2024-01-04

Priority Skills for Engineers on the Island of Ireland: Key Stakeholder Perceptions

Rosalind M HENRY
Ulster University, United Kingdom

Margaret MORGAN
Ulster University, United Kingdom

Una Beagon
Dublin Institute Technology, una.beagon@tudublin.ie

See next page for additional authors

Funder: HEA, DFHERIS

Project Report 2

Priority Skills for Engineers on the Island of Ireland: Key Stakeholder Perceptions

Recommended citation: Henry, R., Morgan, M., Beagon, U., Jani, R., McKennedy, J., Bowe, B. (2024) Priority Skills for Engineers on the Island of Ireland: Key Stakeholder Perceptions. PROFESS 12 North South Research Project

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Project title note:

PROFESS 12 is the acronym for “PROFessional skills for Engineering students - Summer School to achieve SDG 12”. The project aims to develop Professional Skills in Engineering Students through an innovative and inclusive Summer School designed to equip students with the intercultural skills necessary to meet the SDGs.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Contents

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Glossary

Acronym / Term	Meaning
CF1	Conference paper 1
EI	Engineers Ireland
EU	European Union
GCSE	General Certificate of Secondary Education, an academic qualification taken by pupils in Northern Ireland
HEA	Higher Education Authority
IStructE	Institution of Structural Engineers
ME1	Online multiplier event 1
NI	Northern Ireland
PROFESS 12	PROFessional skills for Engineering students - Summer School to achieve SDG 12
R2	Report 2
SDG	Sustainable Development Goal
SEFI	European Society for Engineering Education
TU Dublin	Technological University Dublin
UNESCO	United Nations Educational Scientific and Cultural Organization
UU	Ulster University
W2	Webinar 2
WP	Work Package

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Executive Summary

Life on a shared island, in particular the island of Ireland (comprising Ireland and Northern Ireland), presents both challenges and opportunities, including for engineers tasked with addressing problems to help solve the SDGs that are indifferent to boundaries. Research demonstrates that (relative to current engineers) the engineer of the future will require a more diverse range of skills to navigate an increasingly complex work environment. Given this context, identification of relevant priority skills would therefore prove useful in focusing engineering educational initiatives.

Building on a European study (Beagon et al, 2022a) which identified at a European level the professional skills (53 competences in six sets) that engineers will need to achieve Sustainable Development Goals (SDGs), this report focuses on contextualising these skills to the island of Ireland. Part of the rationale for the study is a recognition that educators could feel overwhelmed faced with a list of 53 competences; therefore, it seeks to highlight those which are most important.

An online survey of engineering stakeholders (including academics, stakeholders and students) on the island of Ireland was conducted. Subsequent analysis highlighted the most importance competences for engineers on the island of Ireland in the context of helping to solve the SDGs: Problem Solving, Communication, Teamwork, Respect for Others and Critical Thinking. It also revealed resonance between priorities in both jurisdictions (and generally by gender and stakeholder category (employers, students and academics)).

The report seeks to provide useful insights and improved understanding to inform engineering education at a tertiary level. Not only have the survey findings contributed to the design of a cross-border Summer School, they also improve understanding of stakeholder perceptions (amongst survey respondents) on the most important competences for engineers of the future to help solve the SDGs.

This research offers useful insights for the engineering education community by raising awareness of future-orientated thinking around sustainable development, the SDGs and the skills that engineers will require in this regard. Such improved understanding should inform future development in engineering education to equip engineering graduates with an appropriate skill set to contribute solutions to the big global challenges of our day.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Summary of Overall Research Project

The main purpose of the PROFESS 12 (PROFessional skills for Engineering students - Summer School to achieve SDG 12) project was to build on the global research work on skills requirements, to translate them to an Ireland-specific framework and to then design, trial and evaluate an innovative and inclusive Summer School to provide students with opportunities to develop these skills. The UNESCO (2017) framework, the Guidelines for the Design of Inclusive Engineering Programmes (Mills, Ayre and Gill, 2010) and the use of the "The Intercultural learning for Pupils and Teachers Toolbox" (http://intercultural-learning.eu/) were used as inspiration to design of the School, which was co-created with students from North and South with a focus on solutions for SDG 12 (Responsible Consumption and Production).

We have ***four objectives*** in this project:

- To prioritise the professional skills that engineers will need to meet the SDG goals and Government commitments to 2030.
- To compare and contrast stakeholder views on the importance of specific professional skills so that we may learn from each other through our diverse experiences and gender differences.
- To co-create and test an innovative and inclusive Summer School to help students develop the skills necessary to meet SDG 12.
- To better understand each other's cultural backgrounds and to build mutually beneficial sustainable relationships that capitalise on the intercultural synergies between researchers, academics and students, North and South.

The project consortium has two academic partners (TU Dublin and Ulster University) and the objectives will be achieved through several work packages which are summarised in Figure 1 along with the Project Outputs.

Work Package 1: Literature Review and Professional Skills Survey

First, we identified engineering students', academics' and employers' perceptions of the professional skills that engineers North and South need to meet the SDGs (WP1). Focusing on the seminal work of Wiek et al., (2011) and UNESCO (2017) coupled with the previous work completed by the project partners in the A-STEP 2030 project, we reviewed the relevant literature and distilled the findings to compile a list of professional skills requirements. We were mindful of selecting literature from both genders to ensure an unbiased view. We used this list to create a survey to gather the views of the key stakeholders (employers, academics and students) in engineering education (North and South) to help us prioritise the key skills required. The literature review is presented in Report R1.

Work Package 2: Key stakeholder perceptions on priority skills

WP 1 set the scene for skills requirements on a global scale: WP2 turned our focus to the Island of Ireland. Using the results of the survey, we compared and contrasted stakeholder views based on the local context North and South, the stakeholder view and also the gender specific perception (WP2). The ***key aim of this Work Package*** was to learn from each other, hence a detailed analysis of the survey differentiated by key

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

perspectives helped us better understand the perceptions of each group. Key findings from this analysis are presented in this document, Report R2.

Work Package 3: The PROFESS Summer School

WP3 ran in parallel with WP2 to meet the key milestones of the project and involved the design and trialing of the PROFESS 12 Summer School. Based on the skills identified in WP1 and WP2, we initially created a Briefing Document for the Summer School (R3).

The design of the PROFESS 12 Summer School was ***co-created with engineering students*** from both Universities in two separate Multiplier Events (ME1 and ME2) in early 2023. These events were think tanks where students were encouraged to be creative and outrageous in their ideas surrounding the design of the Summer School.

The Summer School took place ***physically over five days*** with a kick off session (in the border region, meeting half way) on 4th March 2023, to coincide with the World Engineering Day for Sustainable Development. We then spent two and a half days in the North and two and a half days in the South and in addition to student centred classroom activities, we included cultural trips and activities to help the students integrate. We created a Toolkit for the Summer School (R4).

Work Package 4: Evaluation of the PROFESS Summer School

The impact of engaging students, researchers and academics in this Summer School was evaluated in WP4. The evaluation has three aims. Firstly, through both qualitative (discussions) and quantitative measurements, the effectiveness of the Summer School from the students' perspective was assessed. Students were also asked to reflect on their experiences and to provide feed forward advice for the next iteration of the project at a European scale. The findings of this aspect are presented in Report R5.

We also wished to acknowledge and reflect on the importance of an all-Ireland project such as this as a way to help collaboration between researchers, academics and Higher Education Institutions (HEIs), North and South. Hence we undertook a focus group to better understand the experiences of the researchers involved in the project. The findings from this aspect are presented in Report R6.

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

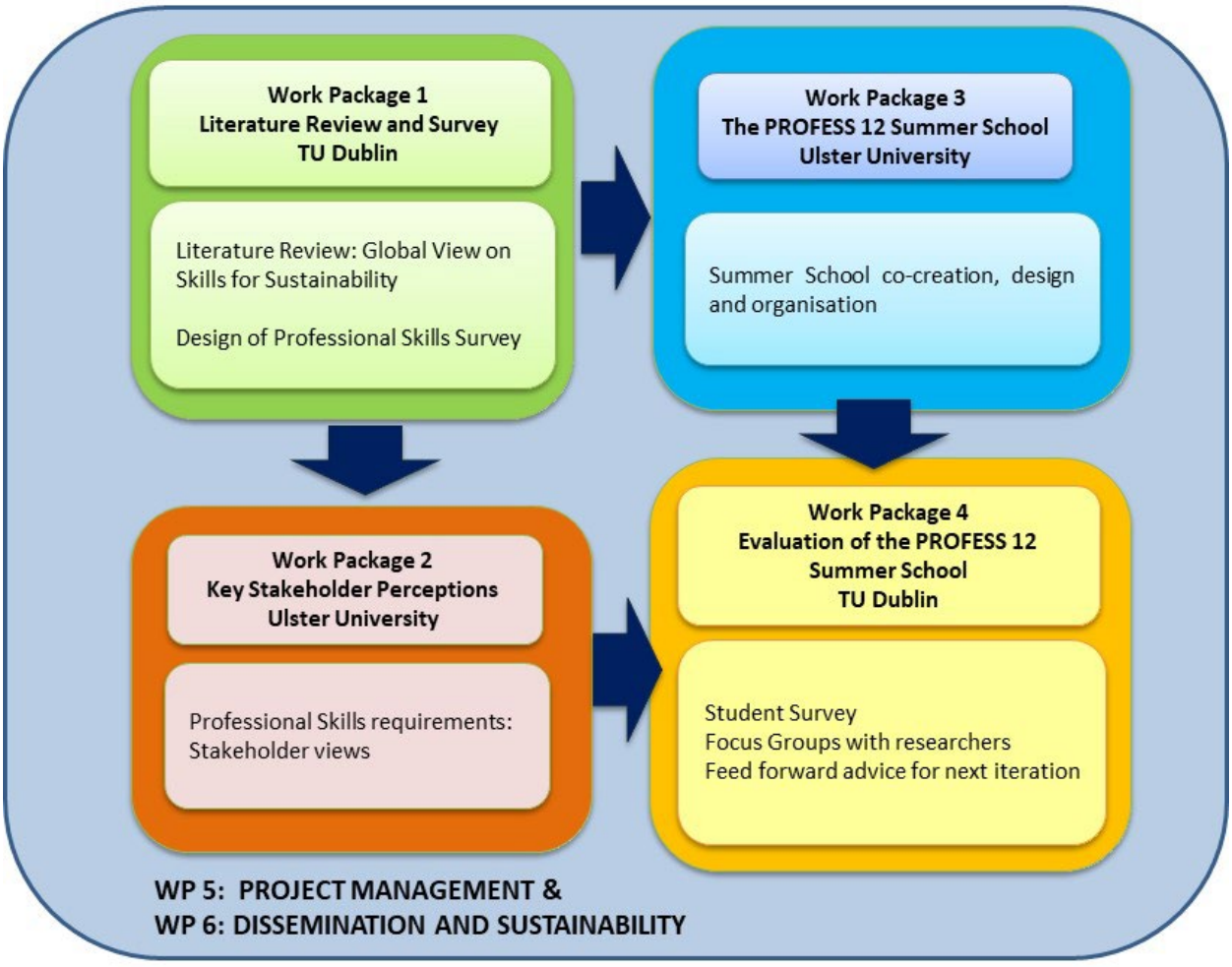

Figure 1: Work packages and Project Outputs in PROFESS 12

Funded by:
HEA HIGHER EDUCATION AUTHORITY AN tÚDARÁS um ARD-OIDEACHAS

Context for Research

Geographic Context: One Island, Two Jurisdictions

The island of Ireland is by no means unique in facing both challenges and opportunities in the context of sustainable development. However, as a shared island (comprising Ireland and Northern Ireland), there are additional considerations. 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 years). 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.

Literature Review

The professional skills required by engineers have been the subject of considerable attention: previous research studies into the generic skills that engineers require have typically been conducted at national or international level (Passow and Passow 2017; Male et al. 2011; Kovesi and Csizmadia 2016; Colman and Willmott 2016). More specifically, influential work (Wiek et al. 2011; de Haan 2010; Rieckmann 2012) addressed skills requirements for sustainable development highlighting a range of competences that are needed for a sustainable future.

More recent work as part of a European project (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, 2022a). 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

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

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 region/locality could prove useful in focusing educational initiatives in individual universities.

Whilst the professional skills that engineers will need to achieve Sustainable Development Goals (SDGs) have been identified at a European level (Beagon et al, 2022a), this report focuses on contextualising these to a smaller scale (national, regional and/or local level). It considers stakeholder perspectives on the specific professional skills required for engineers on the island of Ireland in the context of achieving the SDGs. It examines the extent to which stakeholder perspectives differ (if at all), comparing and contrasting the views according to local context (Northern Ireland (NI) and Ireland), gender and stakeholder category (employers, students and academics). The report seeks to provide useful insights and improved understanding to inform engineering education at a tertiary level.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Research Questions

This report presents key findings from a skills survey of stakeholders including academics, engineering students and engineering employers (primarily on the island of Ireland). The survey was informed by the literature review report completed in WP1 which synthesized the literature in relation to the skills that engineers need in the future, setting the scene for skills requirements on a global scale.

This report examines the professional skills requirements and specifically skills for sustainability in order to:

- inform WP3 (design of the Summer School – in particular identifying priority professional skills).
- compare and contrast stakeholder views on the importance of specific professional skills so that we may learn from each other through our diverse experiences and gender differences.
- better understand differences (if any) between respondents in Ireland and Northern Ireland (and thus help us break open perceived barriers in the collaborative relationship both between academics and students in the project).
- provide a foundation for a future project to explore more deeply the reasons underpinning the perceptions reported.

Drawing on survey findings, this report focuses on the following research questions:

1. What are the priority professional competences that respondents perceive that engineers of the future will need to help solve the SDGs?
2. To what extent do priority professional competences differ by:
    a. jurisdiction (Ireland, Northern Ireland)?
    b. gender?
    c. stakeholder category (academic, student, engineering employer)?

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Methodology

Context for Survey (within the Research Project)

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.

The survey drew on previous research (Beagon et al, 2022a) which identified (at a European level (based on a study in four countries)) the skills that engineers need to meet the SDGs. Whilst it identified skills required, that research noted a lack of agreement on which should be prioritized. This research therefore is novel in identifying the relative importance of these skills on the island of Ireland (and hence priorities) amongst a sample of engineering academics, employers and students.

Approach

A professional skills survey was designed, drawing on previous research (Beagon et al, 2022a). Ethical approval for the survey was granted by the Research Ethics and Integrity Committee in TU Dublin (REIC-21-74). A questionnaire, developed using Microsoft Forms, was piloted prior to launch in November 2022. This sought to ensure it operated as planned (both in terms of practically administering the survey and in ensuring understanding of terminology); some minor changes were made after the pilot. The questionnaire requested information on respondent profile capturing characteristics such as category (academic / employer (including sector and size) / student (including year of study)) and demography (gender, age, region (where respondents operate from or work/study in)).

Stakeholder perceptions were captured using questions with 5-point Likert scales. These questions investigated awareness of the SDGs, importance of 53 competences and then in relation to six competence sets: preparedness of engineering students and graduates and finally priorities for teaching. Finally, an open text response box was provided for additional feedback (if any).

For reference, the 53 competences and six sets are (Beagon et al. 2022a):

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);

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

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

The exploratory nature of the survey combined with practical and resource (time, cost, etc.) constraints informed the choice of sampling method: convenience sampling, a non-probability sampling approach. 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)).

Response: Number and Characteristics

The survey was completed by 242 respondents involved in engineering: this included academics, students and engineering employers (ranging from SMEs to large multinationals) on the island of Ireland in 2022. Given that the research project was focused on the island of Ireland, seven responses were excluded from the analysis. These respondents did not operate from or work/study in Ireland or NI and in fact were based in several locations.

The profile of respondents is included in the findings section of this report. This illustrates the diversity of respondents in terms of jurisdiction, age, gender, stakeholder category, sector (employer respondents only) and year of study (student respondents only).

Analysis

This report presents findings in relation to survey questions about awareness of SDGs and the importance of the competences only. Descriptive statistics have been produced including:

- respondent profile, providing number and proportions in total and disaggregated by various characteristics.
- awareness of SDGs and importance of competences. For these questions, descriptive statistics include number and proportions for each rating (on the 5-point Likert scale) and for each question: average score, minimum score, maximum score and range of scores. Data is presented at an overall level and disaggregated by various characteristics.

The characteristics by which data is disaggregated include **jurisdiction**, **gender**, **stakeholder category** (academic, employer (three sizes), student); and for **employers, by sector** and for **students, by year of study**. Using these characteristics, analysis of survey responses has been undertaken to examine similarities and differences overall and within sub-sets of respondents.

Limitations

Generalizability of findings, along with objectivity, reliability and validity of the research instrument (as described by Borrego et al (2009)) are important factors in considering the quality of quantitative research. Acknowledging these quality factors and reflecting on the exploratory nature of this survey, it is important to be aware of research design limitations and implications for interpretation of the findings.

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Research design limitations include:

- the number of questions was restricted to minimise respondent burden. Some descriptive information was collected about respondents (ideally, the list of variables collected could have been more extensive) and detailed definitions of certain terms were not included; and
- the sampling method used (convenience sampling, a non-probability sampling approach) was dictated by practical and resource constraints. Whilst the survey invitation was shared extensively, the population it reached had limitations (in terms of size and characteristics of potential respondents).

These limit our ability to comment on the representativeness of the findings and thus the extent to which findings may be generalised. Small numbers of respondents in some subcategories in particular also compound this issue. Although findings should be interpreted with a degree of caution, nonetheless they provide new and interesting insights, exposing further lines of enquiry that merit exploration.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Findings: Number and Profile of Respondents

The findings presented in this section describe those who responded to the exploratory scoping survey. This provides context for interpretation of findings relating to the Research Questions. Table 1 presents a profile of respondents considering: jurisdiction, stakeholder category, gender, age, employer-subsector and student-year of study. In some cases, when data is disaggregated, the number of respondents is small and should therefore be treated with caution. Analysis is based on 235 respondents to the survey from the island of Ireland. A small number of responses (n=7) from elsewhere were excluded from analysis.

Overall and Jurisdiction: Ireland and Northern Ireland

As shown in Table 1, there were 235 survey respondents, just over one third were based in/operating from Northern Ireland (NI) (n=88, 37.4%), with the majority in/operating from Ireland (n=147, 62.6%).

Gender and Jurisdiction

Table 1 shows the composition of respondents by gender; more than twice as many men as women responded to the survey overall. This was also reflected in both jurisdictions.

Age and Jurisdiction

Most respondents are aged up to 49 years old (over 85%), with a substantial proportion (more than one third, 37.4%) aged 22 years or younger. This is consistent with the high proportion of student respondents. It is interesting to note that respondents are skewed to the younger age groups with over one third aged 22 years or younger and just under one third aged either 22-39 years or 40 years or more respectively. The overall pattern (in Table 1) is broadly reflected amongst respondents in Ireland. Whilst the skew towards younger respondents is evident in both Ireland and NI, it is much more pronounced amongst NI respondents (44.3% aged 22 years or younger compared to 33.3% of Ireland respondents).

Stakeholder Category and Jurisdiction

Table 1 illustrates that more than half of responses were provided by students (129, 54.9%) with similar proportions from academics (54, 23.0%) and employers-all categories (52, 22.1%) respectively accounting for almost between one fifth and one quarter of responses respectively. Employer responses comprised mostly multi-nationals and SMEs (21, 8.9% each) with a smaller proportion from nationals (10, 4.3%).

Students account for a greater proportion of responses in NI than in Ireland (about two thirds of respondents (64.8%) compared to about half (49.0%) respectively) as is evident in Table 1. In contrast, a greater proportion of respondents in Ireland were academics or employers (about one quarter each) than in NI (approximately one fifth and just under one sixth respectively).

Employer–Sub Sectors and Jurisdiction

Amongst employer respondents, those from Ireland accounted for the majority: almost three quarters based in/operating from Ireland (n=38) compared with just over one quarter based in/operating from NI (n=14). Employer respondents were invited to select the sector which most closely describes their business. Amongst employer respondents, the two largest sectors were consultancy (34.6% of employer

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

respondents) and manufacturing (26.9%). Almost all employer respondents based in NI, 78.6% were in the manufacturing sector, there were none in consultancy and other sectors had very minor representation. There was, however, somewhat greater diversity in the sectors represented by respondents in Ireland. Whilst the majority (almost half, 47.4%) were in consultancy, the second highest sector, contracting (21.1%) had less than half as many respondents as consultancy. All sectors were represented amongst respondents based in Ireland.

Table 1: Profile of Respondents by Jurisdiction

Variable	Northern Ireland		Ireland		All	
	Number	Percentage	Number	Percentage	Number	Percentage
TOTAL						
All	**88**	**100.0%**	**147**	**100.0%**	**235**	**100.0%**
GENDER						
Man	60	68.2%	101	68.7%	161	68.5%
Woman	28	31.8%	46	31.3%	74	31.5%
AGE						
< 22 years old	39	44.3%	49	33.3%	88	37.4%
22-29 years old	20	22.7%	15	10.2%	35	14.9%
30-39 years old	10	11.4%	31	21.1%	41	17.4%
40-49 years old	9	10.2%	30	20.4%	39	16.6%
50-59 years old	8	9.1%	15	10.2%	23	9.8%
60 years or older	2	2.3%	7	4.8%	9	3.8%
STAKEHOLDER CATEGORY						
Academic	17	19.3%	37	25.2%	54	23.0%
Employer – Multinational	7	8.0%	14	9.5%	21	8.9%
Employer – National	1	1.1%	9	6.1%	10	4.3%
Employer – SME	6	6.8%	15	10.2%	21	8.9%
Employer – All	*14*	15.9%	*38*	25.9%	*52*	*22.1%*
Student	57	64.8%	72	49.0%	129	54.9%
EMPLOYER – SECTOR		**% of employers**		**% of employers**		**% of employers**
Consultancy	0	0.0%	18	47.4%	18	34.6%
Contracting	1	7.1%	8	21.1%	9	17.3%
Manufacturing	11	78.6%	3	7.9%	14	26.9%
Research & Development	1	7.1%	4	10.5%	5	9.6%
Other	1	7.1%	5	13.2%	6	11.5%
STUDENT - YEAR OF STUDY		**% of Students**		**% of Students**		**% of Students**
1st Year	20	35.1%	25	34.7%	45	34.9%
2nd Year	8	14.0%	18	25.0%	26	20.2%
3rd Year	17	29.8%	16	22.2%	33	25.6%
4th Year	11	19.3%	9	12.5%	20	15.5%
5th Year	0	0.0%	2	2.8%	2	1.6%
Postgraduate	1	1.8%	2	2.8%	3	2.3%

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Student–Year of study and Jurisdiction

The number of student respondents based in Ireland was somewhat higher than in NI (n=72 vs n=57). Almost all were in Years 1-4 with a small minority in Year 5 or postgraduate. Overall, about one third of student respondents were in Year 1, a quarter in Year 3, a fifth in Year 2 and almost one sixth in Year 4. Turning to the two jurisdictions, some of these findings are repeated. Whilst most respondents are in Years 1-4 and around one third are in Year 1, there are interesting differences between the jurisdictions. In Ireland, the proportion in each year decreases: one quarter (25%) in Year 2, over a fifth (22.2%) in Year 3 and one eighth (12.5%) in Year 4. However, in NI whilst Year 1 accounts for most responses, those in Year 3 account for the next highest proportion (29.8%), with notably fewer in Years 2 and 4 (14.0% and 19.3% respectively).

Stakeholder Category and Gender

Appendix B Table 6 includes the profile of respondents by stakeholder category and gender; more than twice as many men as women responded (overall). This pattern was broadly similar for academics, students and employers-all.

Age and Gender

Overall, one third of respondents are under 22 years; this is the largest age-group for both women and men (Appendix B Table 7). The largest proportions of respondents are men aged under 22 years (over one quarter of all), men aged 22-39 years (more than one fifth of all) and women aged under 22 years (over one tenth of all). The profile of respondents is skewed to the younger age groups overall and for both women and men. There are disproportionately fewer women respondents aged 50 years or more (1.7% of all respondents aged 50-59 years, none aged 60 years or older) compared to men respondents aged over 50 years (8.1% of all respondents aged 50-59 years and 3.8% of respondents aged 60 years or older.

Student - Year of study and Age

Table 2 shows the number of student respondents by year of study and age with percentages in terms of total student respondents. Most are under 30 years old: over two thirds are 22 years or younger and almost one quarter aged 22-29 years. Few are aged 30 years or more and very few are in Year 5 or postgraduate. As illustrated in Table 2 (green shading), the majority of students are aged 22 years or younger and in Years 1-3 or aged 22-29 years and in Year 3-4.

Table 2: Profile of Respondents by Year of Study and Age (Student Respondents Only)

Year of Study / Age	< 22 years old		22-29 years old		30-39 years old		40-49 years old		Total	
	N	%	N	%	N	%	N	%	%	%
1st Year	44	34.1%	1	0.8%	0	0.0%	0	0.0%	45	34.9%
2nd Year	21	16.3%	3	2.3%	2	1.6%	0	0.0%	26	20.2%
3rd Year	18	14.0%	13	10.1%	1	0.8%	1	0.8%	33	25.6%
4th Year	5	3.9%	11	8.5%	3	2.3%	1	0.8%	20	15.5%
5th Year	0	0.0%	1	0.8%	1	0.8%	0	0.0%	2	1.6%
Postgraduate	0	0.0%	1	0.8%	1	0.8%	1	0.8%	3	2.3%
Total	**88**	**68.2%**	**30**	**23.3%**	**8**	**6.2%**	**3**	**2.3%**	**129**	**100.0%**

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Findings: Importance of Competences for Engineers of the Future to Help Solve the SDGs

To address research questions 1 and 2, consideration is given to the importance rating of competences. Respondents rated **importance** on a 5-point Likert scale (5-*very important* to 1-*not important*) for 53 competences. Specifically, they were invited to indicate how important each competence is for engineers of the future to help solve the SDGs.

Consideration is given to highest and lowest ranked competences (ranked out of 53, with 1 most important), the range of average importance scores, and similarities and differences when data is disaggregated by variables of interest. At the outset, it is worth noting that average importance scores are all relatively high; differences between scores are typically not substantial. In some cases, competences share average importance scores and thus have equal ranking. Nonetheless, scores and ranks help to illustrate where relative priorities lie; comparisons also reveal interesting similarities and differences between sub-sets of respondents.

Overall and Jurisdiction: Ireland and Northern Ireland

Overall, all 53 competences are regarded as having some importance: average importance scores for all are **at least 3.3** (see Appendix B Table 8). Table 3 shows the **five most important competences** overall: **Problem Solving, Communication, Teamwork, Respect for Others** and **Critical Thinking**. Overall and for both jurisdictions, all five have similar, high average importance scores, greater than 4.5 (4.56 to 4.74).

Table 3: Average Importance Scores (Most and Least Important Competences) by Jurisdiction

Rank	Northern Ireland	Ireland	All
	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

Note:

- *Score: = Average Importance Score, where 5 – Extremely Important to 1 – Not at all Important*
- *Rank = Average Importance Score ranked, where 1 = Highest and 53 = Lowest*
- *Colour code to identify competences which feature in top 5 overall or bottom 6*
- *Table includes up to six competences with lowest rated importance as two had joint rank = 48 (NI)*
- *n/a indicates no competence in this rank position due to tied scores/ranks in higher position*

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Disaggregating results by jurisdiction 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 and average importance. Problem Solving, rated 4.75, is the most important competence in NI, whilst Communication (also 4.75) is highest in Ireland.

Overall, the **six least important competences** (see Table 3) are: **Entrepreneurship, Economic Skills, Holistic Thinking, General Knowledge, Intercultural Skills** and **Challenging the Status Quo**. All have average importance scores less than **4.0,** most are tightly grouped (between 3.73 and 3.93). Both highest (Problem Solving, 4.74) and lowest (Entrepreneurship, 3.31) competences are in Competence Set 2.

There is a high level of commonality in both jurisdictions. Four of the six competences **ranked as least important** in NI and Ireland are the same (and also amongst bottom six overall), though rank and average importance scores vary. Entrepreneurship, the least important competence in both jurisdictions (and overall), is rated somewhat lower in Ireland (3.22) than in NI (3.47). The three other competences which are also common in the bottom six are: Economic Skills, Holistic Thinking, Intercultural Skills. There is some similarity amongst other lowest ranked competences: General Knowledge and Challenging the Status Quo (overall); General Knowledge and Agility (Ireland); and Challenging the Status Quo and Negotiation (NI). Average importance scores for the six lowest competences range from 3.22 to 3.93, thus being of some importance.

The **range of average importance scores** (overall) is **1.43**. However, excluding Entrepreneurship which is an outlier, the next nearest competence is some 0.42 points higher (Economic Skills, 3.73); that reduces the range to **1.01**. Thus, average importance scores for all competences are high and closely grouped, within a relatively small range. The same is evident in NI and Ireland with **ranges** (excluding Entrepreneurship, the outlier) as follows:

- **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).

It is also interesting to observe that for the majority of competences (39 of 53), average importance scores for Ireland are higher than for NI. However, whilst there are some differences between average importance scores (and corresponding ranking) for competences in NI and Ireland, these are typically quite small (the largest magnitude difference is 0.32).

Gender

Exploring average importance scores and rank by gender reveals a high degree of consistency (see Appendix B Table 9 for importance scores and ranks for all competences by gender). Table 4 presents the **competences ranked in the top five by gender**, using the same colour coding (for top five) as in Table 3. The high degree of consistency is evident in that **women and men place the same competences in ranks 1 to 4 as overall,** though average importance scores vary. A minor exception is that **Communication** is ranked jointly first with **Problem Solving** by women though ranked second by men and overall. It is also notable that average importance scores are somewhat higher for women than men.

Considering **fifth place**, **Critical Thinking** occupies this position **overall and for men** but does not feature in the top five for women (it is ranked 9th by women). Instead, **three other competences** share the same

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

average importance score (4.65) and are **ranked jointly 5th by women**. These are: **Sustainability Awareness, Environmental Awareness** and **Open-Mindedness**.

Table 4: Average Importance Scores (Competences Ranked 1-5) by Gender

Rank	Man	Woman	All
1	Problem Solving, 4.69	Problem Solving, 4.85 Communication, 4.85	Problem Solving, 4.74
2	Communication, 4.60	n/a	Communication, 4.68
3	Teamwork, 4.55	Teamwork, 4.82	Teamwork, 4.64
4	Respect for Others, 4.53	Respect for Others, 4.76	Respect for Others, 4.60
5	Critical Thinking, 4.53	Sustainability Awareness, 4.65 Environmental Awareness, 4.65 Open Mindedness, 4.65	Critical Thinking, 4.56

Note:

- *Score: = Average Importance Score, where 5 – Extremely Important to 1 – Not at all Important*
- *Rank = Average Importance Score ranked, where 1 = Highest and 53 = Lowest*
- *Colour code to identify competences which feature in top 5 overall; cells shaded in lilac indicate competences that are not in top 5 overall but are in top 5 for at least one gender.*
- *Table includes up to 7 competences (Woman) as some competences have tied scores/equal rank*
- *n/a indicates no competence in this rank position due to tied scores/ranks in higher position*

Turning to **competences ranked least important**, again there is a good degree of agreement between women and men. Both place the same competences in the bottom four positions (50th – 53rd) as overall. These are: **General Knowledge; Holistic Thinking; Economic Skills** and **Entrepreneurship.** For women, the rank mirrors overall rank; however, there is a minor difference in rank for men. Moving up to the next lowest ranked competence (49th), there is inconsistency. This position is occupied by **Intercultural Skills** (average importance score 3.91) overall, though women rank Leadership (4.07) and men rank Challenging the Status Quo (3.78) in this position. As already noted, **Entrepreneurship** is an outlier overall; its score is markedly lower than other competences; this is also true for women and men.

Women typically have higher average importance scores than men: this is the case for 52 of the 53 competences. The exception is Curiosity which has the same average importance score for women and men. Whilst the average importance scores (and corresponding ranking) for competences differ between women and men, these are typically quite small (largest magnitude difference is 0.52).

Stakeholder Category

Disaggregating results by stakeholder category offers another perspective on priority skills (see Appendix B Table 10 for importance scores and ranks for all competences by stakeholder category). Whilst the **competences ranked most important by each category are broadly similar**, there are also notable differences such as: rank and inclusion/exclusion of some competences by each category. Considering the competences ranked as **top five most important**, ten different competences feature across all stakeholder categories, reflecting some differing priorities. It is also of note that in some categories, there are more than five competences in the top five places as some competences share the same average importance scores. For example, the Employer-SME category has three competences tied at rank 1 and two at rank 5.

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Table 5 presents the competences ranked in the **top five by each stakeholder category**, using the same colour coding (for top five) as in Table 3. There are five additional competences in this table (which are not in Table 3) shown in lilac.

Problem Solving, Communication and **Teamwork** which are in the top five overall feature in the top five ranked competences (and towards the higher end of these) in each stakeholder category. Within the top five ranks, there is considerable variation in rank and scores (though differences in scores are relatively small) across the stakeholder categories. The lowest score in Table 5 is 4.54, reflecting the high average importance scores attached to all competences in the table.

Table 5: Average Importance Scores (Competences Ranked 1-5) by Stakeholder Category

Rank	Academic	Emp-Multi	Emp-Nat	Emp-SME	Emp-ALL	Student	All
1	Problem Solving, 4.74	Problem Solving, 4.76 Communication, 4.76	Communication, 4.90	Problem Solving, 4.81 Communication, 4.81 Teamwork, 4.81	Communication, 4.81	Problem Solving, 4.75	Problem Solving, 4.74
2	Teamwork, 4.61 Critical Thinking, 4.61	n/a	Teamwork, 4.80	n/a	Teamwork 4.73	Communication, 4.69	Communication, 4.68
3	n/a	Respect for Others, 4.71	Critical Thinking, 4.70 Time Management, 4.70 Sustainability Awareness, 4.70	n/a	Problem Solving, 4.71	Respect for Others 4.64	Teamwork, 4.64
4	Respect for Others, 4.57	Collaboration, 4.67	n/a	Adaptability, 4.71	Critical Thinking, 4.56 Collaboration, 4.56	Teamwork, 4.61	Respect for Others, 4.60
5	Communication, 4.54 Collaboration, 4.54	Teamwork, 4.62 Critical Thinking, 4.62 Technical Skills, 4.62	n/a	Collaboration, 4.62 Time Management, 4.62	n/a	Time Management 4.54	Critical Thinking, 4.56

Note:

- *Score: = Average Importance Score, where 5 – Extremely Important to 1 – Not at all Important*
- *Rank = Average Importance Score ranked, where 1 = Highest and 53 = Lowest*
- *Colour code to identify competences which feature in top 5 overall; cells shaded in lilac indicate competences that are not in top 5 overall but are in top 5 for at least one stakeholder category.*
- *Table includes up to seven competences per category as some have tied scores/equal rank*
- *n/a indicates no competence in this rank position due to tied scores/ranks in higher position*

Compared to competences which are ranked in the top five / most important overall, academics have the same five competences ranked as most important though rank differs. Due to some tied average importance scores, academics also include a sixth competence: **Collaboration** (ranked 5=, average

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

importance score 4.54) in their top five ranking. Academics rank **Problem Solving** as the most important competence (average importance score 4.74).

Similarly, **Problem Solving** (average importance score 4.75) is ranked highest by students. Indeed, students' top five most important competences broadly reflect overall results: with four competences in common although the ranking differs. **Time Management** (ranked 5, average importance score 4.54) replaces **Critical Thinking** in students' top five. However, the latter is ranked just one place lower (6th) and its average importance score is only marginally lower (4.53).

Employers (all categories) rank **Communication** as the most important competence (average importance score 4.81). Employers' top five rankings have much in common with overall top five rankings: four of the same competences are common to the top five for both. However, employers exclude **Respect for Others** (rank 6, average importance score 4.54), including instead **Collaboration** (rank 4=, average importance score 4.56) compared to overall.

Considering **employer categories**:

- Multi-nationals have the same top five competences as overall. Due to tied scores, multi-nationals also have two more competences in their top five rankings: **Collaboration** and **Technical Skills.** **Problem Solving** and **Communication** are ranked joint first (average importance score 4.76) whilst **Teamwork, Critical Thinking** and **Technical Skills** share fifth place (average importance score 4.62).
- Nationals include three of five competences ranked most important overall in their most important competences. However, **Problem Solving** and **Respect for Others** are excluded from their top five, replaced by **Time Management** and **Sustainability Awareness**. Together with **Critical Thinking**, they share a rank of 3 and average importance score of 4.70. National employers rated **Communication** as most important (average importance score 4.90).
- SMEs have three of five competences ranked most important in common with those ranked most important overall but exclude **Respect for Others** and **Critical Thinking** from their top five. Instead, they include **Adaptability, Collaboration, Time Management**. Three competences: **Problem Solving, Communication** and **Teamwork** are jointly ranked most important (average importance score 4.81).

All stakeholder categories rank **Entrepreneurship** lowest (53rd) with average importance scores ranging from 3.10 to 3.46 across stakeholder categories. Whilst there is agreement on the lowest ranked competence, there is less consistency for others ranked amongst the lowest. There is some agreement (though not universal) on the next lowest ranked competence: **Economic Skills** (ranked 52nd overall and by academics, SMEs, employers-all; 51st by multi-nationals and 50th by students and 26th by national-employers). Average importance scores for Economic Skills range from 3.57 to 4.20. Regardless of rank, all average importance scores are relatively high and fairly close amongst the lower ranked competences, though the rank varies across the different stakeholder categories. Furthermore, for most stakeholder categories, there are more than five competences in the bottom five rankings as many competences share average importance scores.

Comparing stakeholder categories, the evidence is mixed: no category has average importance scores that are consistently higher or lower than other categories. Comparisons are shown below (with maximum magnitude difference in brackets):

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

- Academics compared to employers: academics score 24 competences lower, 2 same, 27 lower (0.44)
- Academics compared to students: academics score 30 competences lower, 23 higher (0.55)
- Employers compared to students: employers score 26 competences lower, 27 higher (0.72).

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Discussion

Key Findings - Research Questions 1 and 2

The survey results offer an understanding of stakeholder perceptions (amongst survey respondents on the island of Ireland) on the most important competences for engineers of the future to help solve the SDGs. The main findings by Research Question are presented below.

Research Question 1: What are the priority professional competences that respondents perceive that engineers of the future will need to help solve the SDGs?

- The five priority professional competences overall are: Problem Solving, Communication, Teamwork, Respect for Others and Critical Thinking. All five competences have fairly similar, high average importance scores, greater than 4.56 (where 5-*very important* to 1-*not important*). Entrepreneurship was found to be the least important competence overall.
- All 53 competences are regarded as having some importance: average importance scores for all are at least 3.31. Overall, the range of average importance scores is 3.31 to 4.74. Average importance scores are all relatively high and differences between scores are typically not substantial. Nonetheless, scores and ranks helps to illustrate where relative priorities lie.

Research Question 2: To what extent do priority professional competences differ by: jurisdiction (Ireland, Northern Ireland); gender; and stakeholder category (academic, student, engineering employer)?

There is broad alignment on many of the competences identified as priorities when the data is disaggregated (by variables: jurisdiction, gender and stakeholder category), despite nuances and some variation in ranking and average importance scores. Key findings by variable are presented in turn:

- **Jurisdiction (Ireland, NI):** The same competences overall are also in the top five in NI and Ireland. Respondents in Ireland tend to rate competences more highly though differences are not large. For the majority of competences (39 of 53), average importance scores for Ireland are higher than for NI (largest magnitude difference is 0.32).
- **Gender:** The same competences feature in the top four places for women and men as overall. Whilst women rank three other competences jointly fifth (Sustainability Awareness, Environmental Awareness and Open-Mindedness), the ranking for men reflects the overall ranking: Critical Thinking is ranked fifth. Women typically gave higher average importance scores than men (higher for 52 competences, one has the same score).
- **Stakeholder category (academic, student, engineering employer):** Three competences (Problem Solving, Communication and Teamwork) which are in the top five overall are in the top five ranked competences (and towards the higher end of these) in each stakeholder category demonstrating a fair degree of consensus. Rankings for academics and multi-national employers have much in common with overall rankings: the same five competences feature in their top five as overall although rank differs. Both academics and multi-nationals also include a sixth competence in their top five (due to tied scores). Students and employers (all) each have four competences in their top five in common with overall rankings although rank differs. National employers and SMEs each include three of five

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

competences ranked most important overall in their top five. For all 53 competences, there is some variation in average importance scores and ranking across the stakeholder categories. Findings are mixed: no stakeholder category has average importance scores that are consistently higher or lower than another. Across the categories (academics, employers and students), there is broad agreement on the most important competences required by engineers although there are also differences of note. Considering the employer categories only, some competences (Communication, Teamwork) feature in all employer categories' top five, whilst there are also distinctive competences perceived as important by each employer category.

Discussion of Key Findings

This research (and in particular, the analysis of survey findings in relation to Research Questions 1 and 2) is set in the context that engineers of the future will be challenged to address problems and respond to opportunities arising from the SDGs that are indifferent to geographic/political boundaries. Whilst professional skills required by engineers have been explored in previous research studies (see Context for Research section of this report), this research is novel. It builds on previous studies, providing new insights as it identifies and prioritises skills requirements (to help solve the SDGs) for engineers that are contextually relevant to the island of Ireland.

The survey findings identify the most important competences for engineers on the island of Ireland to help solve the SDGs. They provide useful insights and improve understanding which could prove useful in informing engineering education at a tertiary level and in particular focusing educational initiatives in individual universities. There is scope for engineering education programmes to reinforce and further develop these important competences.

Amongst survey respondents, all competences are regarded as having a level of importance with average importance scores above 3.3 (where 5 is Extremely important and 1 is Not at All Important). Although there is some variation in scores, there is some measure of importance attached to all. This is encouraging, reflecting a degree of awareness and understanding (amongst survey respondents) of the broader range of skills that engineers of the future require. As stated by Beagon et al. (2022b), "the role of the engineer in the future will be broader than at present with entanglement in social, environmental and global issues". Thus, the engineer of the future will require a more diverse range of skills to navigate an increasingly complex work environment.

There is a high degree of consistency in the most important competences when data is disaggregated by jurisdiction and gender in particular. This suggests that amongst survey respondents (in both jurisdictions, both women and men) there are very similar perceptions about the priority competences required of engineers. Similarly, there is a fair degree of consensus when data is disaggregated by stakeholder category though there are more nuances (reflecting greater disaggregation).

On the one hand, the similarity in ranking of importance of the competences is perhaps surprising to some extent, particularly given some differences in the two jurisdictions (for example: public policy, economic and social context, education systems, etc.). On the other hand, however, cross-border mobility (for education, employment, trade, etc.) together with the global nature of SDGs (and the fact that sustainable development challenges are unconstrained by geography) may account for similarities to some extent.

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

The convergence of perceptions of the most important competences is also reassuring given the complementary and inter-connected roles that students, academics and employers play in responding to these.

Overall, this suggests there is scope for shared engineering education initiatives to reinforce and further develop these important competences.

However, it is important not to overlook some degrees of difference on the most important competences revealed by the survey data, particularly by stakeholder category. For example, there are distinctive competences perceived as important by each employer category which may reflect the differing nature of engineering roles in these organisations. In preparing students for the local and global workforce, this suggests that it would be important for those developing engineering education programmes/initiatives to take into account the somewhat differing priorities of different categories of employer. There may be a role for greater industry/university collaboration to facilitate this, perhaps mediated through the appropriate professional body.

Further research could be undertaken to build on this study. In the absence of practical and resource constraints this could survey a larger, potentially more diverse population using a probability sampling approach; consideration could be given to an updated research instrument. This might include standard definitions of some key terms (such as employer categories), seek additional respondent information (such as institution/discipline for academics and students, job title for academics and employers) and perhaps use standardised rating scales for some questions.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Conclusions

The report provides a snapshot of perspectives on the island of Ireland on priorities for skills to address SDG challenges for future engineers. The findings are drawn from an exploratory scoping survey amongst a sample of academics involved in engineering, engineering employers and engineering students. The survey identified the most important competences for engineers on the island of Ireland to help solve the SDGs. They also reveal that all 53 competences in the survey are regarded as having a level of importance with average importance scores above 3.3 (where 5 is Extremely important and 1 is Not at All Important).

The design of the Summer School, a joint engineering education initiative between two 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 sought 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.

Not only have the survey findings contributed to the design of a cross-border Summer School, they also improve understanding of stakeholder perceptions (amongst survey respondents) on the most important competences for engineers of the future to help solve the SDGs. They provide useful insights for the engineering education community by raising awareness of future-orientated thinking around sustainable development, the SDGs and the skills that engineers will require in this regard. There is scope for engineering education programmes to reinforce and further develop these important competences.

The resonance between priorities in both jurisdictions (and generally across gender and stakeholder categories) suggests 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.

These findings seek to improve engineering educators' understanding of the perceptions of each stakeholder group. Such improved understanding should inform opportunities for future development in engineering education. Academics may consider this in engineering curriculum design and in managing students' expectations to reflect employer priorities; meanwhile employers may also consider their role and involvement in university/industry collaborations to support universities in the development of engineers for the future. Together this would help to equip engineering graduates with an appropriate skill set to contribute solutions to the big global challenges of our day.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Appendix A: Questionnaire

PROFESS 12 - Survey of Competence Requirements for SDGs

Thank you for taking the time to complete our survey as part of a research project called PROFESS 12, which should take 4 minutes.

PARTICIPANT INFORMATION

Nature of the study:
Our research hopes to inform the design of a teaching activity to help students develop the necessary skills required to help solve the SDGs. We wish to run a summer school for engineering students and to trial some learning and teaching approaches, but we firstly would like to better understand the perceptions of employers, academics and students on the most important skills.

We would like therefore to gather your views through this short survey.

Researchers:
The study is being undertaken by Dr. Una Beagon from TU Dublin and Prof. Margaret Morgan from Ulster University.

Research Work:
The data we collect will be used to help design the summer school and we also hope to write some academic papers outlining our findings in scientific publications, books or conference proceedings.

Confidentiality and Withdrawal:
The survey is completely voluntary and anonymous.
You may withdraw part way through the survey, however you will be unable to withdraw after it has been submitted (as it is anonymous).

Health and Safety:
There are no health and safety implications to this research.

Data retention:
We are obliged to retain data (including this consent form) for the period of the study (to December 2024), during which time it will be held securely and confidentially on password protected computers, and after which it will be destroyed. The data will only be accessible to the researchers involved in the PROFESS 12 project.

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Ethical Approval:
This project has been approved by the TUDublin Research Ethics and Integrity Committee on 2nd November 2022. You are free to contact the ethics committee researchethics@tudublin.ie should you wish to make a complaint on ethical grounds.

Queries:
Please feel free to contact us should you have any queries on una.beagon@tudublin.ie or m.morgan@ulster.ac.uk.

Consent:

1

CONSENT FORM:

Please review the following to indicate your consent:

I confirm that I have:

- Read and understood the participant information related to this study (Included above).
- Been fully informed of the nature of the study by the researcher.
- Had the opportunity to ask questions about the research.
- Received sufficient information about the potential health and or safety implications of the research.
- Been fully informed of your ability to withdraw participation and/or data from the research.
- Been fully informed about what will happen to the data generated by my participation in the study and how it will be kept safe.
- Been informed that this consent form shall be kept securely and in confidence by the researcher.

I therefore agree to take part in the study, the results of which may be disseminated in scientific publications, books or conference proceedings. *

◯ I consent

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

2

Let's start with some background information.
Please indicate if you are an employer, academic or student. *

- ◯ Academic
- ◯ Student
- ◯ Employer - SME
- ◯ Employer - National
- ◯ Employer - Multinational

3

Which year of study are you in? *

- ◯ 1st Year
- ◯ 2nd Year
- ◯ 3rd Year
- ◯ 4th Year
- ◯ 5th Year
- ◯ Postgraduate

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

4

Please tick the sector which most closely describes your business. *

- ◯ Consultancy
- ◯ Manufacturing
- ◯ Research & Development
- ◯ Contracting
- ◯ Other

5

Now for some demographic questions:

Gender: *

- ◯ Woman
- ◯ Man
- ◯ Gender Non-Conforming
- ◯ Non-Binary
- ◯ Transgender
- ◯ Prefer to self-describe
- ◯ Prefer not to say
- ◯ Not listed

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

6

Age: *

- ◯ < 22 years old
- ◯ 22-29 years old
- ◯ 30-39 years old
- ◯ 40-49 years old
- ◯ 50-59 years old
- ◯ 60 years or older

7

Please confirm which region you operate from or work/study in: *

- ◯ Ireland - South
- ◯ Ireland - North
- ◯ Elsewhere in UK
- ◯ Outside of Ireland and UK

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

8

Are you aware of the Sustainable Development Goals (SDGs)? *

- ◯ Not at all aware
- ◯ Slightly Aware
- ◯ Somewhat Aware
- ◯ Moderately Aware
- ◯ Extremely Aware

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

9

The next series of questions follows on from some European research work on the competences engineers require to help solve the Sustainable Development Goals (SDGs) (Beagon et al., 2021).

If you would like more information on the SDGs, please look here: https://www.undp.org/sustainable-development-goals

This section is presented in 6 parts with different types of competences.

Please indicate how important you think each competence is for engineers of the future to help solve the SDGs.

Competency Set 1- Fundamental Technical Skills *

	1- Not important	2	3	4	5 - Very important
Mathematics Skills	○	○	○	○	○
Digital Skills	○	○	○	○	○
Economic Skills	○	○	○	○	○
Research Skills	○	○	○	○	○
Technical Skills	○	○	○	○	○

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

10

Competency Set 2- Application Skills *

	1- Not important	2	3	4	5 - Very important
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)	○	○	○	○	○

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

11

Competency Set 3- Outward Facing - People Orientated Skills *

	1- Not important	2	3	4	5 - Very important
Intercultural Skills	◯	◯	◯	◯	◯
Collaboration	◯	◯	◯	◯	◯
Leadership	◯	◯	◯	◯	◯
Conflict Management	◯	◯	◯	◯	◯
Negotiation	◯	◯	◯	◯	◯
Communication	◯	◯	◯	◯	◯
Respecting Diversity	◯	◯	◯	◯	◯
Teamwork	◯	◯	◯	◯	◯

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

12

Competency Set 4- Inward Facing - Ways of Thinking *

	1- Not important	2	3	4	5 - Very important
Critical Thinking	◯	◯	◯	◯	◯
Life Cycle Thinking	◯	◯	◯	◯	◯
Holistic Thinking	◯	◯	◯	◯	◯
Systems Thinking	◯	◯	◯	◯	◯
Creativity	◯	◯	◯	◯	◯
Analytical Thinking	◯	◯	◯	◯	◯
Stress Management	◯	◯	◯	◯	◯
Time Management	◯	◯	◯	◯	◯
Self Reflection	◯	◯	◯	◯	◯
Multi-perspective Thinking	◯	◯	◯	◯	◯

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

13

Competency Set 5- Worldview *

	1- Not important	2	3	4	5 - Very important
Global Awareness	◯	◯	◯	◯	◯
Social Responsibility	◯	◯	◯	◯	◯
Challenging the status quo	◯	◯	◯	◯	◯
Sustainability Awareness	◯	◯	◯	◯	◯
Environmental Awareness	◯	◯	◯	◯	◯
General Knowledge	◯	◯	◯	◯	◯
Life Long Learning	◯	◯	◯	◯	◯

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

14

Competency Set 6- Character and Ethical Orientation *

	1- Not important	2	3	4	5 - Very important
Respect for others	◯	◯	◯	◯	◯
Open Mindedness	◯	◯	◯	◯	◯
Agility	◯	◯	◯	◯	◯
Adaptability	◯	◯	◯	◯	◯
Curiosity	◯	◯	◯	◯	◯
Empathy	◯	◯	◯	◯	◯
Emotional Intelligence	◯	◯	◯	◯	◯
Perseverance/ Grit	◯	◯	◯	◯	◯
Ethical Conscience	◯	◯	◯	◯	◯
Personal Engagement	◯	◯	◯	◯	◯

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

15

Thank you for letting us know your thoughts.

Referring back to the 6 types of competences mentioned above, please indicate your view on how well prepared current engineering students and graduates are in each of these competences. *

	1- Engineering Students and Graduates are not well prepared	2	3	4	5 - Engineering Students and Graduates are very well prepared
Fundamental Technical Skills	○	○	○	○	○
Application Skills	○	○	○	○	○
Outward Facing - People Orientated	○	○	○	○	○
Inward Facing - Ways of thinking	○	○	○	○	○
Worldview	○	○	○	○	○
Character and Ethical Orientation	○	○	○	○	○

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

16

Finally, this question aims to help us consider what competences to help develop in students as a priority.

Referring back to the 6 types of competences mentioned above, please indicate which competencies you believe should be taught as a priority. *

	1- Not a priority	2	3	4	5 - Needs to be a priority
Fundamental Technical Skills	◯	◯	◯	◯	◯
Application Skills	◯	◯	◯	◯	◯
Outward Facing - People Orientated	◯	◯	◯	◯	◯
Inward Facing - Ways of thinking	◯	◯	◯	◯	◯
Worldview	◯	◯	◯	◯	◯
Character and Ethical Orientation	◯	◯	◯	◯	◯

17

Thank you for taking the time to complete this survey. This is an open text box where you can add any competences you think we have missed or general feedback on your thoughts.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

18

If you are interested in learning more about the SDGs skills list, please refer to **Reference:** Beagon, U., Kövesi, K., Tabas, B., Nørgaard, B., Lehtinen, R., Bowe, B., ... & Spliid, C. M. (2022). Preparing engineering students for the challenges of the SDGs: what competences are required?. *European Journal of Engineering Education*, 1-23. https://www.tandfonline.com/doi/pdf/10.1080/03043797.2022.2033955

If you wish to hear more about our PROFESS 12 Project - please email una.beagon@tudublin.ie or m.morgan@ulster.ac.uk

☆ ☆ ☆ ☆ ☆

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Appendix B: Survey Results - Detailed

Number and Profile of Respondents

Stakeholder Category and Gender

Table 6: Profile of Respondents by Stakeholder Category and Gender (% of ALL)

Category	Man		Woman		All	
	Number	Percentage	Number	Percentage	Number	Percentage
Academic	35	14.9%	19	8.1%	54	23.0%
Employer – Multinational	17	7.2%	4	1.7%	21	8.9%
Employer – National	5	2.1%	5	2.1%	10	4.3%
Employer – SME	12	5.1%	9	3.8%	21	8.9%
Employer – All	*34*	*14.4%*	*18*	*7.6%*	*52*	*22.1%*
Student	92	39.1%	37	15.7%	129	54.9%
Total	**161**	**68.5%**	**74**	**31.5%**	**235**	**100.0%**

Age and Gender

Table 7: Profile of Respondents by Age and Gender (% of ALL)

Age	Man		Woman		All	
	Number	Percentage	Number	Percentage	Number	Percentage
< 22 years old	61	26.0%	27	11.5%	88	37.4%
22-29 years old	24	10.2%	11	4.7%	35	14.9%
30-39 years old	26	11.1%	15	6.4%	41	17.4%
40-49 years old	22	9.4%	17	7.2%	39	16.6%
50-59 years old	19	8.1%	4	1.7%	23	9.8%
60 years or older	9	3.8%		0.0%	9	3.8%
Total	**161**	**68.5%**	**74**	**31.5%**	**235**	**100.0%**

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Importance of Competences for Engineers of the Future to Help Solve the SDGs - Jurisdiction

Table 8: Average Importance Scores and Ranks by Jurisdiction

	Average Importance Score: 5 Very, 1 Not			Average Importance Score: Rank 1 high, 53 low		
	N	S	All	N	S	All
Number of respondents	**88**	**147**	**235**	**88**	**147**	**235**
Competency Set 1-Fundamental Technical Skills						
Mathematics Skills	4.27	4.20	4.23	17	30	23=
Digital Skills	4.40	4.24	4.30	9=	25	17
Economic Skills	**3.72**	**3.74**	**3.73**	**51***	**52***	**52***
Research Skills	4.20	4.28	4.25	23	19=	21=
Technical Skills	**4.45**	**4.45**	**4.45**	7=	10	10
Set Average	**4.21**	**4.18**	**4.19**			
Set Range (Max-Min)	**0.74**	**0.71**	**0.72**			
Competency Set 2- Application Skills						
Multidisciplinary Skills	4.11	4.03	4.06	28	40=	33=
Problem Solving	**4.75**	**4.73**	**4.74**	**1***	**2***	**1***
Design Skills	3.94	**4.00**	**3.98**	41=	45	44=
Interpretation Skills	**3.91**	4.10	4.03	45=	35	40
Conceptual understanding	4.10	4.28	4.21	29	19=	27
Resources optimisation	4.05	4.03	4.04	31	40=	38
Innovation	4.17	4.27	4.23	26	22=	23=
Entrepreneurship	**3.47**	**3.22**	**3.31**	**53***	**53***	**53***
Decision Making Skills	4.25	4.40	4.34	18	13	14=
Learning to Learn	4.36	4.33	4.34	13	15	14=
Project Management	4.01	4.06	4.04	33=	37=	37
Organisation Skills	4.18	4.29	4.25	25	18	21=
Problematisation (to consider or treat as a problem)	**3.91**	4.03	3.99	45=	40=	43
Set Average	**4.09**	**4.14**	**4.12**			
Set Range (Max-Min)	**1.28**	**1.52**	**1.43**			
Competency Set 3- Outward Facing - People Orientated Skills						
Intercultural Skills	**3.82**	**3.96**	**3.91**	**48=***	**48***	**49***
Collaboration	4.47	4.51	4.49	6	8	6
Leadership	3.99	4.06	4.03	35=	37=	39
Conflict Management	3.89	3.97	3.94	47	47	47
Negotiation	**3.82**	4.11	4.00	**48=***	34	42
Communication	**4.57**	**4.75**	**4.68**	**3***	**1***	**2***
Respecting Diversity	4.23	4.32	4.29	20=	16=	18
Teamwork	4.56	4.69	4.64	**4***	**3***	**3***
Set Average	**4.17**	**4.30**	**4.25**			
Set Range (Max-Min)	**0.75**	**0.79**	**0.77**			

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

	Average Importance Score: 5 Very, 1 Not			Average Importance Score: Rank 1 high, 53 low		
	N	S	All	N	S	All
Number of respondents	**88**	**147**	**235**	**88**	**147**	**235**
Competency Set 4- Inward Facing - Ways of Thinking						
Critical Thinking	**4.48**	**4.61**	**4.56**	**5***	**4***	**5***
Life Cycle Thinking	3.99	4.21	4.13	35=	28=	30=
Holistic Thinking	**3.67**	**3.78**	**3.74**	**52***	**50***	**51***
Systems Thinking	4.08	4.03	4.05	30	40=	35=
Creativity	4.01	4.20	4.13	33=	31	30=
Analytical Thinking	4.24	4.37	4.32	19	14	16
Stress Management	3.98	4.12	4.06	39	33	33=
Time Management	4.40	4.44	4.42	9=	11	11
Self Reflection	3.95	3.99	3.98	40	46	44=
Multi-perspective Thinking	4.23	4.22	4.22	20=	27	26
Set Average	**4.10**	**4.20**	**4.16**			
Set Range (Max-Min)	**0.81**	**0.83**	**0.82**			
Competency Set 5- Worldview						
Global Awareness	4.03	4.14	4.10	32	32	32
Social Responsibility	3.94	4.27	4.14	41=	22=	29
Challenging the status quo	**3.80**	4.01	3.93	**50***	44	**48***
Sustainability Awareness	**4.34**	**4.54**	**4.47**	14=	6	7
Environmental Awareness	**4.34**	**4.54**	4.46	14=	7	8=
General Knowledge	3.92	**3.76**	**3.82**	44	**51***	**50***
Life Long Learning	4.15	4.21	4.19	27	28=	28
Set Average	**4.07**	**4.21**	**4.16**			
Set Range (Max-Min)	**0.55**	**0.78**	**0.65**			
Competency Set 6- Character and Ethical Orientation						
Respect for others	**4.64**	**4.59**	**4.60**	**2***	**5***	**4***
Open Mindedness	4.45	4.47	4.46	7=	9	8=
Agility	**3.93**	**3.95**	**3.94**	43	**49***	46
Adaptability	4.40	4.43	4.42	9=	12	12
Curiosity	4.19	4.25	4.23	24	24	23=
Empathy	3.99	4.04	4.02	35=	39	41
Emotional Intelligence	3.99	4.09	4.05	35=	36	35=
Perseverance/Grit	4.40	4.32	4.35	9=	16=	13
Ethical Conscience	4.23	4.27	4.26	20=	21	20
Personal Engagement	4.31	4.24	4.26	16	26	19
Set Average	**4.25**	**4.26**	**4.26**			
Set Range (Max-Min)	**0.70**	**0.63**	**0.66**			

Note:

Col 1: Light Red/Light Green shading = competences ranked 48-53 / ranked 1-5 either N &/or S &/or All

Col 2-4: Red/Green shading = least / most important competence per set (in column)

Col 5-7: Light Red/Light Green shading = bottom 20 (rank 34-53)/top 20 (rank 1-20) competences (in column)

*Light Red/Light Green shading **bold*** = competences ranked 48-53 / ranked 1-5 (in column)*

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Importance of Competences for Engineers of the Future to Help Solve the SDGs - Gender

Table 9: Average Importance Scores and Ranks by Gender

	Average Importance Score: 5 Very, 1 Not			Average Importance Score: Rank 1 high, 53 low		
	Man	Woman	All	Man	Woman	All
Number of respondents	**161**	**74**	**235**	**161**	**74**	**235**
Competency Set 1-Fundamental Technical Skills						
Mathematics Skills	4.19	4.32	4.23	20	29=	23=
Digital Skills	4.27	4.36	4.30	14=	27	17
Economic Skills	**3.68**	**3.85**	**3.73**	**51***	**52***	**52***
Research Skills	4.22	4.32	4.25	19	29=	21=
Technical Skills	**4.42**	**4.51**	**4.45**	7	16	10
Set Average	**4.16**	**4.28**	**4.19**			
Set Range (Max-Min)	**0.75**	**0.66**	**0.72**			
Competency Set 2- Application Skills						
Multidisciplinary Skills	3.98	4.24	4.06	35	35=	33=
Problem Solving	**4.69**	**4.85**	**4.74**	**1***	**1=***	**1***
Design Skills	3.89	4.18	**3.98**	42	42	44=
Interpretation Skills	3.98	4.15	4.03	36	44=	40
Conceptual understanding	4.16	4.34	4.21	23	28	27
Resources optimisation	3.93	4.28	4.04	39=	31=	38
Innovation	4.14	4.42	4.23	24	23=	23=
Entrepreneurship	**3.22**	**3.51**	**3.31**	**53***	**53***	**53***
Decision Making Skills	4.26	4.53	4.34	16	15	14=
Learning to Learn	4.28	4.49	4.34	13	17=	14=
Project Management	4.01	4.12	4.04	34	46	37
Organisation Skills	4.17	4.42	4.25	21	23=	21=
Problematisation (to consider or treat as a problem)	3.85	4.28	3.99	46	31=	43
Set Average	**4.04**	**4.29**	**4.12**			
Set Range (Max-Min)	**1.47**	**1.34**	**1.43**			
Competency Set 3- Outward Facing - People Orientated Skills						
Intercultural Skills	**3.82**	4.09	**3.91**	48	48	**49***
Collaboration	4.44	4.61	4.49	6	10=	6
Leadership	4.02	**4.07**	4.03	32	**49***	39
Conflict Management	3.86	4.11	3.94	44	47	47
Negotiation	3.93	4.16	4.00	39=	43	42
Communication	**4.60**	**4.85**	**4.68**	**2***	**1=***	**2***
Respecting Diversity	4.14	4.61	4.29	25	10=	18
Teamwork	4.55	4.82	4.64	**3***	**3***	**3***
Set Average	**4.17**	**4.42**	**4.25**			
Set Range (Max-Min)	**0.78**	**0.78**	**0.77**			

Funded by:
HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

	Average Importance Score: 5 Very, 1 Not			Average Importance Score: Rank 1 high, 53 low		
	Man	Woman	All	Man	Woman	All
Number of respondents	**161**	**74**	**235**	**161**	**74**	**235**
Competency Set 4- Inward Facing - Ways of Thinking						
Critical Thinking	**4.53**	**4.62**	**4.56**	**5***	9	**5***
Life Cycle Thinking	4.09	4.22	4.13	29	39	30=
Holistic Thinking	**3.63**	**3.96**	**3.74**	**52***	**51***	**51***
Systems Thinking	3.96	4.24	4.05	38	35=	35=
Creativity	4.12	4.15	4.13	26	44=	30=
Analytical Thinking	4.27	4.43	4.32	14=	20=	16
Stress Management	3.97	4.27	4.06	37	33	33=
Time Management	4.35	4.58	4.42	11	13=	11
Self Reflection	3.88	4.19	3.98	43	40=	44=
Multi-perspective Thinking	4.10	4.49	4.22	27	17=	26
Set Average	**4.09**	**4.31**	**4.16**			
Set Range (Max-Min)	**0.89**	**0.66**	**0.82**			
Competency Set 5- Worldview						
Global Awareness	4.04	4.23	4.10	31	37=	32
Social Responsibility	4.01	4.43	4.14	33	20=	29
Challenging the status quo	3.78	4.26	3.93	**49***	34	48
Sustainability Awareness	**4.39**	**4.65**	**4.47**	8	**5=***	7
Environmental Awareness	4.38	**4.65**	4.46	9=	**5=***	8=
General Knowledge	3.74	**4.00**	**3.82**	**50***	**50***	**50***
Life Long Learning	4.07	4.43	4.19	30	20=	28
Set Average	**4.06**	**4.38**	**4.16**			
Set Range (Max-Min)	**0.65**	**0.65**	**0.65**			
Competency Set 6- Character and Ethical Orientation						
Respect for others	**4.53**	**4.76**	**4.60**	**4***	**4***	**4***
Open Mindedness	4.38	4.65	4.46	9=	**5=***	8=
Agility	**3.83**	**4.19**	**3.94**	47	40=	46
Adaptability	4.32	4.64	4.42	12	8	12
Curiosity	4.23	4.23	4.23	18	37=	23=
Empathy	3.86	4.38	4.02	45	26	41
Emotional Intelligence	3.89	4.39	4.05	41	25	35=
Perseverance/Grit	4.24	4.58	4.35	17	13=	13
Ethical Conscience	4.09	4.61	4.26	28	10=	20
Personal Engagement	4.16	4.49	4.26	22	17=	19
Set Average	**4.15**	**4.49**	**4.26**			
Set Range (Max-Min)	**0.70**	**0.57**	**0.66**			

Note:

Col 1: Light Red/Light Green shading = competences ranked 49-53 / ranked 1-5 either M &/or W &/or All

Col 2-4: Red/Green shading = least / most important competence per set (in column)

Col 5-7: Light Red/Light Green shading = bottom 20 (rank 34-53)/top 20 (rank 1-20) competences (in column)

*Light Red/Light Green shading **bold*** = competences ranked 49-53 / ranked 1-5 (in column)*

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Importance of Competences for Engineers of the Future to Help Solve the SDGs – Stakeholder Category

Table 10: Average Importance Scores and Ranks by Stakeholder Category

	Average Importance Score: 5 Very, 1 Not							Average Importance Score: Rank 1 high, 53 low						
	Acad-emic	Emp-Multi	Emp-Nat	Emp-SME	Emp-ALL	Stud-ent	All	Acad-emic	Emp-Multi	Emp-Nat	Emp-SME	Emp-ALL	Stud-ent	All
Number of respondents	**54**	**21**	**10**	**21**	**52**	**129**	**235**	**54**	**21**	**10**	**21**	**52**	**129**	**235**
Competency Set 1-Fundamental Technical Skills														
Mathematics Skills	4.15	3.95	4.30	4.14	4.10	4.32	4.23	30	42=	18=	27=	34	18	23=
Digital Skills	4.30	4.33	**4.50**	4.19	4.31	4.30	4.30	16=	17=	8=	23=	16=	19=	17
Economic Skills	**3.70**	**3.57**	**4.20**	**3.62**	**3.71**	**3.75**	**3.73**	**52***	**51=***	26=	**52***	**52***	**50***	**52***
Research Skills	4.17	4.24	**3.80**	3.90	4.02	4.38	4.25	28=	22=	44=	47=	39=	15	21=
Technical Skills	**4.48**	**4.62**	**4.40**	**4.38**	**4.48**	**4.43**	**4.45**	8	**5=***	11=	14=	9=	13	10
Set Average	**4.16**	**4.14**	**4.24**	**4.05**	**4.12**	**4.24**	**4.19**							
Set Range (Max-Min)	**0.78**	**1.05**	**0.70**	**0.76**	**0.77**	**0.67**	**0.72**							
Competency Set 2- Application Skills														
Multidisciplinary Skills	4.31	4.05	3.80	4.00	3.98	3.99	4.06	14=	40	44=	38=	42=	42=	33=
Problem Solving	**4.74**	**4.76**	**4.40**	**4.81**	**4.71**	**4.75**	**4.74**	**1***	**1=***	11=	**1=***	**3***	**1***	**1***
Design Skills	4.09	3.81	4.10	4.10	3.98	3.93	**3.98**	35=	47	37=	29=	42=	45	44=
Interpretation Skills	4.19	3.90	3.80	4.10	3.96	3.99	4.03	26=	44	44=	29=	45	42=	40
Conceptual understanding	4.30	3.86	3.80	4.29	4.02	4.26	4.21	16=	45=	44=	18=	39=	23=	27
Resources optimisation	4.04	3.57	3.70	4.00	3.77	4.15	4.04	37=	**51=***	**50=***	38=	**51***	29	38
Innovation	4.20	4.19	4.20	4.19	4.19	4.26	4.23	22=	29=	26=	23=	27=	23=	23=
Entrepreneurship	**3.46**	**3.24**	**3.10**	**3.14**	**3.17**	**3.30**	**3.31**	**53***	**53***	**53***	**53***	**53***	**53***	**53***
Decision Making Skills	4.33	4.24	4.30	4.33	4.29	4.37	4.34	13	22=	18=	16=	18=	16	14=
Learning to Learn	4.20	4.14	4.40	4.29	4.25	4.44	4.34	22=	32=	11=	18=	22=	9=	14=
Project Management	4.02	3.71	4.40	4.05	3.98	4.08	4.04	40=	48=	11=	35=	42=	34	37
Organisation Skills	4.20	4.14	4.40	4.48	4.33	4.24	4.25	22=	32=	11=	9	15	26	21=
Problematisation (to consider or treat as a problem)	4.00	3.71	4.20	3.95	3.90	4.02	3.99	42=	48=	26=	43=	47=	40	43
Set Average	**4.16**	**3.95**	**4.05**	**4.13**	**4.04**	**4.14**	**4.12**							
Set Range (Max-Min)	**1.28**	**1.52**	**1.30**	**1.67**	**1.54**	**1.45**	**1.43**							

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

	Average Importance Score: 5 Very, 1 Not							Average Importance Score: Rank 1 high, 53 low						
	Acad-emic	Emp-Multi	Emp-Nat	Emp-SME	Emp-ALL	Stud-ent	All	Acad-emic	Emp-Multi	Emp-Nat	Emp-SME	Emp-ALL	Stud-ent	All
Number of respondents	**54**	**21**	**10**	**21**	**52**	**129**	**235**	**54**	**21**	**10**	**21**	**52**	**129**	**235**
Competency Set 3- Outward Facing - People Orientated Skills														
Intercultural Skills	4.04	4.19	**3.30**	3.90	**3.90**	**3.85**	**3.91**	37=	29=	**52***	47=	47=	47=	**49***
Collaboration	4.54	4.67	4.20	4.62	4.56	4.45	4.49	**5=***	**4***	26=	**5=***	**4=***	8	6
Leadership	4.00	**3.95**	4.10	4.00	4.00	4.06	4.03	42=	42=	37=	38=	41	35	39
Conflict Management	**3.80**	4.10	3.80	**3.81**	3.92	4.01	3.94	**50=***	36=	44=	**49=***	46	41	47
Negotiation	3.87	4.24	4.20	**3.81**	4.06	4.03	4.00	47	22=	26=	**49=***	36=	37=	42
Communication	4.54	**4.76**	**4.90**	4.81	**4.81**	**4.69**	**4.68**	**5=***	**1=***	**1***	**1=***	**1***	**2***	**2***
Respecting Diversity	4.35	4.38	4.30	4.00	4.21	4.29	4.29	11=	15=	18=	38=	26	21	18
Teamwork	**4.61**	4.62	4.80	**4.81**	4.73	4.61	4.64	**2=***	**5=***	**2***	**1=***	**2***	**4***	**3***
Set Average	**4.22**	**4.36**	**4.20**	**4.22**	**4.27**	**4.25**	**4.25**							
Set Range (Max-Min)	**0.81**	**0.81**	**1.60**	**1.00**	**0.90**	**0.84**	**0.77**							
Competency Set 4- Inward Facing - Ways of Thinking														
Critical Thinking	**4.61**	**4.62**	**4.70**	4.43	**4.56**	4.53	**4.56**	**2=***	**5=***	**3=***	10=	**4=***	6	**5***
Life Cycle Thinking	4.17	4.24	4.20	4.05	4.15	4.10	4.13	28=	22=	26=	35=	31=	31	30=
Holistic Thinking	4.00	4.24	4.30	4.05	4.17	3.45	**3.74**	42=	22=	18=	35=	29=	**52***	**51***
Systems Thinking	4.11	4.00	**4.00**	**3.76**	**3.90**	4.09	4.05	33=	41	42	**51***	47=	33	35=
Creativity	4.00	4.14	4.20	3.95	4.08	4.20	4.13	42=	32=	26=	43=	35	28	30=
Analytical Thinking	4.30	4.29	4.30	4.29	4.29	4.35	4.32	16=	19=	18=	18=	18=	17	16
Stress Management	3.83	4.14	4.50	4.19	4.23	4.09	4.06	**49***	32=	8=	23=	24=	32	33=
Time Management	4.13	4.10	4.70	**4.62**	4.42	**4.54**	4.42	31=	36=	**3=***	**5=***	13	**5***	11
Self Reflection	**3.80**	**3.86**	4.40	4.10	4.06	4.02	3.98	**50=***	45=	11=	29=	36=	39	44=
Multi-perspective Thinking	4.02	4.19	4.30	4.24	4.23	4.30	4.22	40=	29=	18=	21=	24=	19=	26
Set Average	**4.10**	**4.18**	**4.36**	**4.17**	**4.21**	**4.17**	**4.16**							
Set Range (Max-Min)	**0.81**	**0.76**	**0.70**	**0.86**	**0.65**	**1.09**	**0.82**							

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

	Average Importance Score: 5 Very, 1 Not							Average Importance Score: Rank 1 high, 53 low						
	Acad-emic	Emp-Multi	Emp-Nat	Emp-SME	Emp-ALL	Stud-ent	All	Acad-emic	Emp-Multi	Emp-Nat	Emp-SME	Emp-ALL	Stud-ent	All
Number of respondents	**54**	**21**	**10**	**21**	**52**	**129**	**235**	**54**	**21**	**10**	**21**	**52**	**129**	**235**
Competency Set 5- Worldview														
Global Awareness	4.26	4.24	**3.80**	**3.95**	4.04	4.05	4.10	21	22=	44=	43=	38	36	32
Social Responsibility	4.31	4.43	4.20	4.10	4.25	4.03	4.14	14=	14=	26=	29=	22=	37=	29
Challenging the status quo	4.04	4.48	4.40	4.10	4.31	**3.74**	3.93	39	11=	11=	29=	16=	**51***	48
Sustainability Awareness	**4.50**	**4.48**	**4.70**	**4.43**	4.50	**4.44**	**4.47**	7	11=	**3=***	10=	8	9=	7
Environmental Awareness	4.46	**4.57**	**4.60**	**4.43**	**4.52**	**4.44**	**4.46**	9	8=	6=	10=	7	9=	8
General Knowledge	**3.85**	**3.67**	3.90	3.95	**3.83**	3.81	**3.82**	48	**50***	43	43=	**50***	**49***	**50***
Life Long Learning	4.28	4.33	4.30	4.19	4.27	4.12	4.19	19=	17=	18=	23=	20=	30	28
Set Average	**4.24**	**4.31**	**4.27**	**4.16**	**4.24**	**4.09**	**4.16**							
Set Range (Max-Min)	**0.65**	**0.90**	**0.90**	**0.48**	**0.69**	**0.71**	**0.65**							
Competency Set 6- Character and Ethical Orientation														
Respect for others	**4.57**	**4.71**	4.10	4.57	**4.54**	**4.64**	**4.60**	**4***	**3***	37=	7	6	**3***	**4***
Open Mindedness	4.41	4.57	4.20	4.52	4.48	4.48	4.46	10	8=	26=	8	9=	7	8=
Agility	**4.00**	**4.10**	**3.70**	4.33	**4.12**	**3.85**	**3.94**	42=	36=	**50=***	16=	33	47=	46
Adaptability	4.35	4.38	4.20	**4.71**	4.48	4.42	4.42	11=	15=	26=	**4***	9=	14	12
Curiosity	4.13	4.48	4.20	4.10	4.27	4.26	4.23	31=	11=	26=	29=	20=	23=	23=
Empathy	4.20	**4.10**	4.10	4.24	4.15	3.89	4.02	22=	36=	37=	21=	31=	46	41
Emotional Intelligence	4.09	4.29	4.10	4.14	4.19	3.98	4.05	35=	19=	37=	27=	27=	44	35=
Perseverance/Grit	4.11	4.24	4.50	4.43	4.37	4.44	4.35	33=	22=	8=	10=	14	9=	13
Ethical Conscience	4.28	4.29	4.30	**4.00**	4.17	4.28	4.26	19=	19=	18=	38=	29=	22	20
Personal Engagement	4.19	4.52	**4.60**	4.38	4.48	4.21	4.26	26=	10	6=	14=	9=	27	19
Set Average	**4.23**	**4.37**	**4.20**	**4.34**	**4.33**	**4.24**	**4.26**							
Set Range (Max-Min)	**0.57**	**0.62**	**0.90**	**0.71**	**0.42**	**0.79**	**0.66**							

Note:

Column 1: *Light Red/Light Green shading = competences ranked 49-53 / ranked 1-5 competences in any Stakeholder Category &/or All*

Column 2-8: *Red/Green shading = least / most important competence per set (in column)*

Column 9-15: *Light Red/Light Green shading = bottom 20 (rank 34-53)/top 20 (rank 1-20) competences (in column)*

*Light Red/Light Green shading **bold*** = competences ranked 49-53/ ranked 1-5 competences (in column)*

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

References

Beagon, U., Kövesi, K., Tabas, B., Nørgaard, B., Lehtinen, R., Bowe, B., Gillet, C. and Spliid, C.M. (2022a) Preparing engineering students for the challenges of the SDGs: what competences are required? *European Journal of Engineering Education* 48 (1): 1-23. https://doi.org/10.1080/03043797.2022.2033955

Beagon, U., Morgan, M., Jani, R., Bowe, B. (2022b) The Global View on Skills Needed for Sustainability. *PROFESS 12 North South Research Project: Report 1*

Borrego, M., Douglas, E. P. and Amelink, C. T. (2009). Quantitative, Qualitative, and Mixed Research Methods in Engineering Education. *Journal of Engineering Education* (98): 53-66. https://doi.org/10.1002/j.2168-9830.2009.tb01005.x

Colman, B. and Willmott, P. (2016) How soft are 'soft skills' in the engineering profession? In *Proceedings of the 44th Annual SEFI Conference: Engineering Education on Top of the World: Industry-University Cooperation, Tampere University, Finland, 12-15 September 2016.*

de Haan, G. (2010) The Development of ESD-Related Competencies in Supportive Institutional Frameworks. *International Review of Education* 56 (2): 315–328. https://doi.org/10.1007/s11159-010-9157-9

Kovesi, K. and Csizmadia, P. (2016) Industry perception of new engineering graduates: the gap between requirements and reality. In *Proceedings of the 44th Annual SEFI Conference: Engineering Education on Top of the World: Industry-University Cooperation, Tampere University, Finland, 12-15 September 2016.*

Male, S. A., Bush, M. B. and Chapman, E.S. (2011) An Australian study of generic competencies required by engineers. *European Journal of Engineering Education*, 36 (2): 151-163. https://doi.org/10.1080/03043797.2011.569703

Passow, H. J., and Passow, C. H. (2017) What competencies should undergraduate engineering programs emphasize? A systematic review. *Journal of Engineering Education*, 106(3): 475-526. https://doi.org/10.1002/jee.20171

Rieckmann, M. (2012) Future-oriented higher education: Which key competencies should be fostered through university teaching and learning? *Futures*, 44(2): 127-135. https://doi.org/10.1016/j.futures.2011.09.005

UNESCO. (2017) *Education for Sustainable Development Goals: Learning Objectives*. Paris, France: UNESCO

Wiek, A., Withycombe, L. and Redman, C.L. (2011) Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science* 6(2), 203–218. https://doi.org/10.1007/s11625-011-0132-6

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS

Acknowledgements

The authors would like to acknowledge the support of the HEA, DFHERIS and the Shared Island Fund for support of this project under the North South Research Programme.

We would also like to thank the academics, employers and students who contributed to the survey.

Funded by:

HEA HIGHER EDUCATION AUTHORITY
AN tÚDARÁS um ARD-OIDEACHAS