGs and sustainable development challenges unconstrained by geography may account for similarities to some extent.

Given the resonance between priorities in both jurisdictions, this suggests there is scope for education provision to develop these competences in similar ways in both jurisdictions or indeed in more connected ways. Specifically, partnering between universities can enable an exchange of best practice. The design of the Summer School, a joint project between two such universities, was informed by several strands of research including these survey findings: in particular, the top five most important competences (Problem Solving, Communication, Teamwork, Respect for Others and Critical Thinking). The Summer School also specifically addressed Intercultural Skills (ranked as one of the least important competences in this survey). The impact of survey findings on curriculum design and engineering education in both jurisdictions arises through providing a better understanding of stakeholder perceptions (amongst survey respondents) and also in contributing to the design of a cross-border Summer School. The Summer School seeks to provide a model of best practice in engineering education (offering a concise, focused and innovative approach (including innovative teaching practices) to cover SDG content). Educators could emulate this in other jurisdictions, as they balance requirements to introduce SDG material in an already packed engineering curriculum.

Limitations

This paper presents interesting findings from an exploratory survey which offer a snapshot of perceptions on priorities for skills to address SDG challenges for future

engineers. It is important that these are interpreted with a degree of caution given practical and resource constraints associated with the survey; these affect the extent to which the findings may be generalised.

Further Research

Further analysis could examine data on preparedness of graduates and priorities for teaching. Interrogating data by sub-group (gender, category (employer / educator / student), employer size (SME vs large multi-national), etc.) may also help to explain differences and similarities in the two jurisdictions, such as: difference in awareness of SDGs; and whether similarities in importance of competences are consistent in sub-groups.

There is also scope for further potential research to: 1) compare the outcome of the survey in each jurisdiction with local accreditation criteria (defined by Engineers Ireland and Engineering Council UK, respectively); and 2) examine the impact of Brexit on skills from the perspective of mobility of engineers (considering for example: Washington Accord and work being undertaken by the Engineering Council UK in relation to mutual recognition of professional qualifications).

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