ENGINEERS IRELAND

Engineering 2020

A barometer of the profession in Ireland

A community of creative professionals delivering solutions for society

www.engineersireland.ie

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Foreword

Happy World Engineering Day for Sustainable Development!

Wednesday, 4th March 2020 is the first annual World Engineering Day for Sustainable Development, a UNESCO international day to highlight the achievements of engineers and engineering in our modern world and improve public understanding of how engineering and technology is central to modern life and sustainable development.

We are delighted that the World Engineering Day takes place during our STEPS Engineers Week, which brings the fascinating world of engineering to life in communities throughout Ireland. This week aims to inspire today's children to engineer the Ireland of tomorrow. STEPS Engineers Week is a fantastic week to showcase the profession to primary and secondary students and highlight the ways engineers in Ireland are pushing the limits of ingenuity and innovation.

Engineers Week and the World Engineering Day are opportunities to highlight how a career in engineering is accessible to all those who have an interest in the sector. There are many misconceptions about the 'type of person' who should pursue engineering and we can show people that the world of engineering is open to everyone - girls, boys, creative thinkers, curious minds, problem-solvers and leaders.

Engineering 2020 takes up these issues in an informative and engaging manner. This annual report from Engineers Ireland has become an established resource for engineers, educators, policy-makers and recruiters. This year, in addition to the latest trends in engineering, the report highlights the contribution of the profession to achieving the Sustainable Development Goals.

I would like to thank the researchers from TU Dublin and NUI Galway and all who contributed to the production of this important volume. It is our hope that this report will help to stimulate discussion on the development of the engineering profession and its impact on society and the education of future generations of engineers.

Caroline Spillane

Director General

4th March 2020

Executive Summary

Engineering 2020: A barometer of the profession in Ireland captures the latest trends in engineering employment, perspectives and education, based on surveys of more than 2,000 engineers, 1,000 statistically-representative members of the public, 150 engineering leaders and 90 engineering academics. This extensive engagement is complemented by the analysis of data collected by State agencies and collaborations with engineering educators and researchers.

Over the past year, the Irish economy continued its impressive growth (employment up 3.5%) and engineering-related sectors have been some of the strongest performers. Seven-out-of-ten engineering employers told us that their financial performance improved in 2019 and the same proportion expect improvement through 2020. Engineering organisations would like to hire more than 5,000 engineers in 2020 with demand strongest in the public/utilities/other category. These metrics, while positive, are lower than this time last year and indicate engineering leaders' ongoing concerns regarding skills shortages, housing and Brexit.

Skills shortages continue to be a major concern with 91% of engineering leaders listing this as a barrier to growing their workforce. The National Skills Bulletin again highlights the growing demand for engineering skills across R&D, construction, climate action and other sectors. Engineering organisations have been increasingly taking initiatives to overcome skills shortages, including investing in upskilling/reskilling current employees (84% of organisations), offering flexible working options (68%) and collaborating with educational institutions (68%). Over the next ten years, the in-demand engineering skills will be communication, management, digitalisation and sustainability.

The number of students taking higher level Science, Technology, Engineering and Maths (STEM) subjects is growing: by 4% at Junior Certificate and by 5% at Leaving Certificate in 2019. Combined with the 8% increase in CAO first preferences for Level 8 engineering-related programmes, this reflects very positively on the Government's STEM Education Policy Statement. However, the continuing gender gap requires greater attention and action – in Ireland and internationally. While engineering is the most commonly cited occupation for 15-year-old boys, it does not feature in the top ten for girls. Most female engineers feel that the engineering sector in Ireland has better opportunities for men than it does for women.

Almost two-thirds of Irish adults (three-quarters of 16-24 year olds) are interested in finding out about new ideas in science and engineering and their innovation priorities are health, climate change and education. Furthermore, the public (and engineers themselves) believes that engineers have an ethical responsibility to tackle climate change and biodiversity loss. These areas should be considered priorities in terms of tackling societal challenges while raising the standing of the profession. A useful framework in this regard is the UN Sustainable Development Goals, the achievement of which will require engineers to play a central role over the next ten years.

Demand for **engineering recruits** in **2020**

Indicator 1 p6

Median salary, Engineer with **1-2 years'** experience

Indicator 2 p9

Median salary, Chartered Engineer with **6-10 years'** experience

Indicator 3 p10

Engineering is a **rewarding career** choice for **young people**

Indicator 4 p12

There are **plenty** of **engineering jobs** in **Ireland today**

Indicator 5 p13

The **engineering sector** has **better opportunities** for **men** than for **women**

Indicator 6 p13

I enjoy **finding out** about **new ideas** in **science and engineering**

Indicator 7 p19

Leaving Certificate **higher level STEM** sittings

Indicator 8 p23

Leaving Certificate **higher level STEM** sittings **by girls**

Indicator 9 p26

CAO **Level 8 first preferences** for **engineering-related** courses

Indicator 10 p29

Introduction

This is the third in the series of Engineering reports, the barometer of the engineering profession in Ireland. Previous reports established baselines across engineering employment, perspectives and education which are updated and analysed in this report. Where possible, five-year and other trends are also examined based on data collected by other organisations. Before delving into this information, it is useful to consider some broader economic, social and political developments.

Climate action

The Climate Action Plan is an all-of-Government plan to tackle climate breakdown, launched the Minister for Communications, Climate Action and Environment in June 2019. The plan contains ambitious and positive opportunities for change which will improve the quality of life of citizens through increased investments and initiatives. Engineers will be to the forefront in implementing these actions in electricity, enterprise, built environment, transport, agriculture, waste and more. Meanwhile, driven by the younger generation, public appetite and pressure has continued to grow for action on climate breakdown and biodiversity loss.

Industry 4.0

'Ireland's Industry 4.0 Strategy 2020-2025: Supporting the digital transformation of the manufacturing sector and its supply chain' was launched by the Minister for Business, Enterprise and Innovation in December 2019. The Strategy sets out a vision that "by 2025 Ireland will be a competitive, innovation-driven manufacturing hub at the frontier of the fourth industrial revolution and at the forefront of Industry 4.0 development and adoption". Forming part of the Future Jobs Initiative, the Strategy recognises the role that reskilling, upskilling and lifelong learning will need to play to exploit new technologies and to deliver the Industry 4.0 transformation.

General Election 2020

The General Election was held on 8th February 2020. As the voice of the engineering profession, Engineers Ireland highlighted five priorities for the new Dáil and Government:

- Implement Project Ireland 2040 and achieve value-for money in infrastructure
- Take urgent action to make Ireland carbon neutral
- Build safe and sustainable homes and communities
- Invest in higher education and lifelong learning
- Future-proof our economy by preparing for the future of work

These priorities reflect the expertise of our members in finding practical and cost-effective solutions to many societal challenges. We look forward to working with those elected to address these priorities which will not only be of benefit today, but also to future generations.

Engineering 2020

The purpose of Engineering 2020 is to measure, analyse and learn from significant trends in the engineering profession in Ireland. The data contained herein will be useful not only for engineers, but also for those considering entering our profession, for industry, for educational institutions and for public policy.

The report is based on four bespoke surveys conducted between September 2019 and January 2020 with:

(i) 90 engineering academics,
(ii) 147 engineering industry leaders,
(iii) 2,180 engineers, and
(iv) 1,000 people statistically-representative of Irish adults.

This information is complemented by summaries of data collected by other organisations such as the Central Statistics Office, Higher Education Authority and State Examinations Commission.

The report is structured as follows: Section 2, Employment, examines financial position and outlook, recruitment and salaries; Section 3, Perspectives, outlines the opinions of the public, employers and qualified engineers on opportunities, skills and priorities; and Section 4, Education, presents data on STEM and engineering education.

A special feature of this edition of the series of reports, Section 5, covers Engineering and the Sustainable Development Goals. This section introduces the World Engineering Day for Sustainable Development, the role of engineering skills in achieving the SDGs and the ethical responsibilities of engineers. Two emerging research projects from Technological University Dublin and the National University of Ireland, Galway are also profiled. The concluding section of the report summarises key trends and lessons for the engineering profession in Ireland.

Engineering Employment

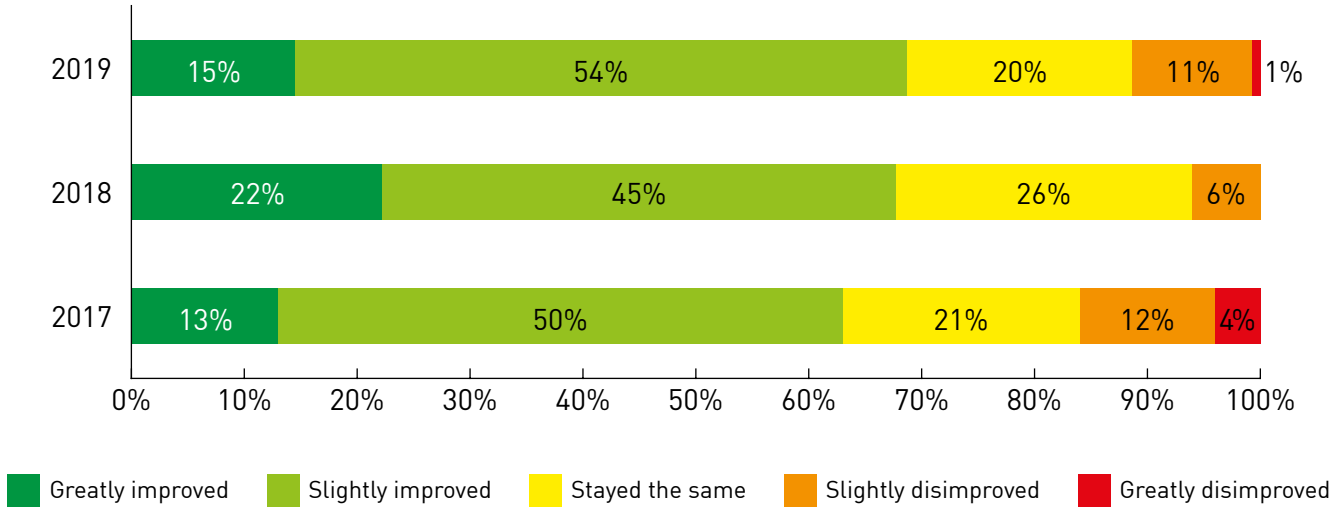
Ireland's economy grew at a strong pace through 2019. According to the Central Statistics Office (CSO), there was an annual increase in employment of 3.5% or 79,900 in 2019, bringing total employment to 2,361,200. As covered in previous Engineering reports and elaborated in the following pages, the engineering sector has been growing even more rapidly. This section of the report presents data on changes in engineering employment in the past year and prospects for the remainder of 2020.

Looking back on 2019

In October 2019, Engineers Ireland engaged with engineering industry leaders to learn about employment conditions, financial performance and recruitment trends. We surveyed a representative sample of engineering organisations across consulting engineering, construction, manufacturing and other industries such as the public sector and utilities. The respondents included 147 engineering leaders with a total of 64,494 employees in the Republic of Ireland. Take a look at Appendix 1 for the survey method and sample.

Engineering employers in Ireland had a good year in 2019. 69% of them told us that their financial position greatly improved or slightly improved during those 12 months when compared to 2018. Meanwhile, 11% felt that their position has disimproved (Figure 1). These results are similar to 2018 performance, but not quite as strong. Meanwhile, four out of five engineering employers recruited engineers in 2019.

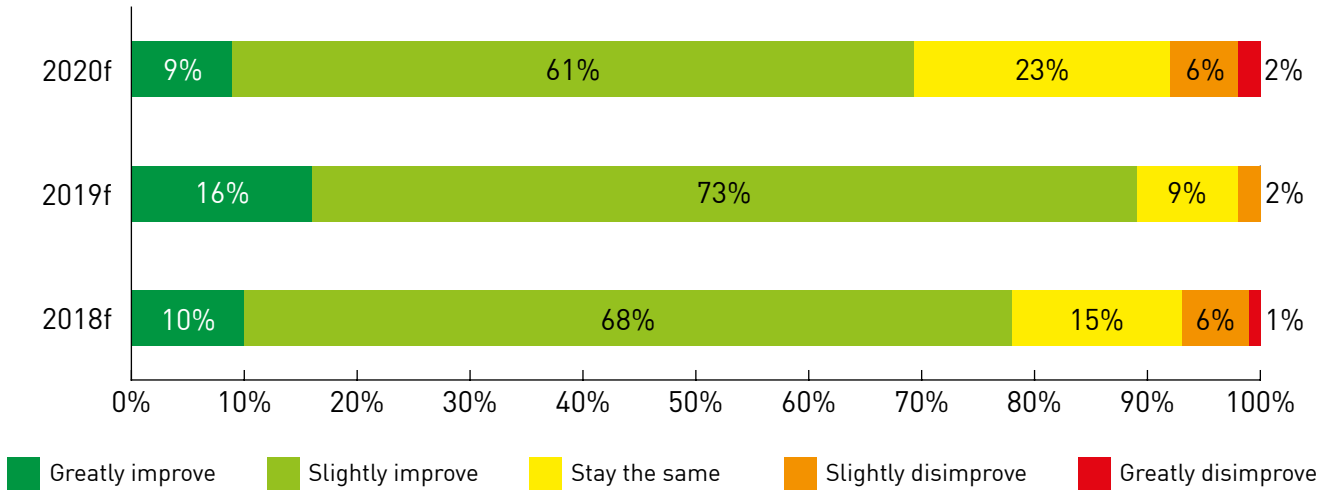
Figure 1 *Reported change in financial position*



Outlook for 2020

Turning to the year ahead, 70% of engineering employers told us that they expect their financial position to greatly improve or slightly improve in 2020 (Figure 2). This represents a 19-point decrease compared to this time last year and indicates that while the sector is growing, engineering employers are not quite as confident as they were for 2019.

Figure 2 *Expected change in financial position*



The engineering employers also told us about their recruitment plans for 2020. By extrapolating these results to the full engineering labour force (weighting by industry), we estimated recruitment trends for the broader engineering sector (see Appendix for method note). This research revealed there is strong demand for engineers right across the economy. More than 5,000 job openings for engineers will be created in 2020 (Table 1).

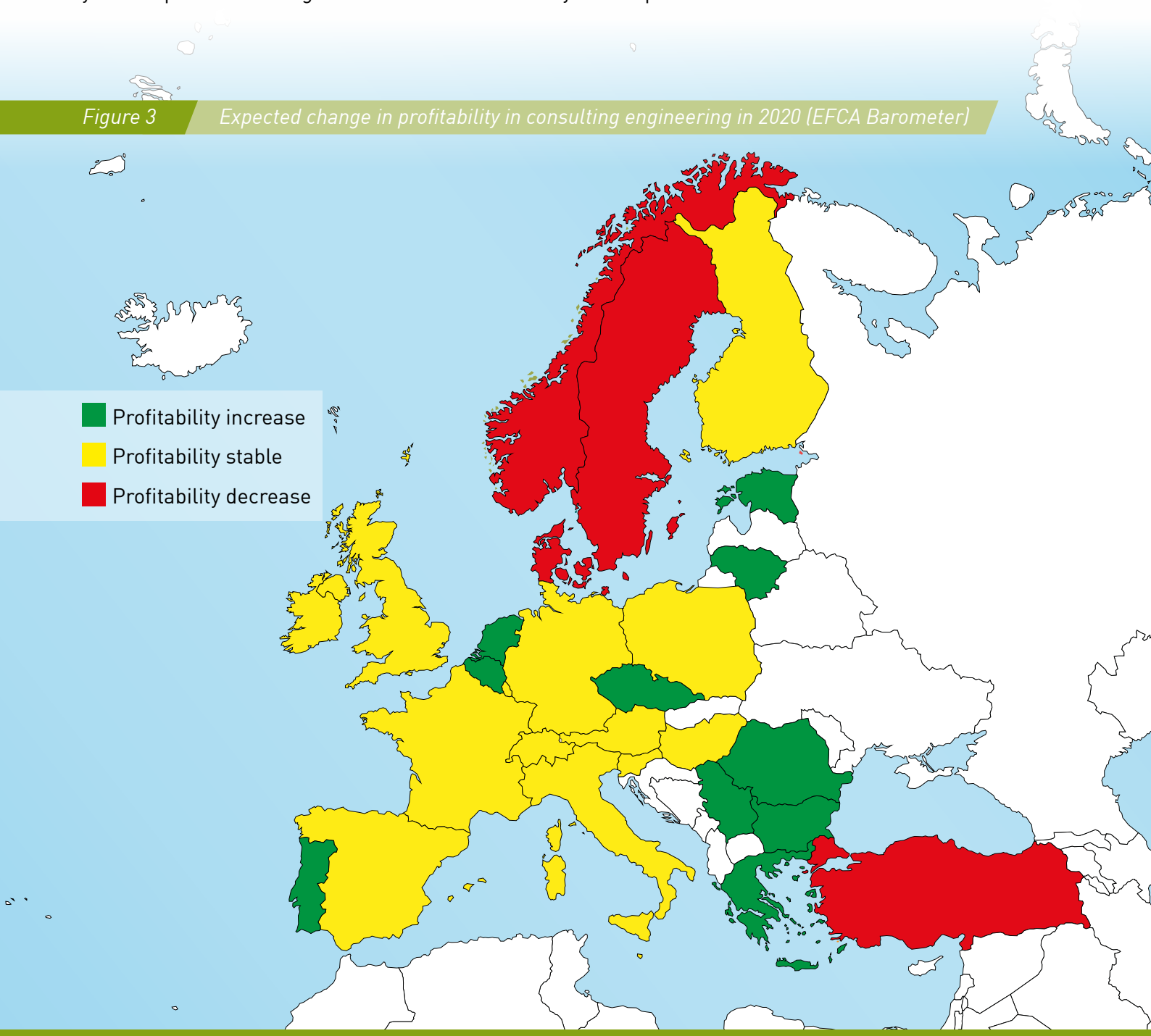
Table 1 *Demand for engineers in 2020 by experience and industry*

	5+ years	3-5 years	0-2 years	All
Construction	510	350	414	1,274
Consultancy	347	329	323	998
Manufacturing	421	403	549	1,373
Other	569	410	528	1,507
All industries	**1,847**	**1,492**	**1,814**	**5,152**

5,152 Demand for engineering recruits in 2020

Demand is strongest in the 'other' category of companies, which includes the public sector, utilities and ICT. Of the four sectors analysed, consulting engineering companies plan to hire the fewest engineers. The European Federation of Engineering Consultancy Associations (EFCA) expects the profitability of Irish consulting engineering to remain stable in 2020 (Figure 3). The demand for engineers is spread across experience levels with employers looking to hire almost as many engineers with less than two years' experience as engineers with more than five years' experience.

Figure 3 *Expected change in profitability in consulting engineering in 2020 (EFCA Barometer)*



Skills shortages indicators

Published in November, the National Skills Bulletin 2019 is a report by SOLAS on behalf of the National Skills Council. The Bulletin presents a set of skills shortage indicators, which informs Government policy in areas such as employment and education. Its method is based on a comparison of estimated demand and supply for 95 occupation groups, which receive a shortage indicator of green, amber or red – see Table 2 for the description of each colour.

Table 2 *Skills shortage indicators (National Skills Bulletin)*

Shortage indicator	Description
🟢	There are no shortages
🟡	There is no overall current shortage, but some issues (e.g. geographical mobility, high turnover), or potential future shortages, have been identified.
🔴	There is an insufficient number of individuals who had the required level of educational attainment, skills set and/or experience to meet the required labour market demand and/or where there is an insufficient number of individuals available to take up employment opportunities in a particular occupation.

The Bulletin identifies shortages in almost all engineering occupations, indicated by red dots in Table 3. The Bulletin specifically highlights shortages in the following engineering occupations: electrical, chemical, automation, validation, mechanical / manufacturing, process, quality control, design, and civil. There are also shortages in related fields such as technicians and construction project managers. The Bulletin states:

> While the supply of graduates in science and engineering has, in the main, increased over the last number of years, these people are sought after across a variety of other sectors (e.g. education, finance, public administration). [...] The strong presence of research, development and innovation (RDI) activities in Ireland means that these skills are also required for R&D project manager roles. [...] Future demand for skills will depend on a number of factors including the roll out of the Climate Action Plan and increased activity in both the residential and commercial sectors.

The results and commentary presented in the Bulletin echo Engineers Ireland's research and engagements (see Section 3 of this report and previous Engineering reports), which have continuously pointed to skills shortages across the sector in recent years. Employment has been growing strongly (annualised growth rate of approximately 11%) and engineering organisations and recruitment agencies are finding it difficult to fill vacancies.

Table 3 *Skills shortages indicators as presented in the National Skills Bulletin 2019*

Occupation	Commentary	Number employed	Growth rate[1]	Difficult to fill[2]	Permits issued[3]	Shortage indicator
Civil engineers & construction project managers Includes - Civil engineers - Construction project managers	Employment growth was strong in this occupation. Shortages are emerging although the numbers required are likely to be small. With declining output from the education and training system, the number of graduates is not expected to be enough to meet growing demand. These shortages could therefore be exacerbated in future years.	17,100	10.6%	✓	26	●
Production, design & QC engineers Includes - Process - Quality control - Design	Job vacancies in this category appear frequently and have been noted as difficult to fill. Demand is mostly for roles requiring sector-specific experience (e.g. medium-high, high-tech and food/beverage manufacturing), although this is likely to be small in number given the number of people employed.	12,600	4.4%	✓	312	●
Other engineering professionals Includes - Electrical - Chemical - Automation - Validation - Mechanical / manufacturing - EHS	Employment growth in this occupational group was above average. Vacancies in these occupations are frequently cited as difficult to fill although the demand is likely to be small in number given the size of the employment stock. While the supply from the education system appears to be growing, demand is mostly for roles requiring sector-specific experience (e.g. medium-high, high-tech and food/beverage manufacturing).	18,700	16.6%	✓	282	●

[1] Employment growth: Annualised rate of employment growth for the period 2014-2018.

[2] Difficult to fill: Results of the SLMRU (SOLAS) Recruitment Agency Survey conducted in April 2019. The occupations with mentions of difficult-to-fill vacancies reported by recruitment agencies are indicated by a tick.

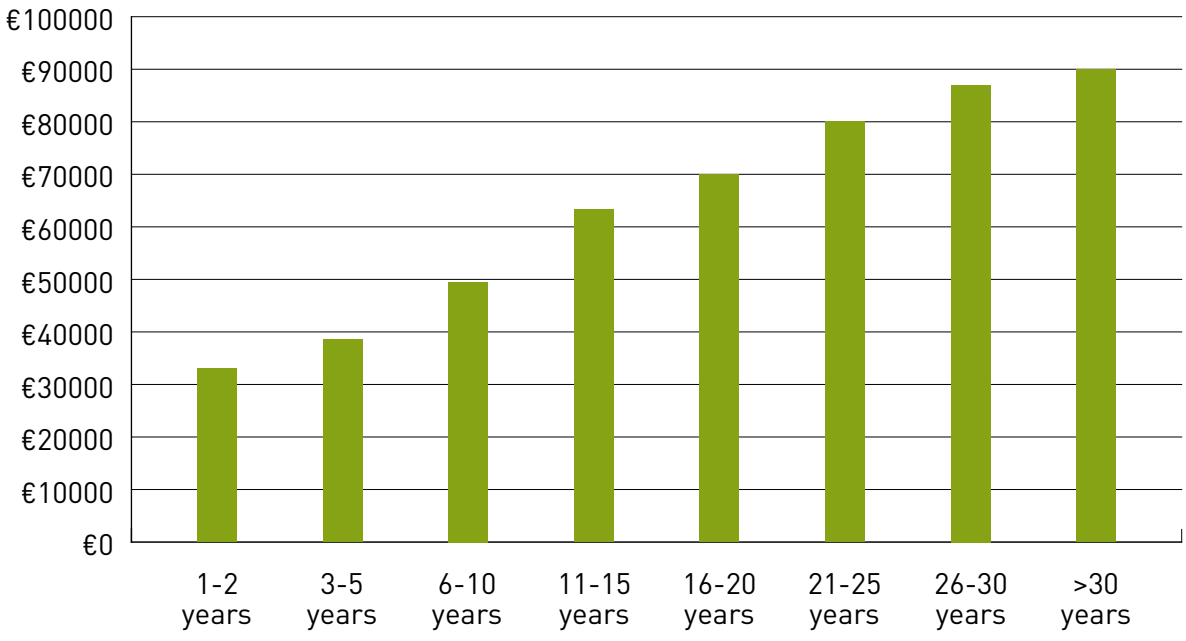
[3] Employment permits: Issued to non-EEA nationals in 2018. This is an indicator of the demand for skills that could not be met from domestic or EEA sources.

Salaries

In January 2020, we asked the Engineers Ireland membership about the levels of remuneration and benefits in the profession. There were 1,692 responses (after data cleaning) and the survey method and characteristics of the sample are provided in the Appendix. The last Engineers Ireland Salary Survey was conducted using a similar approach during the same period in 2019. The data which follow are median salaries.

NOTE | The median is the number in the middle when a list of numbers is sorted from lowest to highest. Half of all engineers earn more than the median salary; half of all engineers earn less than the median salary.

Figure 4 *Median salary by years of experience*



A graduate engineer can expect to earn €33,000, rising to approximately €50,000 with 6-10 years of experience (Table 4). Remuneration levels rise more-or-less consistently with experience and most engineers with more than 30 years of experience can expect to earn more than €90,000 (Figure 4). A large majority of engineers reported receiving a pay increase in the past year, typically more than 2.5%. Almost half of engineers with between three and ten years of experience increased their annual salary by more than 5% last year.

€33,000 Median salary, Engineer with 1-2 years' experience

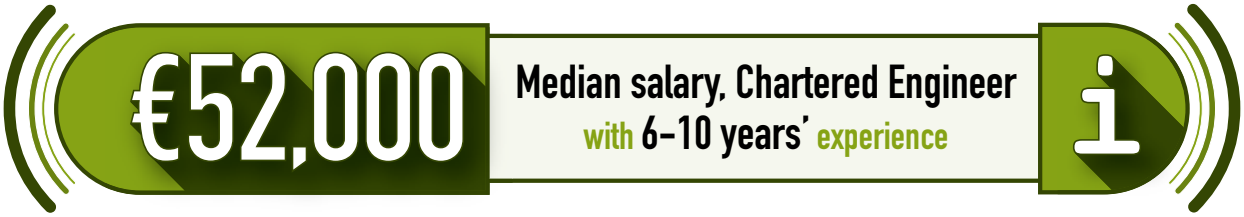
Table 4 *Median salary by years of experience and change since 2014*

Experience	2020	Change since 2019	Change since 2014
1-2 years	€33,000	-2%	+18%
3-5 years	€38,500	-1%	+17%
6-10 years	€49,500	+3%	+15%
11-15 years	€63,250	+5%	+9%
16-20 years	€70,000	-1%	+11%
21-25 years	€80,000	+7%	+10%
26-30 years	€87,000	+2%	+12%
>30 years	€90,000	+1%	+11%

Engineers Ireland awards professional titles such as 'Chartered Engineer' and 'Fellow', recognising the career progression, ethical standards and achievements of our members. The value of these professional titles is recognised through increased remuneration. A Chartered Engineer can expect to earn €5,000 per year more than an untitled engineer with the same number of years of experience (Table 5). It takes more than 20 years of experience before this salary gap closes. At this point, Chartered Engineers who become Fellows of Engineers Ireland can expect to earn an additional €15,000-€20,000 per year.

Table 5 *Median salary by years of experience and professional title*

Experience	Fellow (FIEI)	Chartered Engineer (CEng)	Member (MIEI)
1-2 years	-	-	€33,000
3-5 years	-	-	€38,500
6-10 years	-	€52,000	€48,000
11-15 years	-	€65,000	€60,500
16-20 years	€85,000	€73,000	€68,000
21-25 years	€91,000	€80,000	€80,000
26-30 years	€106,000	€87,000	€85,000
>30 years	€101,000	€82,500	€95,000



NOTE

The Engineers Ireland Salary Survey 2020 report is an exclusive Engineers Ireland member benefit, available to download from the members' area of **www.engineersireland.ie**. This report includes detailed analysis of salaries and other benefits (pensions, bonuses etc.) according to engineering discipline, sector, position and much more.

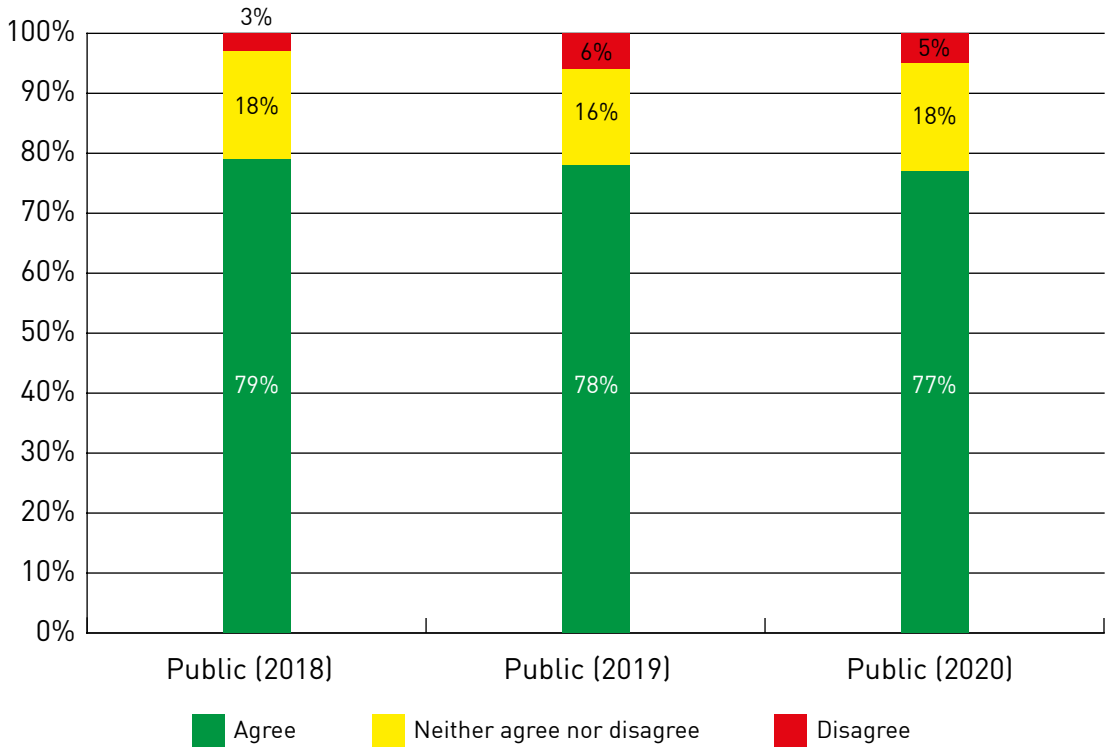
Engineering Perspectives

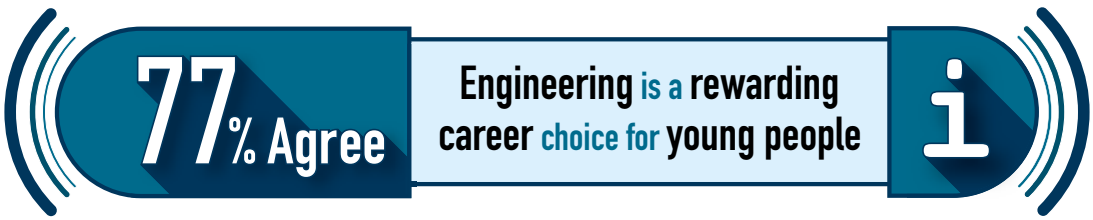
In January 2020, Engineers Ireland commissioned Behaviour & Attitudes to undertake a face-to-face poll with 1,000 members of the public and representative of the Irish population aged 16 years old and over. The poll used the same methodology as in 2018 and 2019, which enables direct comparisons (see Appendix for methodological information). The following section of the report analyses the public's perspectives on aspects of the engineering profession. For some indicators, these perspectives are compared with those of engineers, their employers and academics.

Engineering as a career

Each year, we monitor the general public's perspectives on engineering as a career. When asked whether engineering is a rewarding career choice for young people, the vast majority (77%) agreed – see Figure 5. This level of agreement has remained relatively constant over the past three polls. The proportion of the public who believe that engineering is a rewarding career choice for young people is also relatively consistent across demographics such as gender, area (urban/rural) and social class. When asked the same question, 78% of engineers agreed that the profession is a rewarding choice for young people.

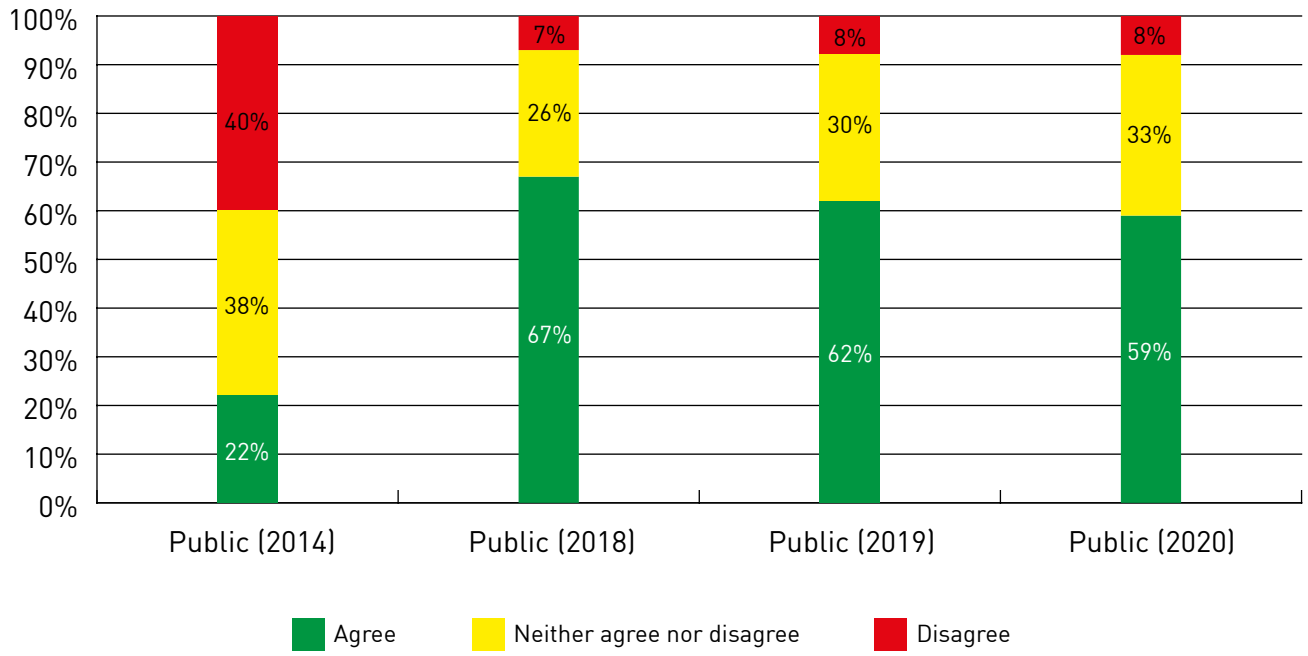
Figure 5 *Engineering is a rewarding career choice for young people*





Members of the public also believe that there are plenty of job opportunities in the engineering sector in Ireland (59% agree), shown in Figure 6. This is a substantial improvement on a similar poll conducted by Engineers Ireland in 2014 when only 22% adults thought that there were plenty of job opportunities. This said, there has been a decrease of eight percentage points in this metric over the past two years, from 67% in 2018 to 59% in 2019. Meanwhile, 78% of engineers agreed that there are plenty of jobs in the sector.

Figure 6 *There are plenty of job opportunities in engineering in Ireland*



The public believes that the engineering sector currently has better opportunities for men than it does for women. There was no significant difference between the opinions of men (58% agree) and women (56% agree) who responded to the public survey. A similar proportion of female engineers (61%) agree, however, male engineers are split on the issue: 32% agreed that there are better opportunities for men, 32% disagreed and 37% neither agreed nor disagreed. Since 2018, when the same question was asked, there has been a 6-8 percentage point reduction in the level of agreement by members of the public, however, the perspectives of male and female engineers have not substantially changed.

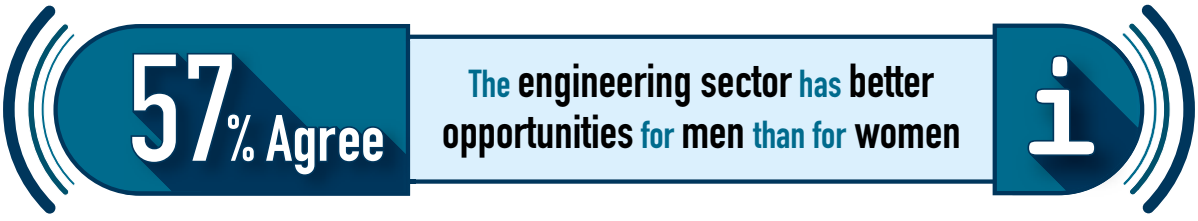
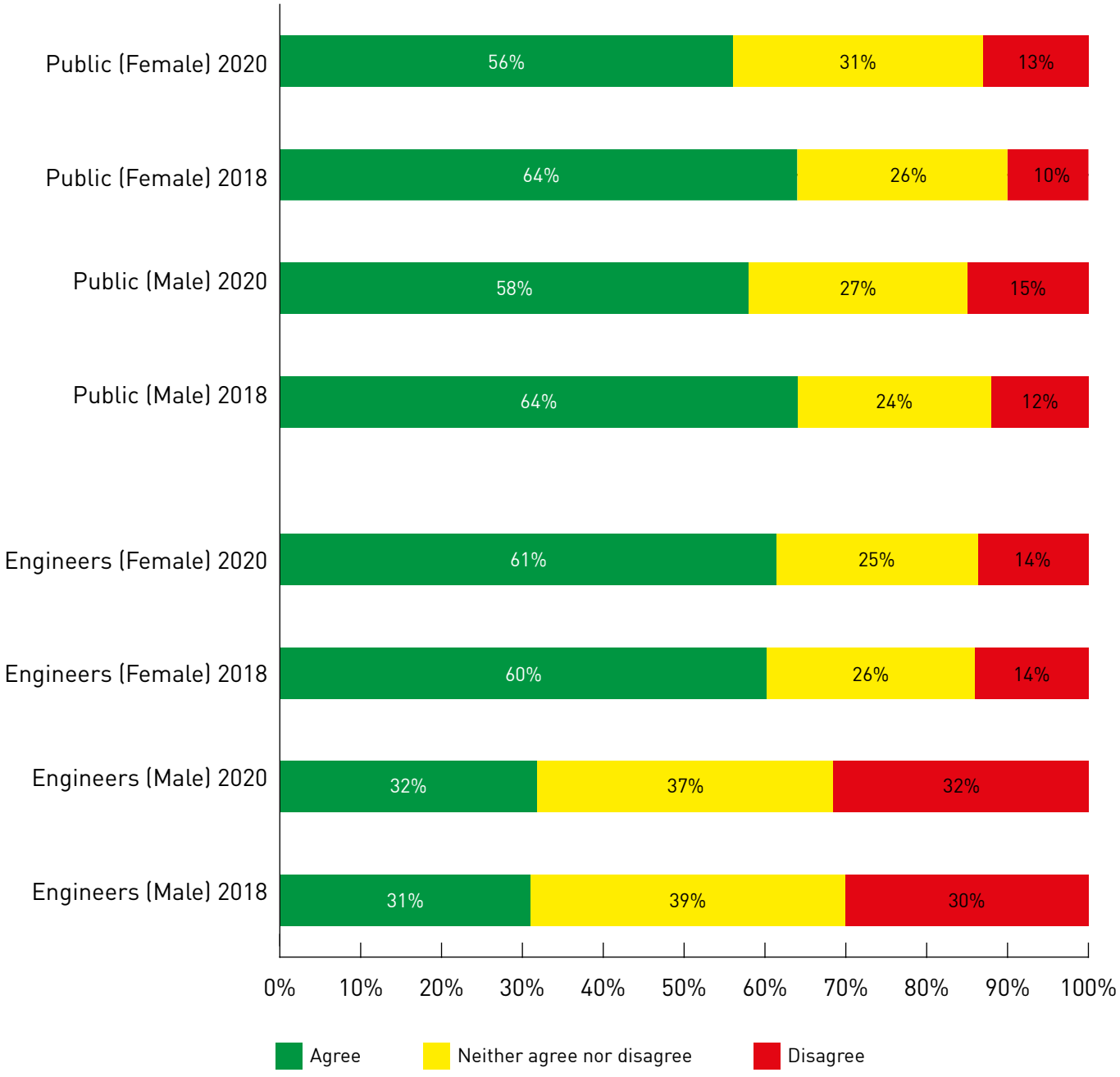


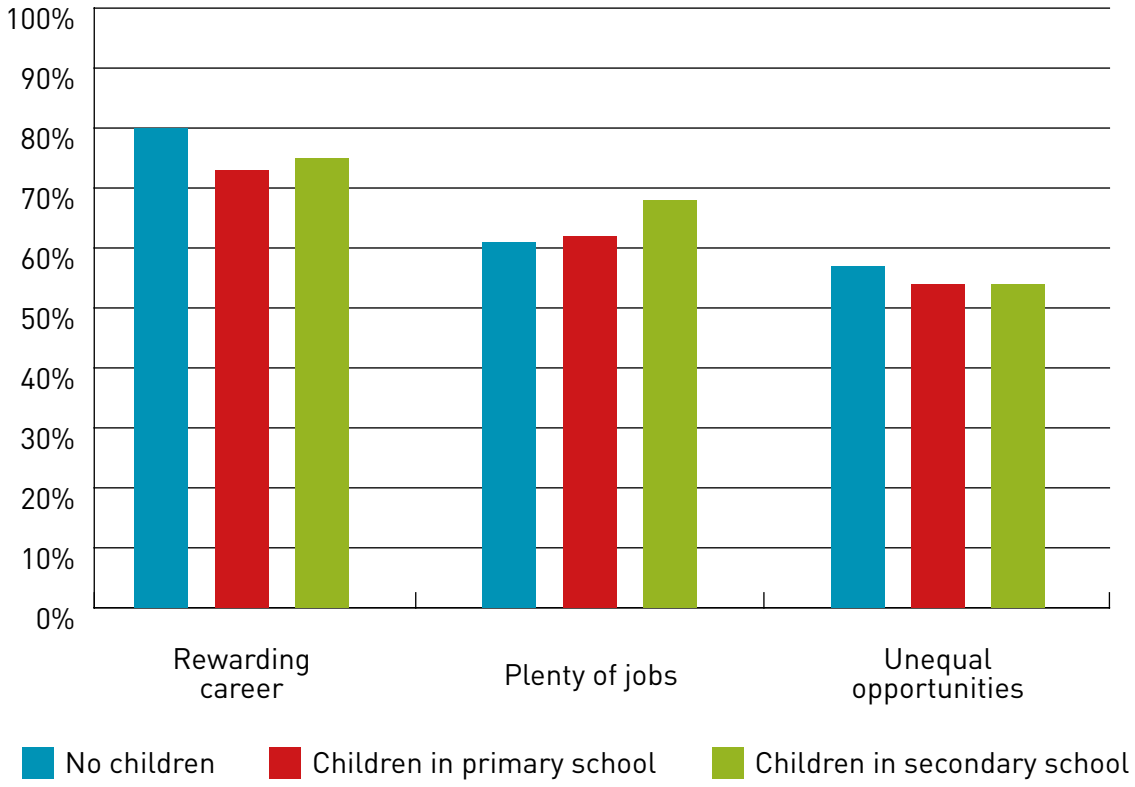
Figure 7 *The engineering sector has better opportunities for men than it does for women*



Research by Science Foundation Ireland, Accenture, Microsoft and many others has found that parents have a hugely important role in encouraging their children to study STEM subjects. We are therefore very interested in understanding and working with parents' attitudes to engineering. Segregating the results of our public poll by lifestage, it was possible to compare the responses of three cohorts (Table 6): single people with no children; people with children in primary school; and people with children in secondary school.

Table 6 *Views on engineering as a career (% agreeing with each statement)*

	No children	Children in primary school	Children in secondary school
Engineering is a rewarding career choice for young people	80%	73%	75%
There are plenty of job opportunities in the engineering sector in Ireland	61%	62%	68%
The engineering sector has better opportunities for men than for women	57%	54%	54%

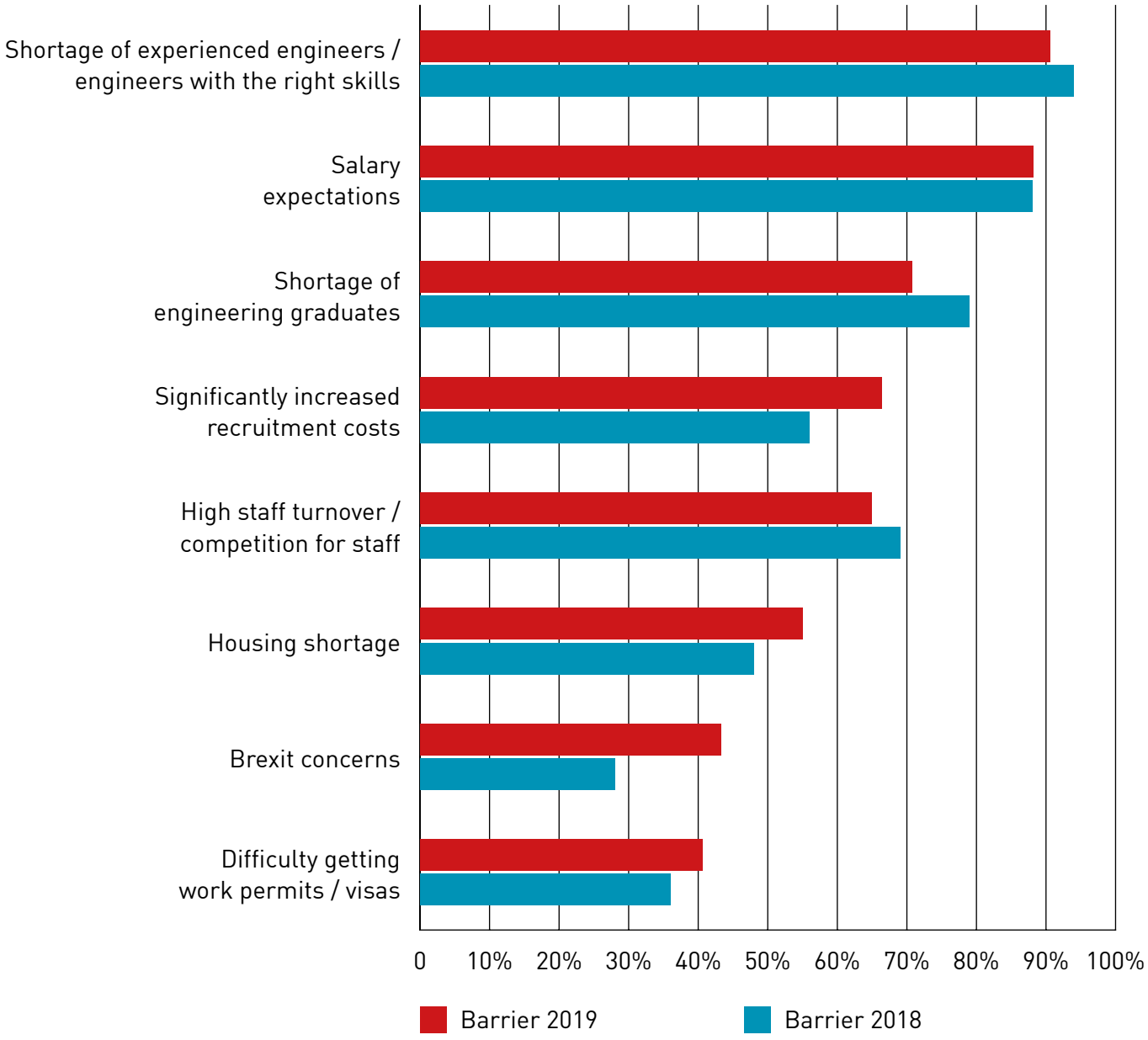


It is very positive that large majorities in all three cohorts believe that engineering is a rewarding career for young people. Similarly, most of these members of the public agree that there are plenty of job opportunities in engineering, more than two-thirds (68%) of parents of secondary school children support this statement. However, most parents of primary school and secondary school children also believe that there are better opportunities for in the sector for men than for women.

Recruitment and skills

In our survey of engineering leaders, we asked about barriers to recruitment over the past two years (2018 and 2019). The leaders' biggest barrier to growth remains a shortage of experienced engineers / engineers with the right skills. 91% of them told us that this is a barrier (69% said that it is a major barrier), a marginal reduction on the previous year (Figure 8). This shortage is related to the shortage of engineering graduates and the competition for staff, which were ranked as the third and fourth largest barriers. Recruitment costs, housing shortage and Brexit concerns all grew as barriers to recruitment over the past 12 months.

Figure 8 *Engineering employers' barriers to recruitment*



We also asked the engineering leaders and a sample of engineering academics the question: 'Over the next 10 years, what skills will engineers need to develop?'. This was an open-ended question and there was a very broad range of responses which could be summarised under 'transversal skills' and 'technical skills':

Transversal skills, particularly communication and management, e.g.

- Communication: verbal and written, technical and non-technical, teamwork
- Management: project management, people skills, commercial awareness

Technical skills, particularly digitalisation and sustainability, e.g.

- Digitalisation: BIM, data management and analytics, programming, AR/VR, AI, IoT
- Sustainability: environmental impact, energy-efficiency, green construction, renewable energy

The following are some illustrative responses:

"The ability to continue to innovate, communicate and build rapport within project teams is a vital component in being able to deliver solutions. These coupled with technical excellence are the engineering skills necessary now and into the future." – Industry, Public sector

"EQ, Empathy, communication and essentially more people skills to complement technical skills." – Industry, Consultancy

"Multitask, diversify, presentation skills, better communication skills, accountancy/ finance skills - cost management, innovative - engineering excellence, work in teams, coaching for performance - ability to mentor, patience, respect for others, understand the life-cycle of projects" – Industry, Other

"Engineers should be adaptable, they should be able to use the latest software tools etc., but not at the expense of understanding the basic principles." – Lecturer, Civil

"Industry 4.0 skills, most notably IT architecture and connectivity to wireless devices. Also data analytics and data management skills." – Industry, Manufacturing

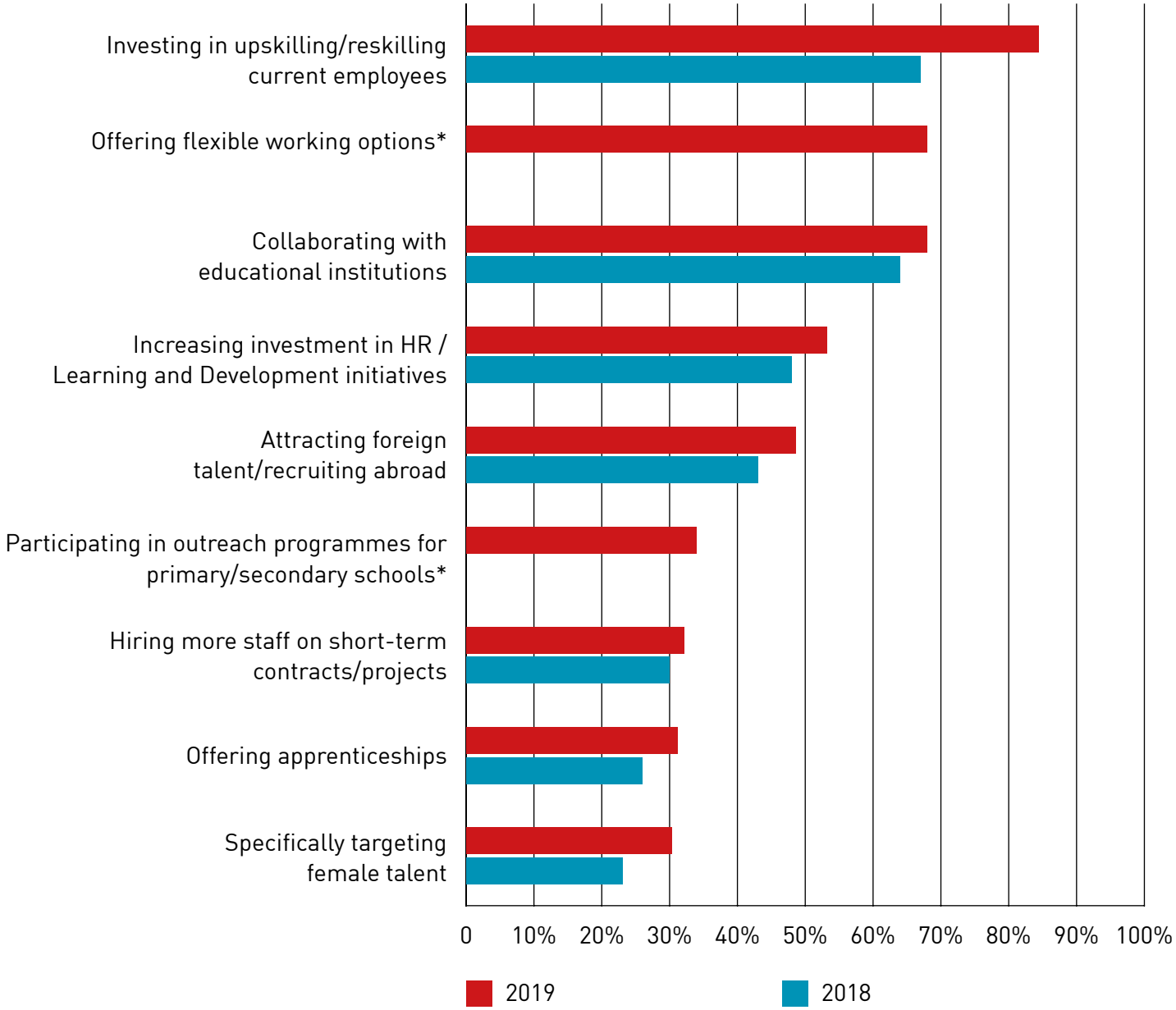
"Ability to apply new and emerging technologies to solve problems. Application of sustainable practices and solutions to engineering problems. More diverse approach to problem solving. Working with diverse teams to come up with innovative solutions." – Industry, Consultancy

"Critical thinking in relation to energy and material utilization. Capacity to scope out [comprehensively specify/define] problems to appropriately account for issues such as recycleability, environment impact, health & safety, not over-designing etc." – Lecturer, Mechanical

"An appreciation of the environmental, social and financial implications of their decisions in a wider global context." – Industry, Other

In recent years, to ensure they have the skills and expertise to undertake future projects, engineering organisations have been increasingly taking initiatives to overcome skills shortages (Figure 9). This includes investing in upskilling/reskilling current employees (84%), offering flexible working options (68%) and collaborating with educational institutions (68%). Interestingly, almost half of the engineering organisations surveyed are targeting foreign talent / recruiting abroad, however, only 30% of companies are offering apprenticeships or specifically targeting female engineering talent.

Figure 9 *Initiatives taken by employers to overcome skills shortages*

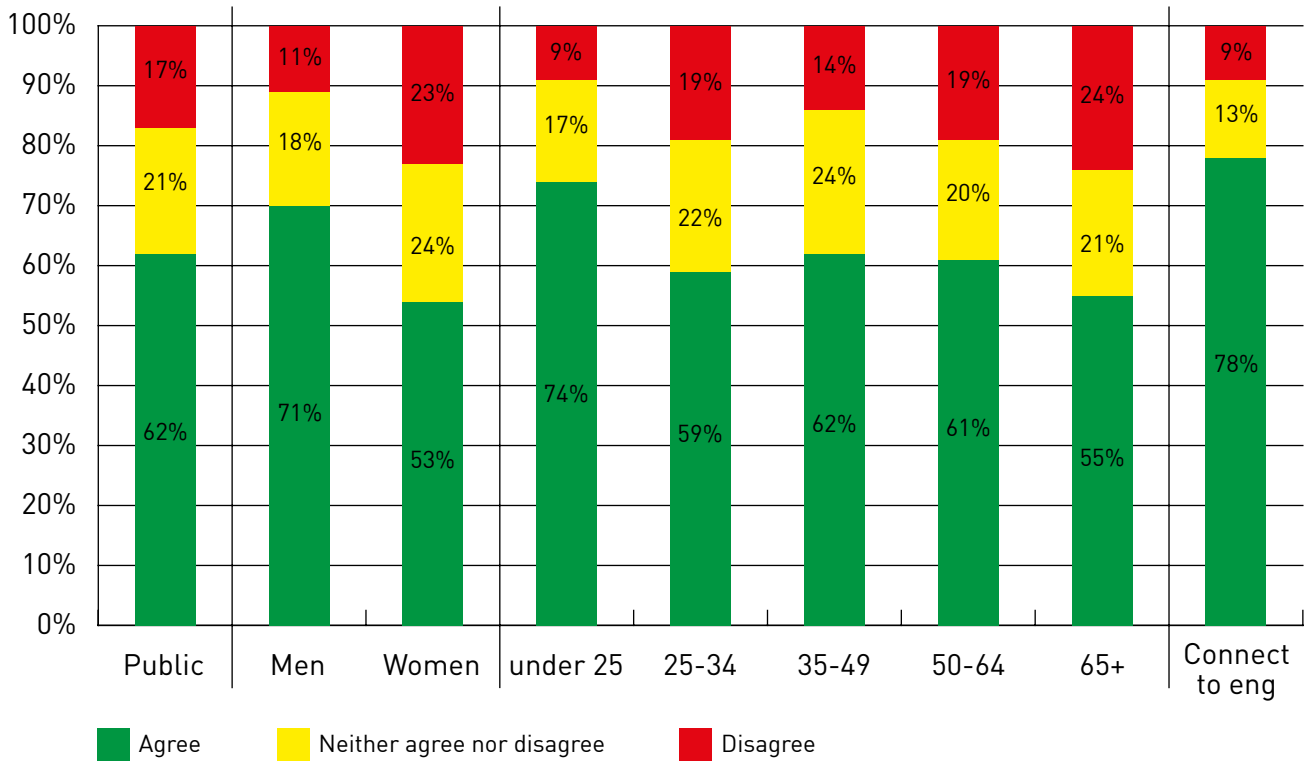


*These options were only included in the 2019 survey

Engagement and innovation priorities

In the public poll, we asked Irish adults whether they agree with the statement: 'I enjoy finding out about new ideas in science and engineering'. Overall, 62% agreed, 17% disagreed and 21% said neither (Figure 10). This level of agreement is a six-percentage-point reduction compared to a similar poll conducted by Science Foundation Ireland (SFI) in 2015. According to Figure 10, men and young people (under 25 years old) are substantially more interested in science and engineering innovation as are those with some connection to engineering, such as working in / studying engineering or having a family member working in / studying engineering.

Figure 10 *I enjoy finding out about new ideas in science and engineering*



We also asked the public: 'Over the next 15 years, what should be the priorities when it comes to science, engineering and technological innovation?'. A list of ten options were presented and respondents asked whether they believe each one to be a priority for innovation or not a priority. The ten options were derived from a similar survey conducted by SFI in 2015 which asked: 'Over the next 15 years, what impact do you think science, engineering and technological innovation will have on the following areas?' (positive impact, no impact, or negative impact).

Table 8 shows the top science, engineering and technological innovation priorities for the public are health, climate change and education. Health was a particularly high priority for older people, while climate change was a particularly high priority for younger people. In general, all ten areas were considered to be important for innovation and there were marginal differences between the priorities of various demographics. The SFI study found that "there are few areas where STEM is perceived to potentially have a negative impact into the future". The public expects science, engineering and technological innovation to have the most positive impacts on health and education.

Table 8 *Public priorities for science, engineering and technological innovation*

	Priority*	Priority highest among	Positive impact**
Health and medical care	95%	Over 65yo (98%), empty nesters (97%), C2DE (96%)	78%
Fight against climate change	90%	Young family (93%), under 25yo (92%), ABC1 (92%)	64%
Education and skills	90%	Conn/Ulster (95%), young family (93%), C2DE (92%)	78%
Quality of housing	89%	Rural (94%), 50-64yo (92%), young couples (92%)	59%
Job creation	89%	Conn/Ulster (95%), under 25yo (93%), farmers (92%)	71%
Energy supply	87%	Conn/Ulster (96%), over 65yo (90%), farmers (89%)	73%
Protection of personal data	85%	Young family (89%), Munster (88%), under 25yo (87%)	56%
Transport and transport infrastructure	84%	Conn/Ulster (96%), farmers (91%), 50-64yo (89%),	63%
Availability and quality of food	84%	Rural (89%), young couples (89%), farmers (87%)	66%
Adaptation of society to an ageing population	81%	Conn/Ulster (90%), empty nesters (87%), rural (85%)	57%

*Engineers Ireland poll: percentage of respondents who think that each area should be a priority for science, engineering and technological innovation

**SFI poll: percentage of respondents who think that science, engineering and technological innovation will have a positive impact on each area

Engineering Education

Junior Certificate

Engineers Ireland, through our STEPS Programme, promotes interest and awareness in engineering as a future career to school students through a portfolio of projects. For the purposes of this report, our analysis of engineering education begins at the Junior Certificate level. Data on the number of students sitting exams in each Junior Certificate subject are provided by the State Examinations Commission (SEC). In the past five years, the total number of STEM sittings at higher level (excluding science) has increased by 14% (Table 9), while the overall increase in Junior Certificate students was 6.6%. There has been particularly strong growth in the number of students taking higher level mathematics, an increase of more than 5,000 students since 2014. In 2019, a new junior cycle science paper was introduced and is examined at common level; this paper was taken by 59,543 students.

Table 9 *Number of students sitting higher level STEM subjects for the Junior Certificate*

Subject	2014	2015	2016	2017	2018	2019	Year-on-year	5 year trend
Science	42,821	42,658	43,898	45,708	46,423	-	-	-
Mathematics	32,041	32,535	32,830	34,822	35,443	37,433	+6%	+17%
Material Technology	13,487	13,271	13,636	14,142	14,634	14,694	n/c	+9%
Technical Graphics	8,953	8,655	8,684	8,912	9,447	9,816	+4%	+10%
Metalwork	6,373	6,409	6,257	6,229	6,447	6,438	n/c	+1%
Technology	2,830	2,852	3,154	3,163	3,573	3,913	+10%	+38%
Total STEM sittings	**106,505**	**106,380**	**108,459**	**112,976**	**115,967**	**-**	**-**	**-**
Excluding Science	**63,684**	**63,722**	**64,561**	**67,268**	**69,544**	**72,294**	**+4%**	**+14%**

Table 10 *Number of students sitting ordinary level STEM subjects for the Junior Certificate*

Subject	2014	2015	2016	2017	2018	2019	Year-on-year	5 year trend
Mathematics	24,047	22,856	23,781	23,570	23,833	23,428	-2%	-3%
Science	11,936	11,632	11,573	11,499	11,785	-		
Technical Graphics	3,396	3,046	3,247	3,500	3,599	3,849	+7%	+13%
Material Technology	2,977	2,874	2,745	2,941	2,833	3,192	+13%	+7%
Metalwork	1,507	1,575	1,630	1,590	1,588	1,559	-2%	+3%
Technology	393	406	422	413	497	662	+33%	+68%
Total STEM sittings	**44,256**	**42,389**	**43,398**	**43,513**	**44,135**	**-**	**-**	-
Excluding science	**32,320**	**30,757**	**31,825**	**32,014**	**32,350**	**32,690**	**1%**	**1%**

Leaving Certificate

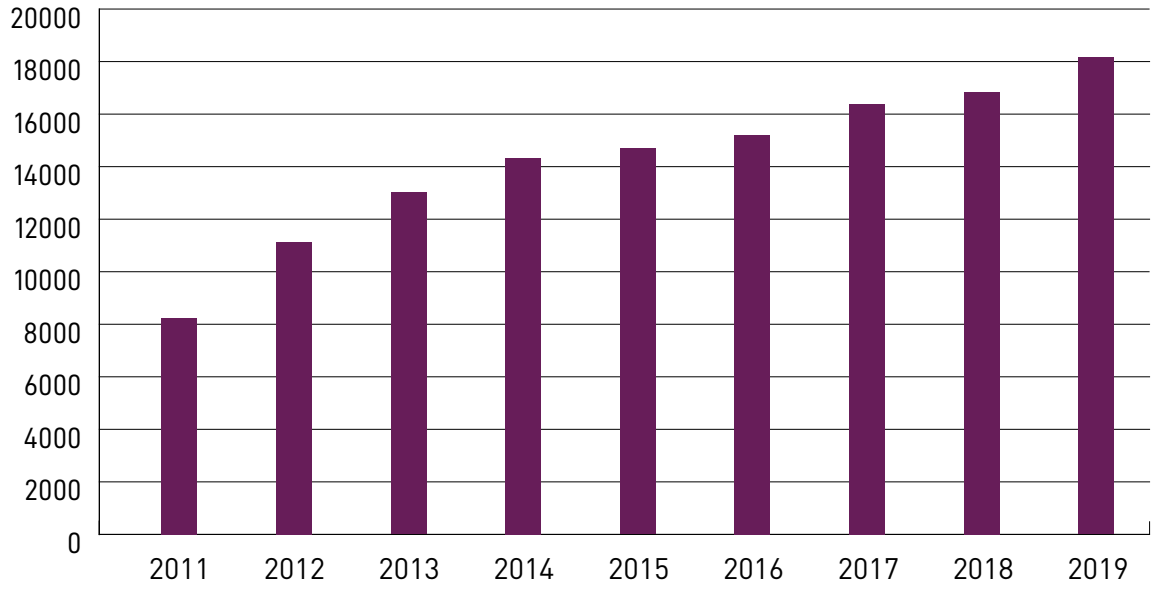
Turning to the Leaving Certificate, data again obtained from the SEC, show that the number of students sitting exams in STEM subjects increased by 5% (Table 11), while the overall number of students sitting the Leaving Certificate increased by 3%. Compared to 2018, there were strong increases in the number of students taking higher level subjects related to engineering and construction, including mathematics (+1316), construction studies (+791), physics (+325) and technology (+255). As the number of students studying STEM subjects at higher level in recent years increased, there were corresponding decreases at ordinary level (Table 12).

Table 11 *Number of students sitting higher level STEM subjects for the Leaving Certificate*

Subject	2014	2015	2016	2017	2018	2019	Year-on-year	5 year trend
Biology	24,442	25,595	25,211	26,684	26,543	27,063	+2%	+11%
Mathematics	14,326	14,691	15,198	16,395	16,837	18,153	+8%	+27%
Chemistry	7,226	7,533	7,658	8,162	7,943	8,244	+4%	+14%
Construction Studies	6,847	6,877	7,087	7,451	7,105	7,896	+11%	+15%
Agricultural Science	6,329	6,067	6,269	6,376	6,543	6,605	+1%	+4%
Physics	5,399	5,764	6,003	6,271	6,258	6,583	+5%	+22%
Engineering*	4,172	4,408	4,489	4,586	4,668	4,765	+2%	+14%
Design & Communication	4,097	4,192	4,350	4,445	4,480	4,566	+2%	+11%
Applied Mathematics	1,569	1,729	1,917	1,869	1,826	1,988	+9%	+27%
Technology	983	1,168	1,244	1,367	1,430	1,685	+18%	+71%
Physics & Chemistry	361	437	439	481	415	464	+12%	+29%
Total STEM sittings	**75,751**	**78,461**	**79,865**	**84,087**	**84,048**	**88,012**	**+5%**	**+16%**

NOTE | The Leaving Certificate subject 'engineering' is the study of a range of mechanical engineering materials, processes and technological applications. It is not a requirement for entry to engineering at third level, which is much broader in scope.

Figure 11 *Number of students sitting higher level mathematics for the Leaving Certificate*



The take-up of higher level maths continues to go from strength to strength; the number of students taking this paper has increased to 18,153, an increase of 8% on 2018 and more than double (120%) since 2011 (Figure 11). Today, one-third of mathematics students take the subject at higher level, up from 18% in 2011.

Table 12 *Number of students sitting ordinary level STEM subjects for the Leaving Certificate*

Subject	2014	2015	2016	2017	2018	2019	Year-on-year	5 year trend
Mathematics	32,428	33,266	32,549	32,334	31,336	31,474	n/c	-3%
Biology	8,514	8,269	8,890	7,608	7,006	7,046	+1%	-17%
Physics	1,778	1,744	1,750	1,314	1,277	1,359	+6%	-24%
Chemistry	1,378	1,405	1,431	1,306	1,224	1,262	+3%	-8%
Construction Studies	1,562	1,392	1,466	1,299	1,143	1,114	-3%	-29%
Agricultural Science	1,597	1,605	1,624	1,284	1,237	1,140	-8%	-29%
Design & Communication	1,257	1,170	1,173	1,130	913	1,025	+12%	-18%
Engineering	1,031	968	890	689	586	650	+11%	-37%
Technology	119	160	171	160	104	176	+69%	+48%
Physics & Chemistry	105	115	140	110	103	74	-28%	-30%
Applied Mathematics	137	190	172	100	128	116	-9%	-15%
Total STEM sittings	**49,906**	**50,284**	**50,256**	**47,334**	**45,057**	**45,436**	**+1%**	**-9%**

Diversity

Bridging the gender gap must be a key driver in engineering and wider STEM education. In this light, it is very positive to note that girls comprise the majority of students who sit Junior Certificate higher level papers in both science and mathematics (51%). Overall, at Junior Certificate level, 35% higher level STEM subject sittings (excluding science) are by female students, an increase of four percentage points in the past five years (Table 13).

Table 13 *Gender gap in Junior Certificate and Leaving Certificate higher level STEM sittings in 2019*

Junior Certificate	**%Girls**	**Year-on-year**	**5 year trend**
Mathematics	51%	+0.1pp	+1.6pp
Material Technology	19%	+1.4pp	+6.9pp
Technical Graphics	20%	+2.1pp	+6.2pp
Metalwork	11%	+1.4pp	+3.4pp
Technology	21%	-0.7pp	+5.1pp
JC STEM (excl. science)	**35%**	**+1.0pp**	**+4.3pp**
Leaving Certificate	**%Girls**	**Year-on-year**	**5 year trend**
Biology	63%	+0.9pp	+1.6pp
Mathematics	49%	+0.6pp	+1.7pp
Chemistry	59%	+1.7pp	+2.4pp
Construction studies	11%	+0.5pp	+4.7pp
Agricultural science	44%	+1.5pp	+3.7pp
Physics	28%	-1.0pp	+1.1pp
Engineering	7%	+0.3pp	+2.0pp
Design & comm.	14%	-0.7pp	+2.3pp
Applied mathematics	26%	-1.2pp	-0.3pp
Technology	18%	+1.7pp	-0.9pp
Physics & chemistry	43%	+0.5pp	-3.2pp
LC STEM	**44%**	**+0.3pp**	**+1.7pp**

pp = percentage points; n/c = no change

For the Leaving Certificate, 44% higher level STEM sittings are by girls, again an increase of 1.7 percentage points in the past five years. However, this proportion is skewed by the number of female students taking higher level biology (63%) and chemistry (59%). Meanwhile, just 28% higher level physics students are girls. As noted on page 29, higher education data for 2018 are not available and therefore the gender gap cannot be calculated for higher education as presented in previous Engineering reports.

The Government's STEM Education Policy Statement 2017-2026, published in November 2017, committed to providing the "highest quality STEM education experience" and set targets such as:

- Increased uptake of Chemistry, Physics, Technology and Engineering by 20%
- Increased uptake by females of STEM subjects by 40%

Table 14 shows that progress has been made against these targets over the past two years, which is encouraging given that the total number of students sitting the Leaving Certificate in 2017 and 2019 was approximately equal. To provide further indicators of progress on education strategies, the Department of Education and Skills (DES) publishes 'Education Indicators for Ireland'. An extract of STEM education indicators is shown in Table 15.

Table 14 *STEM Education Policy Statement performance against targets*

	2019	2017	2019 v 2017	2026 target
Physics, chemistry, technology, engineering sittings (boys and girls)	21,277	20,386	+4%	+20%
STEM sittings by girls	38,332	35,919	+7%	+40%

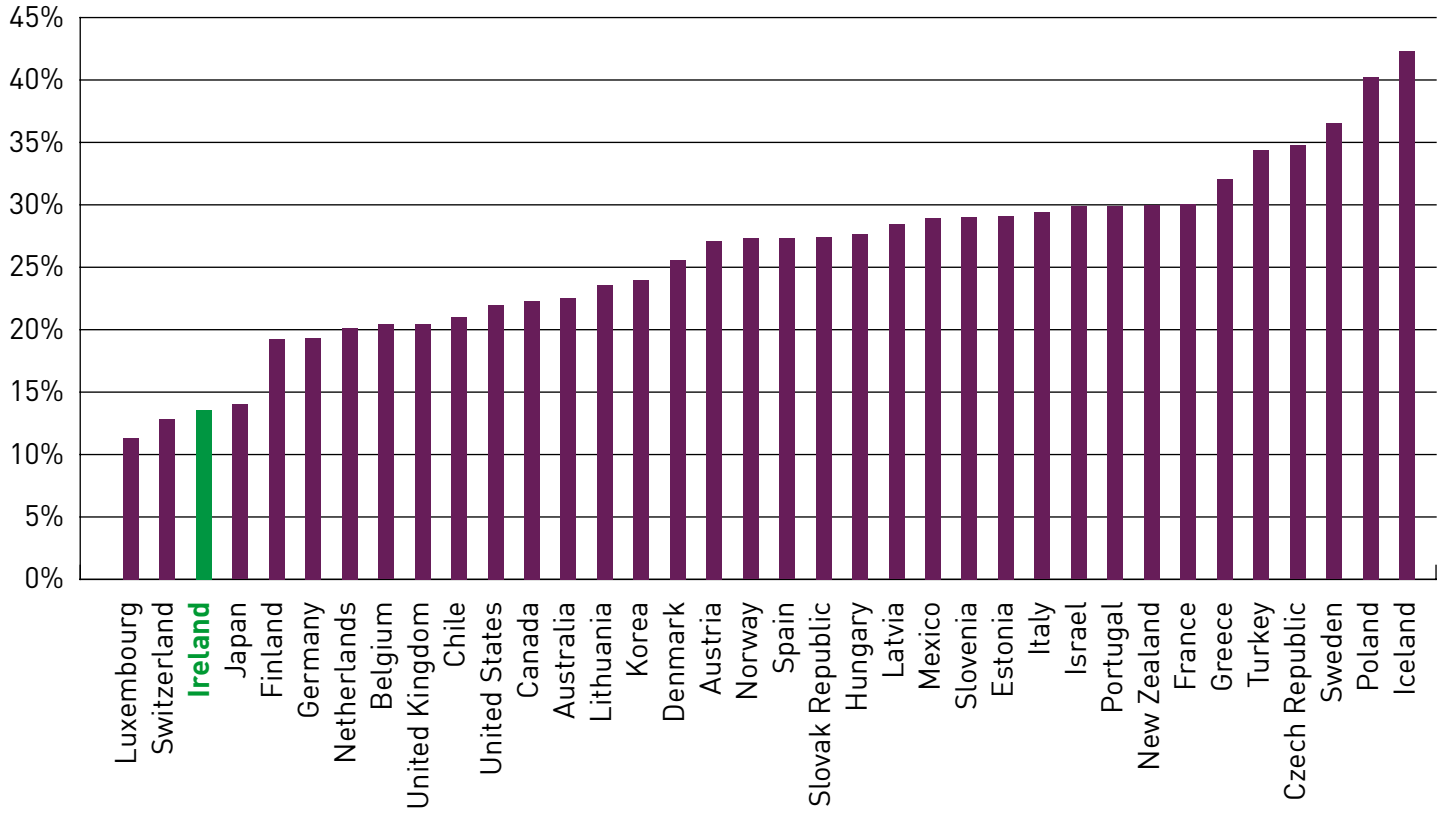
Table 15 *STEM education indicators 2018*

	Boys	Girls
% 3rd years taking at least one STEM subject (other than science or maths)	73%	23%
% 6th years taking 1 or more STEM subjects (excl. maths)	91%	86%
% 6th years taking 1 or more STEM subjects (excl. maths and biology)	72%	94%
% 6th years taking 2 or more STEM subjects (excl. maths)	60%	32%
% 6th years taking 2 or more STEM subjects (excl. maths and biology)	40%	8%
	Boys' schools	**Girls' schools**
% single-sex schools offering physics, chemistry and biology (LC)	92%	77%
% mixed schools offering physics, chemistry and biology (LC)	62%	
% single-sex schools offering a STEM subject other than maths or a science (LC)	96%	56%
% mixed schools offering a STEM subject other than maths or a science (LC)	93%	

Tables 13-15 demonstrate the continuing gender gap in both the provision and selection of STEM subjects in Ireland. Firstly, at Junior Certificate level, less than one-quarter of girls take a STEM subject other than science or maths (i.e. material technology, technical graphics, metalwork or technology), compared to nearly three-quarters of boys. At Leaving Certificate (LC) level, only 56% of all-girls schools even offer a STEM subject other than maths or a science, compared to 96% of all-boys schools. However, it is interesting to note that single-sex schools are more likely than mixed schools to offer all three core science subjects (physics, chemistry and biology).

Ireland does not compare favourably with other OECD countries in terms of gender balance among engineering graduates (Figure 12). Of 36 countries, Ireland is in 33rd place with 14% of bachelor's graduates from engineering-related programmes being women. The top performers are Iceland (42%), Poland (40%) and Sweden (37%); the OECD average is 25%.

Figure 12 *Women as a percentage of engineering bachelor's graduates in OECD countries in 2017*



In 2000 and 2018, an OECD study asked 15-year olds in 41 countries about the job they expect to be doing at age 30. Table 16 shows the top ten most commonly cited occupations for girls, boys, disadvantaged students and advantaged students in 2000 and 2018. It is very positive to note that engineering is the most commonly cited occupation for boys in 2018, up from third place in 2000. However, engineering does not appear in the top ten for girls, who very strongly prefer medicine and teaching. There is also a socio-economic divide in the data: advantaged students (5.9%) are almost twice as likely as disadvantaged students (3.3%) to expect to pursue a career in engineering.

Table 16 *Occupational expectations of 15-year-olds at age 30 (percentage of students expecting to work in one of the top ten most commonly cited occupations across 41 countries in 2000 and 2018)*

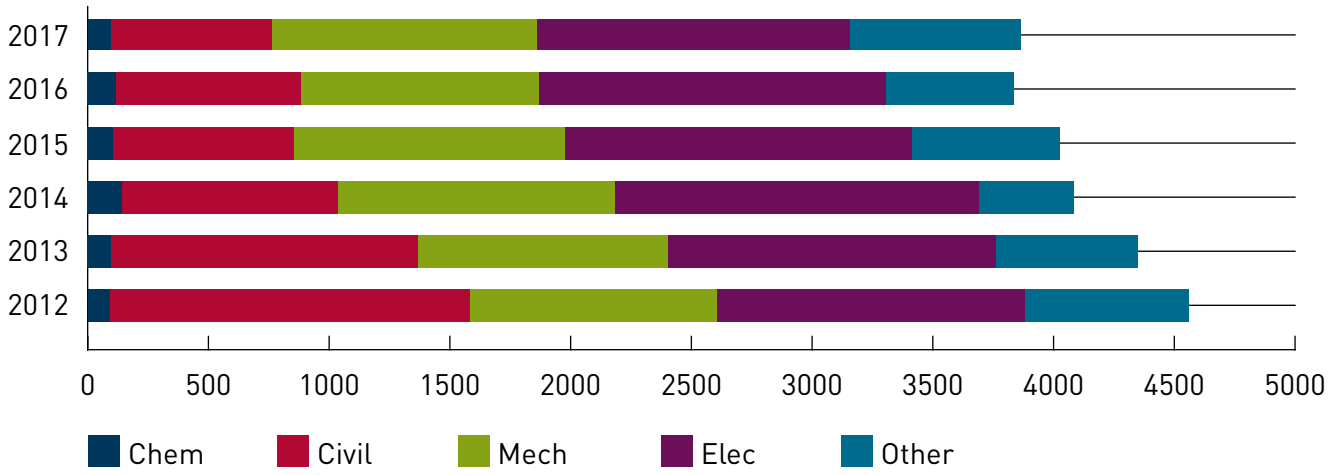
	Girls (2000)		Girls (2018)	
1	Teachers	11.1%	Doctors	15.6%
2	Doctors	11.0%	Teachers	9.4%
3	Lawyers	6.2%	Business managers	5.0%
4	Psychologists	3.9%	Lawyers	4.6%
5	Nursing and midwives	3.2%	Nursing and midwives	4.5%
6	Business managers	3.0%	Psychologists	3.7%
7	Veterinarians	2.9%	Designers	3.0%
8	Writers/journalists	2.6%	Veterinarians	2.8%
9	Secretaries	2.6%	Police officers	2.3%
10	Hairdressers	2.5%	Architects	2.1%
	Boys (2000)		**Boys (2018)**	
1	Business managers	6.8%	Engineers	7.7%
2	ICT professionals	6.1%	Business managers	6.7%
3	Engineers	4.9%	Doctors	6.0%
4	Doctors	4.5%	ICT professionals	5.5%
5	Sportspeople	4.0%	Sportspeople	4.9%
6	Teachers	3.9%	Teachers	4.6%
7	Lawyers	2.7%	Police officers	4.0%
8	Motor vehicle mechanics	1.9%	Motor vehicle mechanics	2.8%
9	Architects	1.9%	Lawyers	2.4%
10	Police officers	1.9%	Architects	2.2%
	Disadvantaged students (2000)		**Disadvantaged students (2018)**	
1	Teachers	8.7%	Doctors	9.4%
2	Doctors	6.6%	Teachers	8.2%
3	Lawyers	4.9%	Business managers	5.2%
4	Business managers	4.6%	Police officers	3.9%
5	Sportspeople	2.7%	Lawyers	3.5%
6	ICT professionals	2.6%	Engineers	3.3%
7	Nursing and midwives	2.4%	Nursing and midwives	3.3%
8	Engineers	2.3%	Sportspeople	3.0%
9	Hairdressers	2.3%	Motor vehicle mechanics	2.5%
10	Motor vehicle mechanics	2.5%	Designers	2.3%
	Advantaged students (2000)		**Advantaged students (2018)**	
1	Doctors	10.5%	Doctors	14.5%
2	Teachers	6.5%	Teachers	6.1%
3	Lawyers	6.3%	Engineers	5.9%
4	ICT professionals	5.5%	Business managers	5.7%
5	Business managers	5.4%	Lawyers	4.1%
6	Engineers	5.2%	ICT professionals	3.8%
7	Writers/journalists	2.8%	Architects	2.9%
8	Psychologists	2.7%	Designers	2.9%
9	Architects	2.4%	Psychologists	2.3%
10	Veterinarians	2.2%	Sportspeople	2.1%

Source: PISA 2000 and 2018 databases, 'Dream Jobs: Teenagers' career aspirations and the future of work' (OECD, 2020)

Higher education

Previous Engineering reports have included analysis of Higher Education Authority statistics on new entrants to engineering programmes, current enrolment and graduation rates by discipline. At the time of print, these data are not available for the 2018 cohort (please check www.hea.ie for the latest statistics). As a summary, the number of engineering graduates (Levels 7 and 8) by broad discipline is reproduced below from Engineering 2019.

Figure 13 *Graduates from Level 7 and Level 8 engineering programmes*



6,614 CAO Level 8 first preferences for engineering-related courses

Data released by the Central Applications Office (CAO) provide an indication of the demand for engineering programmes, albeit at the aggregate level and not by engineering discipline. Table 17 shows the number of students listing a first preference for an engineering/manufacturing/construction course on their CAO Level 8 form (after the 'change of mind' deadline) as well as the number of students receiving a 'round one' offer for one of these courses. These indicators show that between 2018 and 2019, there was a 7-8% increase in demand for Level 8 engineering/manufacturing/construction courses.

Table 17 *First preferences and round one offers for Level 8 engineering programmes*

	2019		2018		Change	
	First Pref	Round 1 Offers	First Pref	Round 1 Offers	First Pref	Round 1 Offers
Engineering and engineering trades	4,039	2,701	3,583	2,452	+13%	+10%
Manufacturing and processing	410	356	403	348	+2%	+2%
Architecture and construction	2,165	1,635	2,150	1,593	+1%	+3%
Engineering, manufacturing and construction total	**6,614**	**4,692**	**6,136**	**4,393**	**+8%**	**+7%**

Apprenticeships

Data on apprenticeships is provided by the Further Education and Training Authority (SOLAS) and the DES. New forms of apprenticeships have been developed in the past five years, led by industry consortia with higher education institution (HEI) partners. These apprenticeships are flexible in delivery, including on-the-job learning (approx. 70%) and on-campus learning (approx. 30%). Apprentices are employed under a formal contract and are paid for the duration of their apprenticeship.

Four of these new apprenticeships relate to the engineering profession (Table 18). These apprenticeships are generally placed at Level 7 on the NFQ with a B.Eng. award upon completion after 2-3 years. There are currently 242 apprentices registered on these programmes and the first cohort graduated in 2018. Further professional engineering apprenticeships are currently in development.

Table 18 *Professional engineering apprentices*

New apprenticeships	NFQ	Duration	HEI lead	Industry lead	2016	2017	2018	2019
Industrial Electrical Engineering	Level 7	2 years	LIT	Stryker	12	31	54	57
Manufacturing Technology	Level 6	2 years	GMIT	Medtech Assoc	-	39	73	82
Manufacturing Engineering	Level 7	3 years	GMIT	Medtech Assoc	-	36	55	57
Polymer Processing Technology	Level 7	3 years	AIT	Plastics Ireland	-	23	38	46
				Total registered	**12**	**129**	**220**	**242**

It should also be noted that there is a major shortage of craft apprentices, numbers of which declined dramatically during the economic recession. While these apprentices do not qualify as engineers, many become engineering technicians or progress to study engineering. More importantly, apprentices play a vital role in the wider engineering and construction sector and the decline in apprentice registrations is a key component of skills shortages in the sector.

WORLD ENGINEERING DAY FOR SUSTAINABLE DEVELOPMENT

SUSTAINABLE DEVELOPMENT GOALS

Engineering and the Sustainable Development Goals

World Engineering Day for Sustainable Development

4th March 2020 is World Engineering Day for Sustainable Development, a UNESCO international day to highlight the achievements of engineers and engineering in our modern world and improve public understanding of how engineering and technology is central to modern life and sustainable development. World Engineering Day for Sustainable Development will be celebrated annually.

The World Federation of Engineering Organisations proposed 4th March as World Engineering Day, the founding day of the Federation, as part of their 50th anniversary celebrations in 2018. In November 2019, the 40th General Conference of UNESCO adopted a resolution to proclaim 4th March of every year a World Engineering Day for Sustainable Development.

World Engineering Day is an opportunity to increase the profile of engineering as a career, highlighting how the profession can change the world for the better. Events on this day can be used to engage governments, industry and the public on the importance of engineers and engineering skills to create and deliver solutions for sustainable development.

The World Engineering Day Logo

"The 17 colours of the UN Sustainable Development Goals are included in the logo and represent the commitment to the UN 2030 Agenda. The colours at the centre of the image are for the Sustainable Development Goals for Water, Energy, Sustainable Infrastructure and Innovation. These are the main areas where engineers are needed most. The goal for Engineering Education is also central as the world needs more engineers with the right engineering skills for sustainable development. The image of the world is incorporated in the logo to show that this is a global day for everyone. The gears of the logo show that engineers are driving the world forward and that engineering is essential for sustainable development."

WORLD ENGINEERING DAY FOR SUSTAINABLE DEVELOPMENT

www.worldengineeringday.net

The World Federation of Engineering Organisations is specifically highlighting the contribution of engineering to achieve the UN Sustainable Development Goals (SDGs) to ensure that everyone has access to clean water, sanitation, reliable energy, and other basic human needs. According to the Federation, the World Engineering Day can be used to say "If you want to change the world for the better, become an engineer."

> "If you want to change the world for the better, become an engineer."

The 17 SDGs are broad-based and interdependent and, since their introduction in September 2015, targets and indicators have been developed for each. Over the past five years, engineering organisations have taken many different approaches to identifying how they can best contribute to the achievement of the SDGs, ranging from broad-based marketing to in-depth analysis of the targets and indicators.

To inform a review of Engineers Ireland's academic accreditation criteria, we asked employers and academics to what extent should each of the UN Sustainable Development Goals be covered in engineering education programmes at third level (Figure 14). The majority of employers and academics selected the same six SDGs to be covered in depth. Examining the targets and indicators for these six SDGs (one target is shown for each below), reveals the pivotal role that engineers will need to play in achieving these particular goals.

SUSTAINABLE DEVELOPMENT GOALS

Ensure availability and sustainable management of water and sanitation for all. By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

Ensure access to affordable, reliable, sustainable and modern energy for all. By 2030, increase substantially the share of renewable energy in the global energy mix.

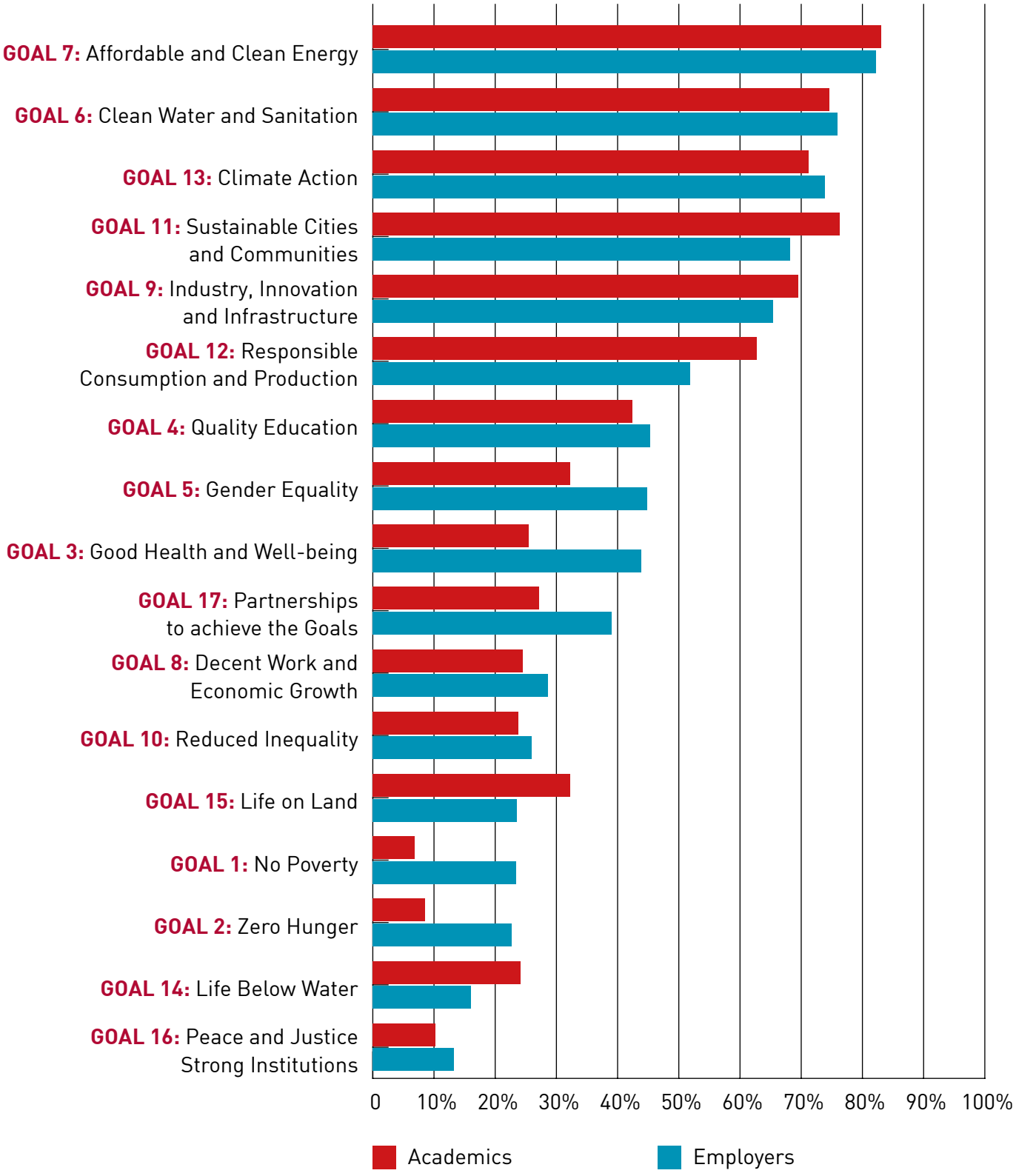
Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

Make cities and human settlements inclusive, safe, resilient and sustainable. By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

Ensure sustainable consumption and production patterns. By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

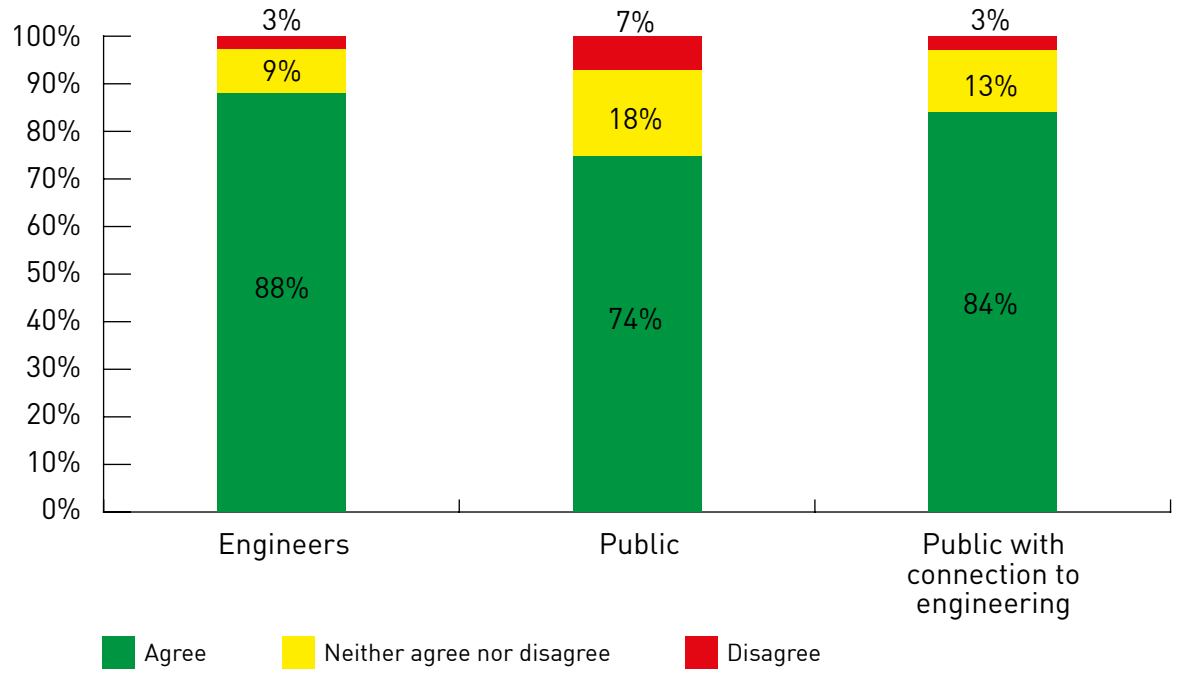
Take urgent action to combat climate change and its impacts. Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

Figure 14 *SDGs which should be covered 'in depth' in engineering education programmes*



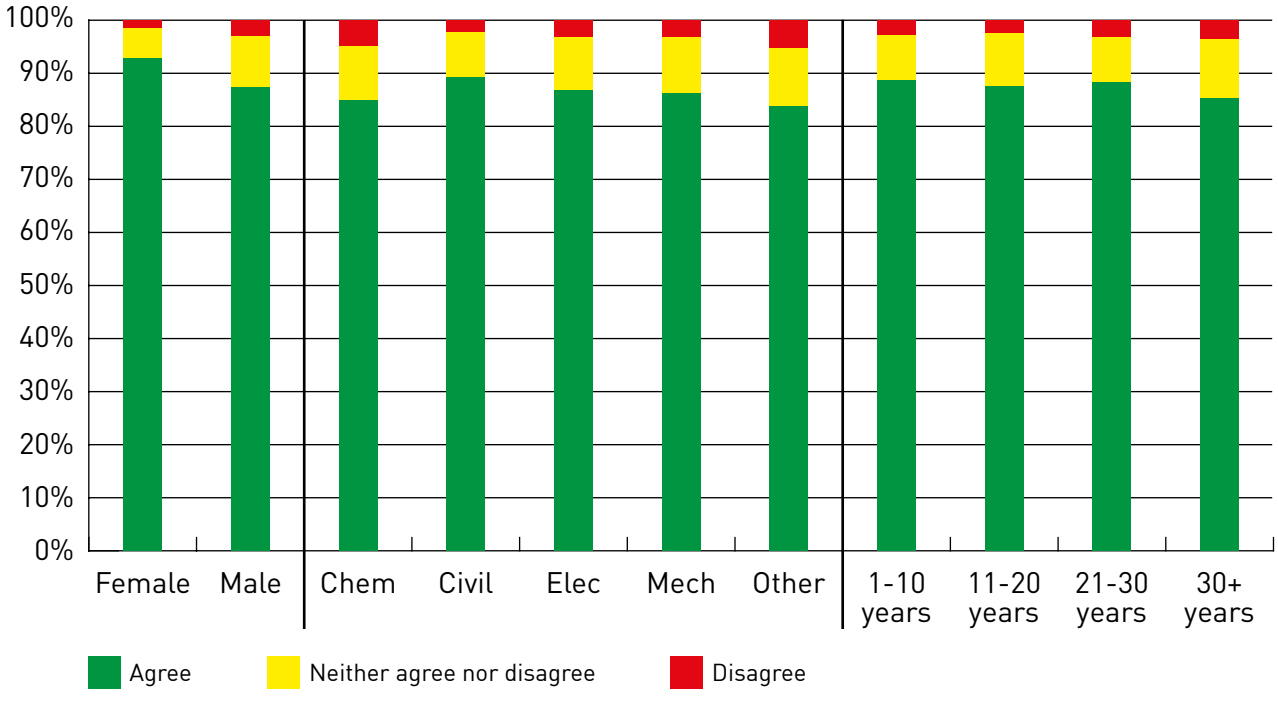
We asked members of Engineers Ireland and members of the public whether they agree with the statement 'Engineers have an ethical responsibility to tackle climate change and biodiversity loss'. The results are shown in Figures 15 and 16.

Figure 15 *Engineers have an ethical responsibility to tackle climate change and biodiversity loss*



The vast majority (88%) of engineers agree that engineers have an ethical obligation to tackle climate change and biodiversity loss (Figure 15). This level of agreement is consistent across the profession (female engineers showed the highest agreement at 93%), see Figure 16. Almost three-quarters (74%) of the public agreed with the statement, while 18% responded that they neither agree nor disagree. Public level of agreement rises to 84% for members of the public with some connection to engineering, such as working in / studying engineering or having a family member working in / studying engineering.

Figure 16 *Engineers have an ethical responsibility to tackle climate change and biodiversity loss (engineers' responses by gender, broad discipline and years of experience)*



Attracting diverse talent to the engineering professions of 2030

By Una Beagon, Technological University Dublin

Engineers and engineering education can play a key role in addressing sustainable development and moving society closer to realising the SDGs, as long as engineering students master the competences required to work in this rapidly changing world. Communication and technical skills will still be the most important attributes required of engineers in the future, according to a new study by the A-STEP 2030 project which aims to develop innovative teaching approaches for engineering students which will attract a more diverse student body to the engineering profession.

TU Dublin, in the first activity of the project organised focus groups across four European countries which compared the views of engineering students, engineering academics and engineering employers. Participants were asked about three key concepts: awareness of sustainable development; awareness of the SDGs, and the skills and competencies that engineers will need to achieve the SDGs.

What emerged was a varied picture of awareness of the SDGs with SDG 13 (Climate Action) topping the list, as shown in Figure 17. Overall, Irish focus group participants showed the highest awareness of the SDGs in general, but this is differentiated significantly with a low awareness from Irish students (compared to all countries) but the highest awareness from academics and employers.

Significant discussion took place on the skills and competences needed to solve the SDGs. Figure 18 shows the word cloud for the most commonly mentioned skills. The picture shows that a balance of technical and non-technical skills is required with communication, technical skills and critical thinking and ethical behaviour being those which emerged as most important.

A-STEP 2030 is funded under EU Erasmus+. It is led by ENSTA Bretagne, France and has academic partners in TU Dublin, Metropolia University of Applied Sciences in Finland and Aalborg University in Denmark.

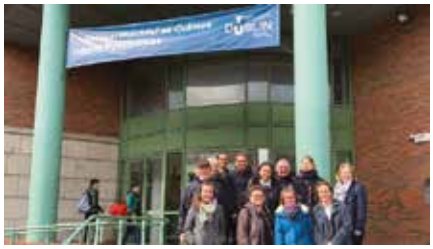
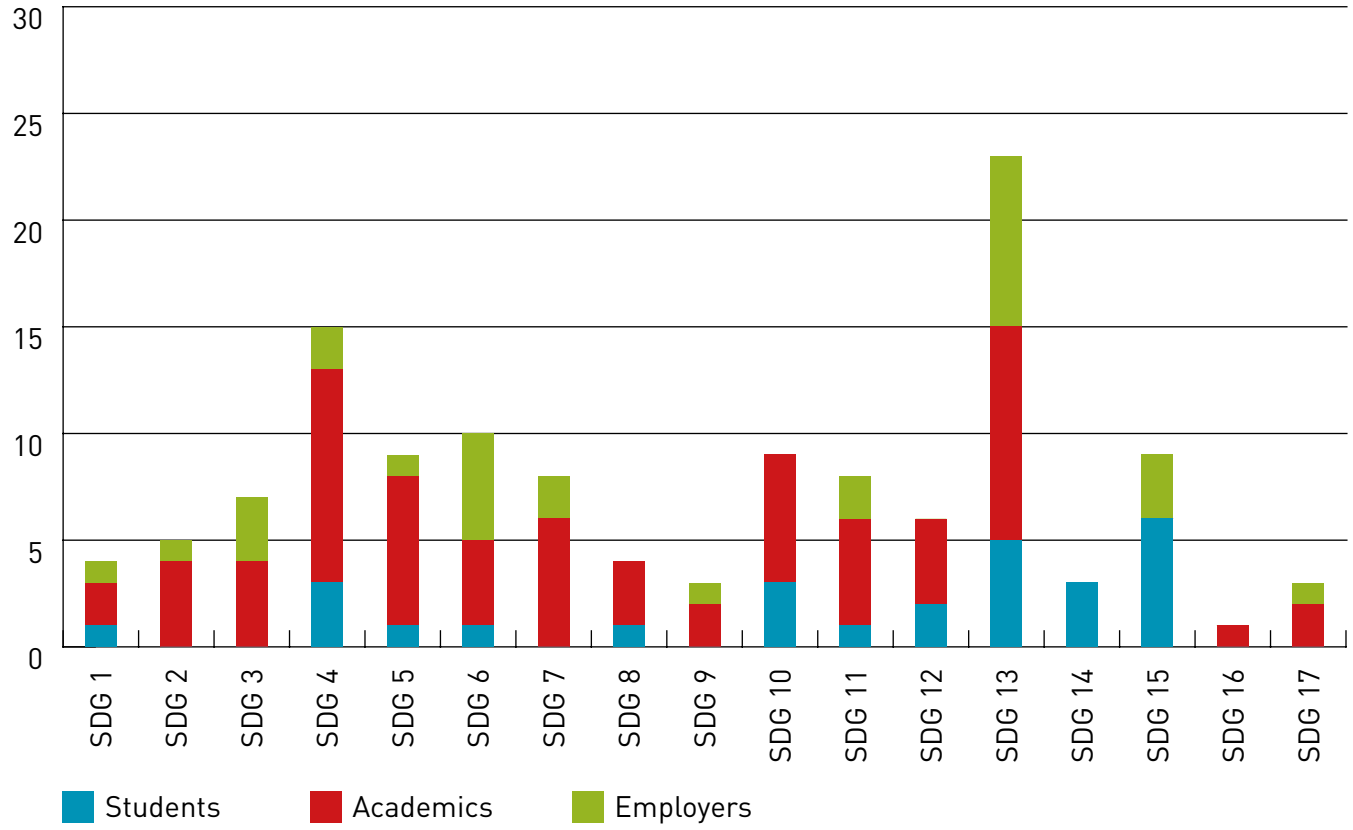


Figure 17 *Number of mentions of each SDG by each participant group (all countries)*

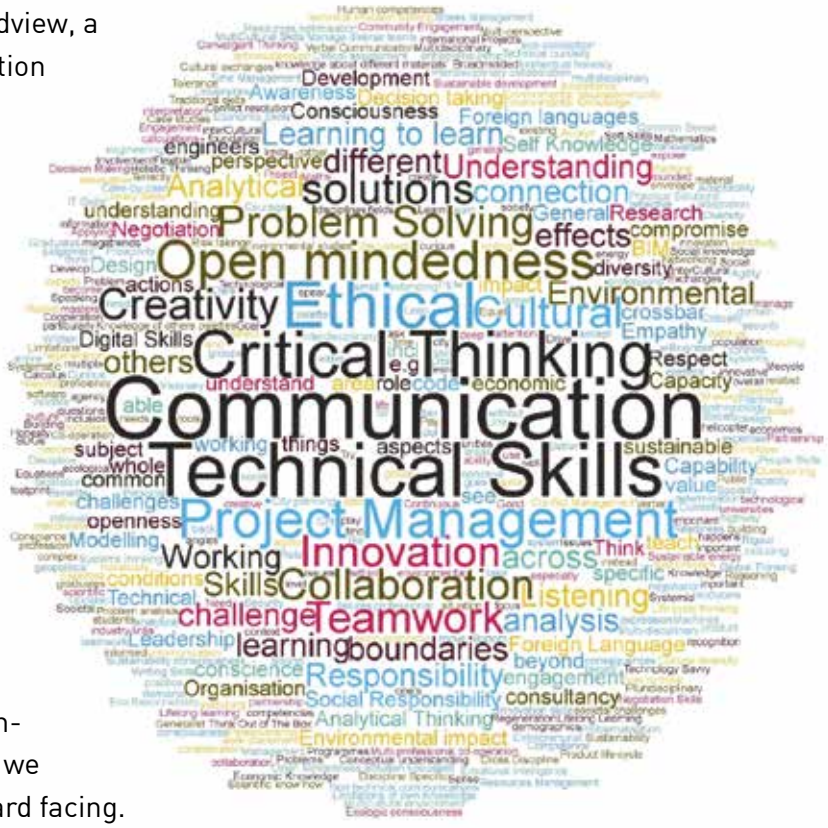


The role of the engineer will move from serving industry to serving society and this requires engineers to be mindful of the impact of their decisions on both society and the environment. Engineers will need new ways of carrying out engineering projects and will need to have greater influence at higher levels of political power. They can no longer focus only on the technical aspects of projects, they are called to look up, face the future and become changemakers in society. By looking upward and outward, they need to have a sustainable worldview, one that acknowledges international and intercultural issues, the diversity of society, and understands how to turn these seeming liabilities into opportunities.

Engineers of the future will be presented with complicated, complex problems and will need to consider multi-perspective views, whilst being conscious of long-term effects, risk and the impacts of decisions on society. These engineers will most certainly need fundamental technical skills, but as the rate of change in technology increases, engineers must also become highly flexible lifelong learners, capable of adapting their practices to new technologies and developments.

With all of these new challenges comes the awareness that engineers of the future will need to know how to work with diversity and with difference in general. They will need to understand how to make the most of teams comprising non-engineers and composed of people with different outlooks. These are attributes which must form the character and the practice of the engineer of the future.

Figure 18 *Skills requirements for engineers to achieve the SDGs*



The model that we are presenting offers a broad picture of a person with an expansive worldview, a sound character and a firm ethical orientation derived from a commitment to and belief in the idea that engineering can be used to further sustainable development. Building on these characteristics, the student engineers of the future will need to master technical tools such as mathematics, as well as a broad pallet of application skills that will allow them to find ways of applying fundamental tools to the practice of achieving sustainable engineering projects.

Throughout their education — and indeed throughout their life-long learning — tomorrow's engineers will also acquire non-technical skills of two primary types: what we have described as inward facing and outward facing. The first of these involves capacities like creativity and critical thinking, both of which will be necessary for the kind of responsible research and innovation that will be characteristic of the practice of tomorrow's engineers. The latter, outward facing skills, will involve people skills of all types, with a particular emphasis on those relating to dealing with diversity, inclusion, and difference.

Overall, tomorrow's engineer will be both better grounded in the urgency of using engineering to bring about sustainable development and better prepared, both in technical and in human terms, for making sustainable development a reality.

In order to prepare engineers to meet this new reality, we need to better inform curriculum design and pedagogical approaches. Without sharing this information among us there is little chance anything will change and thus the next step in the project is to do just that.

Embedding the SDGs in engineering education

By Thomas Adams, Sriram Kishore and Jamie Goggins, NUI Galway

The SDGs are having a significant influence on policy development worldwide. However, there is a key question about whether current and future engineering graduates will be equipped to contribute significantly to the achievement of these goals and provide sustainable solutions. One way to consider this is to better understand the level of focus within existing curricula of engineering degrees towards the SDGs.

This study aims to achieve this through both quantitative and qualitative approaches. After reviewing various methods employed to analyse the contribution of SDGs in a curriculum, the approach of keyword analysis of programme learning outcomes was chosen. Previous researchers have developed a standard set of representative keywords for each of the 17 SDGs and a set of miscellaneous keywords. A tool has been created which can be used by any third level institution to understand the weighting of the learning outcomes within their curricula to sustainable development. Further information on the project methodology is included in the Appendix.

In the first phase of the project, the tool was applied to thirty engineering and science programmes offered at the National University of Ireland, Galway. The average number of SDG keyword hits was 38.5 for the two Bachelor of Science programmes and 31.2 for the six Bachelor of Engineering programmes. The average number of hits was lower for the Master's and diploma programmes, which is unsurprising due to the lower number of modules, ECTS and learning outcomes. Notable exceptions were the seven Master of Engineering programmes which scored an average of 27.9 keyword hits.

The tool was then used to compare the various Bachelor of Engineering programmes (Figure 19) in more detail. Of the five streams considered, Civil and Energy Systems hit the largest number of keywords. For example, the learning outcomes of the BE in Civil Engineering hit 29% of the unique keywords for SDG 7 (energy). The SDGs with the greatest coverage across the programmes were 1, 6, 7, 9, 12 and 13. These goals relate to: poverty; water; energy; industry/innovation/infrastructure; production; and climate action. The keywords for SDG 5 (gender equality) and 17 (partnerships for the goals) received zero hits. The Master of Engineering programmes showed a similar result with the Civil and Energy Systems disciplines hitting the largest numbers of keywords (Figure 20).

Figure 19 *Comparison of Bachelor of Engineering programmes (average unique hits)*

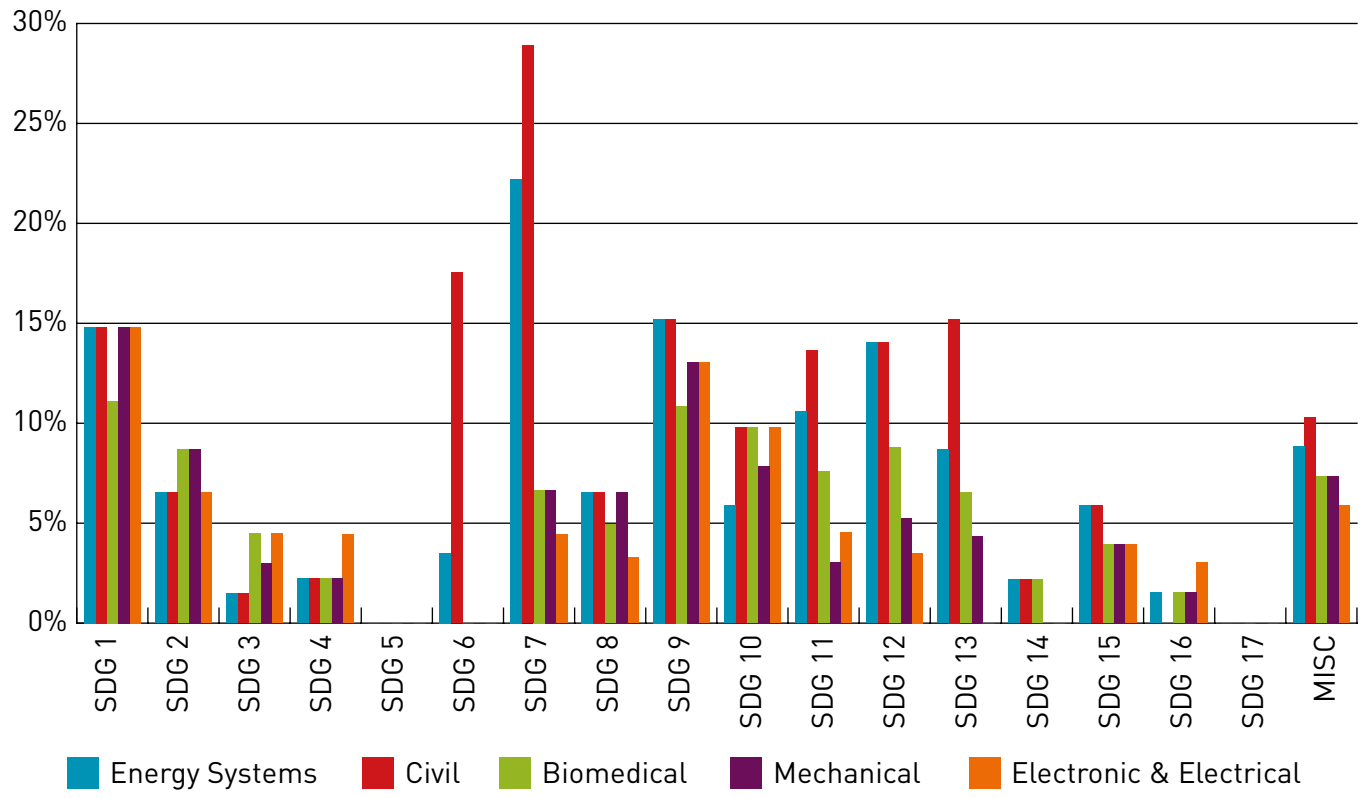
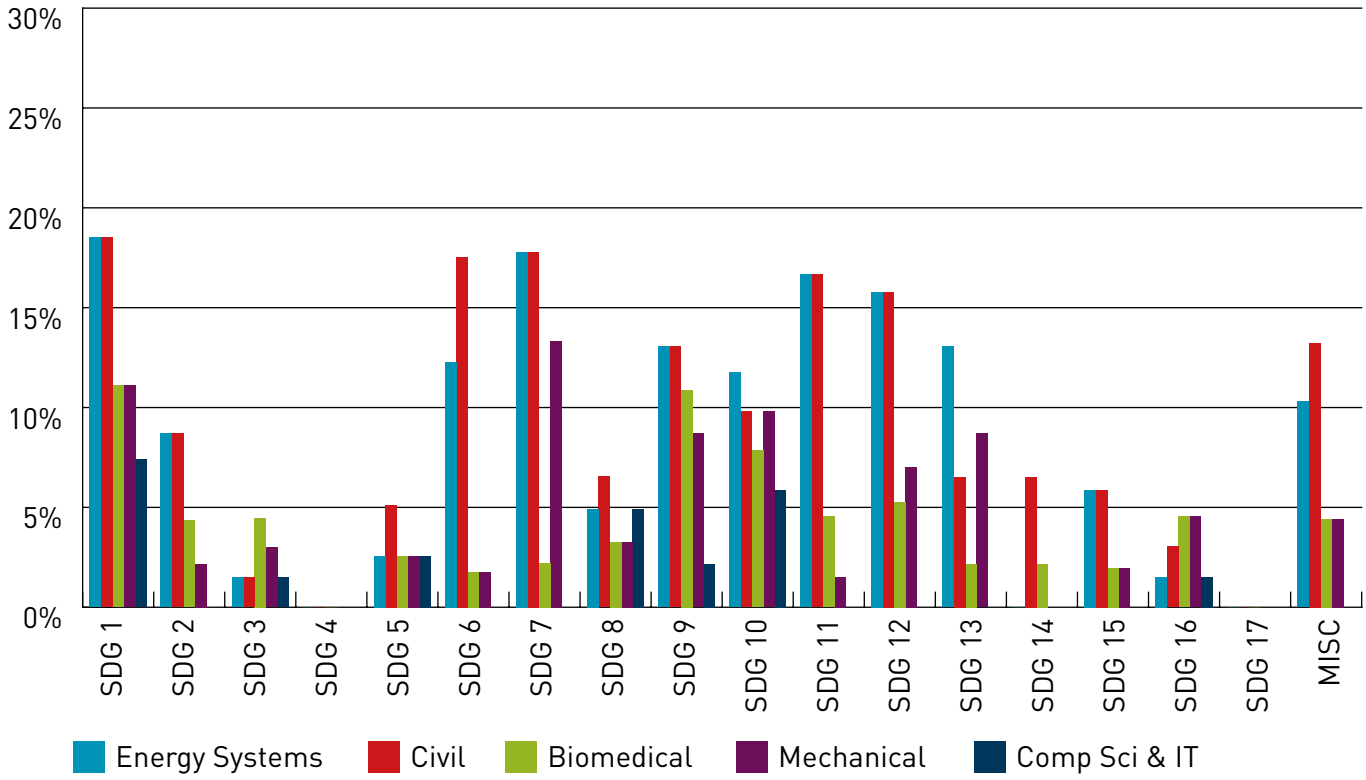


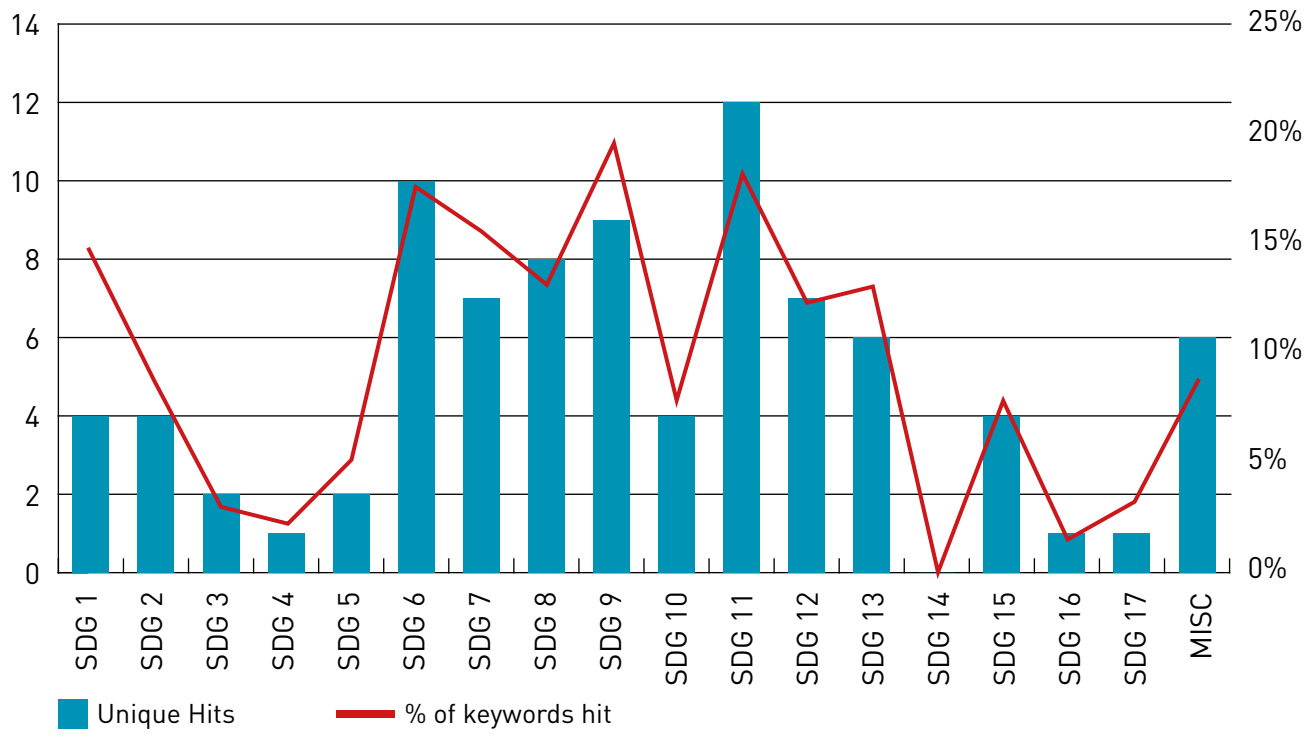
Figure 20 *Comparison of Master of Engineering programmes (average unique hits)*



BSc in Project and Construction Management

Of the thirty programmes considered, the BSc in Project and Construction Management scored the highest and was chosen as a case study. The programme hit keywords 219 times and 59 of these were unique hits, representing 7% of the total number of SDG keywords. The programme hit an average of 5 keywords (10%) per SDG. Figure 21 shows that SDG11 received the largest number of unique keyword hits (12), while SDG9 which has fewer associated keywords received the highest percentage of keywords hit (20%).

Figure 21 *BSc in Project and Construction Management*



NOTE

Unique keywords hit for the BSc in Project and Construction Management

Business, Class, Community, Conservation, Consume, Ecological, Electricity, Employment, Environmental, Ethical, Income, Institutions, Lakes, Land, Life cycle, Medical, Natural systems, Pay, Population, Produce, Production, Race, Research, Rivers, Road safety, Soil, Sustainability, Sustainable development, Technology, Tree, Urban planning, Wastewater, Wastewater treatment, Water quality, Wetlands, Wood, Work, Carbon, Economy, Emissions, Energy, Enterprises, Entrepreneurship, Environment, Greenhouse gas, Greenhouse gas emissions, Health, Infrastructure, Innovation, Pollution, Productivity, Society, Sustainable, Trade, Transport, Urban, Waste, Water

CE3105 Environmental Engineering

The strongest contributor module was CE3105 Environmental Engineering, which, for example, was responsible for almost one third of the BSc in Project and Construction Management programme's hits, highlighting SDGs 6, 7, 11, 12 and 13 in just seven learning outcomes. These learning outcomes of the module are shown on the next page.

CE3105 Environmental Engineering learning outcomes (with hit keywords **highlighted**)

- Recognise the importance of **water** and **wastewater** purification in today's **society** and the role of the **environmental** engineer in the design, development and maintenance of treatment facilities.
- Identify, describe and measure the main physical, chemical and biological characteristics of **water**, and relate their importance in terms of **water quality**.
- List the natural purification processes that occur in **natural systems**, such as **lakes**, **rivers** and estuaries, and explain the mechanisms behind these systems such as filtration, sedimentation and gas transfer.
- Understand the processes involved in the treatment of **wastewater** using septic tanks, **wetlands** and filters, and describe the processes involved with the submission of an application to build such systems.
- Design individual process units such as sedimentation basins, filtration tanks and biological reactors using theoretical equations and empirical design parameters.
- Assemble individual process units into a **working water/wastewater treatment** plant and assess the performance of the plant in terms of the quality of effluent in comparison with EU **water/wastewater** regulations.
- Recognise the importance of '**pollution** swapping' in **environmental** engineering and the importance of **greenhouse gas emissions** on design of **wastewater treatment** systems.

Conclusion

This keyword analysis of thirty engineering and science programmes at NUI Galway found civil engineering and energy systems engineering programmes to include the greatest coverage of the SDGs. The BSc in Project and Construction Management and an environmental engineering module received particularly high scores. The SDGs which receive the most attention in these courses relate to water, energy, sustainable cities etc. Institutions could use this method to identify courses which might be strong (or not so strong) contributors to the SDGs and to ensure that learning outcomes reflect this contribution.

A limitation in this approach is the relevance and context of the 915 SDG keywords utilised in this study. Some of the unique keywords on the previous page (e.g. class and race) are understandably used in a different context in the SDGs than in typical engineering learning outcomes (e.g. class of materials). This said, for this first phase of the project, the standard set of 915 keywords was found to perform well in terms of the SDGs receiving the greatest coverage by the NUI Galway programmes and modules (e.g. see CE3105). In an Austrian approach (see Appendix), a comprehensive list of 1,000 keywords was devised through an iterative process of testing the chosen keywords and manually scanning for errors.

The next steps for the project include a critical analysis of the 915 keywords and applying the refined tool to a larger dataset of fields, disciplines and institutions. Ultimately, the project aims to identify steps that can be taken to improve curricular coverage of the SDGs, not simply in terms of written learning outcomes, but to better equip graduates with the skills needed to achieve the SDGs and a more sustainable world.

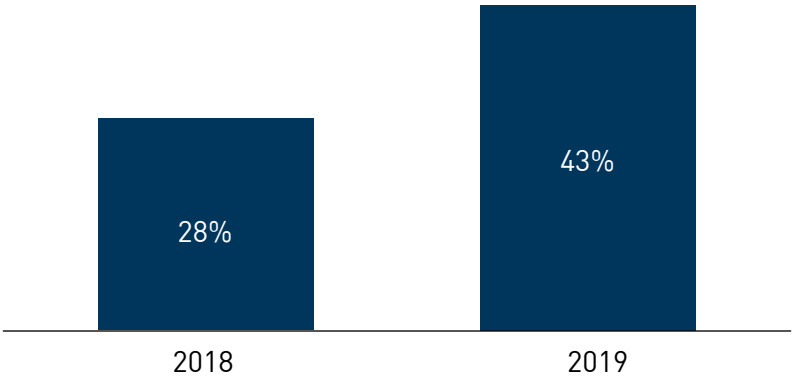
Conclusion

This final section of the report outlines the key trends, based on the preceding data, in engineering employment, perspectives, education and the SDGs. Understanding these trends helps Engineers Ireland and our members to raise the profile of the engineering profession and to deliver solutions for society. These trends also hold important lessons for industry, educational institutions and State bodies who will all be instrumental in preparing Ireland for the opportunities and challenges we face in climate, technology and more.

Trend 1: The demand for engineers continues despite Brexit concerns

Over the past year, one of the biggest challenges for the engineering sector, and the country as a whole, was Brexit. A particular concern was the impact of a potential 'no deal' Brexit on the Construction Products Regulation, where UK 'notified bodies' would lose their legal status to perform assessments of products leading to the 'CE' marking. Other concerns included maintaining the movement of goods and services and the recognition of professional qualifications. Engineers Ireland worked with the Department of Housing, Planning and Local Government, the UK Engineering Council and others to advise and support our members.

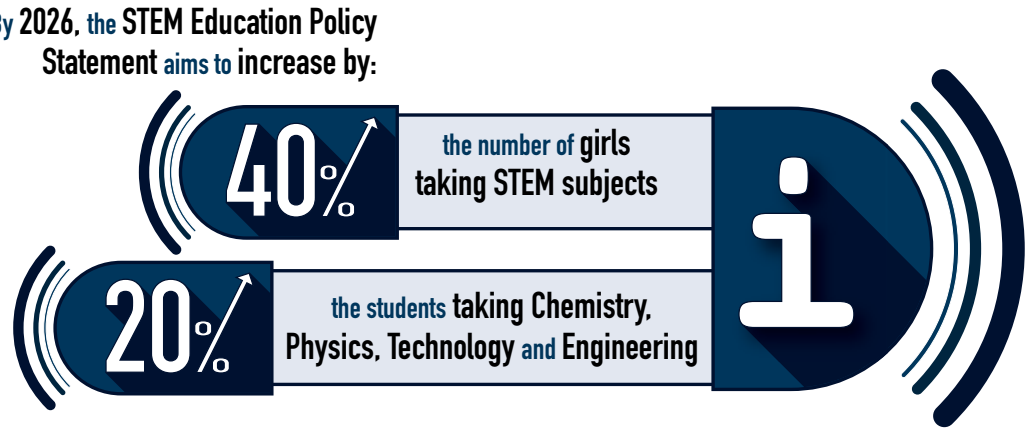
Brexit concerns as a barrier to growth



Despite Brexit concerns, the high demand for engineers continued through 2019 and the outlook for 2020 is positive. Seven-out-of-ten engineering employers expect their financial position to improve in 2020 and engineering organisations would like to hire more than 5,000 engineers in 2020. Indeed, rather than Brexit or the housing shortage, skills shortages continue to be engineering organisations' largest barrier to growth. This said, engineering leaders are still cautious and our metrics suggest that they are not quite as confident as they were at this point last year.

Trend 2: STEM education policy should take steps to close the gender gap

The Government's STEM Education Policy Statement 2017-2026 commits to providing the "highest quality STEM education experience" and this report shows that progress has been made against several targets, such as STEM sittings at Junior and Leaving Certificate level. Meanwhile, there has been a jump in CAO first preferences for Level 8 engineering-related programmes. However, the continuing gender gap requires ever greater attention and action – both in Ireland and internationally. The new Government should take steps to close the gender gap, achieve the targets of the STEM Education Policy Statement and encourage and educate the engineers of the future.



The Engineers Ireland STEPS Programme will play a leading role in these efforts. STEPS is a non-profit outreach programme that promotes interest and awareness in engineering as a future career to school students through a portfolio of projects: Engineers Week, Engineering your Future, Young Engineers Award and Engineering Girl Guides & Brownies Badges. STEPS introduces engineering to primary school children, inspires transition year students to study engineering, and supports community leaders to communicate diverse opportunities in engineering. This programme is funded by Science Foundation Ireland and the Department of Education and Skills. ESB, TII, Arup and Intel also provide funding.

Trend 3: Engineering skills of the future will be both 'digital' and 'human'

New technologies and ways of working are rapidly changing our society and economy. For example, Industry 4.0 represents the digital transformation of manufacturing and other sectors. As highlighted in this report, Engineers Ireland has been working with industry, researchers and State agencies to understand the implications of these trends for engineering skills to ensure that engineers can lead in the innovative use of new technologies and deliver solutions for society.

The World Economic Forum has described the jobs of tomorrow as both 'digital' and 'human'. Indeed, our research presented in this report, demonstrates that the in-demand engineering skills over the next ten years range from transversal such as communication and management to technical such as in digitalisation to sustainability. The Engineers Ireland CPD team has developed a suite of new courses to enable engineers to hone these skills, such as analytical problem solving, critical thinking, and innovation and intrapreneurship, complementing the existing technical and communications courses.

> "Demand for both "digital" and "human" factors is driving growth in the professions of the future. [...] On the one hand, these reflect the adoption of new technologies—giving rise to greater demand for green economy jobs, roles at the forefront of the data and AI economy as well as new roles in engineering, cloud computing and product development. On the other hand, emerging professions also reflect the continuing importance of human interaction in the new economy, giving rise to greater demand for care economy jobs; roles in marketing, sales and content production; as well as roles at the forefront of people and culture."
>
> – World Economic Forum, 'Jobs of Tomorrow'

However, if we are to achieve a knowledge-based future for Ireland, we need a top-quality higher education system, including an excellent student learning experience and strong reputation for our graduates and institutions. This will require increased higher education funding per student and a sustainable funding model including core and programmatic funding, facilities investment and industry collaboration. National funding for research and innovation will also need to be increased to bring us closer to our competitors and establish Ireland as an innovation leader.

Trend 4: The SDGs can popularise engineering and achieve a better world

Starting this year, the World Engineering Day for Sustainable Development is an excellent annual opportunity to highlight the achievements of engineers and engineering, while also pointing to the responsibilities and opportunities for the profession in sustainable development. Also, this report has shown that almost two-thirds of Irish adults (three-quarters of 16-24 year olds) are interested in finding out about new ideas in science and engineering and the public's innovation priorities are health, climate change and education.

The UN Sustainable Development Goals could act as a useful framework to tackle societal challenges while raising the standing of the profession. The achievement of these global goals within the next ten years will require engineers to play their part. This report shows that there are certain goals, such as those relating to water, energy, manufacturing, innovation and infrastructure, where engineers need to lead the way. It is very positive to see that engineering educators and researchers are examining the skills needed to achieve the SDGs and are designing curricula to prepare the next generation of engineers to shape a sustainable world.

Appendix. Methodological Notes

References and data sources

- Climate Action Plan 2019 To tackle climate breakdown' was published by the Department of Communications, Climate Action and Environment on 17th June 2019. Available at www.dccae.gov.ie
- 'Ireland's Industry 4.0 Strategy 2020-2025: Supporting the digital transformation of the manufacturing sector and its supply chain' was published by the Department of Business, Enterprise and Innovation on 16th December 2019. Available at: www.dbei.gov.ie
- 'The State of the European Consulting Engineering Sector – Barometer Autumn 2019' was published by the European Federation of Engineering Consultancy Associations on 7th November 2019. Available at: www.efcanet.org
- 'The National Skills Bulletin 2019' was published by the Further Education and Training Authority (SOLAS) on 5th December 2019. Available at: www.solas.ie
- 'Science in Ireland Barometer' was published by Science Foundation Ireland on 7th October 2015. Available at www.sfi.ie
- Junior Certificate 2019 results were released by the State Examinations Commission on 4th October 2019. Available at: www.examinations.ie
- Leaving Certificate 2019 results were released by the State Examinations Commission on 13th August 2019. Available at: www.examinations.ie
- Higher education student and graduate statistics are provided by the Higher Education Authority. Available at www.hea.ie
- CAO first preferences and offers data were released by the Central Statistics Office on 15th August 2019. Available at www.cao.ie
- Apprenticeships registration data was provided by the Minister of State for Training and Skills to the Oireachtas on 6th September 2019. Available at: www.oireachtas.ie
- 'STEM Education Policy Statement 2017-2026' and 'Implementation Plan 2017-2019' were published by the Department of Education and Skills ion 27th November 2017. Available at www.education.ie
- 'Education Indicators for Ireland' was published by the Department of Education and Skills on 31st October 2019. Available at www.education.ie
- Graduates by field of study statistics are published by the OECD. Available at www.oecd.org
- 'Dream Jobs: Teenagers' career aspirations and the future of work' was published by the OECD (2020) and includes data from PISA 2000 and 2018. Available at www.oecd.org
- World Engineering Day for Sustainable Development was proposed by the World Federation of Engineering Organizations and resources are available at www.worldengineeringday.net
- 'Jobs of tomorrow: Mapping opportunity in the new economy' was published by the World Economic Forum on 3rd January 2020. Available at: www.weforum.org

Broad engineering disciplines

The broad engineering disciplines used in this report are: Chemical & Process (Chem), Civil & Building (Civil), Electrical & Electronic (Elec), Mechanical & Manufacturing (Mech), Other / General (Other). These broad disciplines were developed as part of the Engineering 2018 report to reclassify CSO and HEA data. The HEA uses the International Standard Classification of Education (ISCED) and the table below shows

the grouping of these codes into the broad disciplines used in the report. 'Software and applications development' and 'Computer use' have not been included in this report.

ISCED name	ISCED code	Broad discipline
Electronics and automation	0714	Elec
Building and civil engineering	0732	Civil
Engineering not elsewhere classified	0710	Other
Mechanics and metal trades	0715	Mech
Electricity and energy	0713	Elec
Manufacturing and processing	0720	Mech
Chemical engineering and processes	0711	Chem
Motor vehicles, ships and aircraft	0716	Mech
Environmental protection technology	0712	Other

Engineering academic survey

The engineering academics survey was conducted online between 20 September – 4th October 2019. Participants were sought from Engineers Ireland academic accreditation volunteers and academic contacts. There were 90 responses: Dean/management (11%), Head of Department (12%), Lecturer (39%), and part-time/adjunct/retired/other (38%).

Engineering industry leader survey

The engineering industry leader survey was conducted online between 17-31 October 2019. Participants were sought from Engineers Ireland's corporate partners and other affiliated employers, such as those who use Engineers Ireland's Jobs Desk. Respondents included 147 engineering industry leaders (CEOs, Directors and HR) with a total of 64,494 employees in the Republic of Ireland. Of the people responding to the survey, 80% work in management/HR and 20% work as engineers. The forecast for the demand for engineers in 2020 was developed by extrapolating results to the full engineering labour force. If comparing results with those presented in the Engineering 2019 report, please note the changes in the characteristics of the survey samples in the table below.

	October 2018 survey sample			October 2019 survey sample		
Sector	**Resp.**	**Av. employees**	**Av. engineers**	**Resp.**	**Av. employees**	**Av. engineers**
Construction	15%	324	46	15%	141	39
Consultancy	45%	36	24	43%	87	47
Manufacturing	17%	615	120	12%	748	137
Other	23%	553	27	31%	909	71
Total	**100%**	**295**	**44**	**100%**	**427**	**64**

Engineers Ireland member survey

The Engineers Ireland member survey was conducted online between 8-22 January 2020. A link to the survey was emailed to members of Engineers Ireland on 22 January. There were 2,180 responses, of which 87% were men and 13% were women. The breakdown of the sample according to experience was: 1-2 years (7%), 3-5 years (9%), 6-10 years (20%), 11-15 years (20%), 16-20 years (16%), 21-25 years (13%), 26-30 years (6%) and 30+ years (9%). The breakdown of the sample according to membership type / professional title was: untitled Member (47%), Chartered Engineer (34%), Fellow (3%) and other/ student/non-member (16%). A full Engineers Ireland Salary Survey 2020 report is available to Engineers Ireland members and can be downloaded from the members' area of www.engineersireland.ie.

Public survey

The public survey was conducted face-to-face by Behaviour & Attitudes between 16-28 January 2020. 1,000 adults (aged 16 and over), statistically representative of the adult population in Ireland (in terms of age, gender, region and socio-economic class), were polled at randomly-chosen sampling points. For more information, see www.banda.ie/techniques/barometer/

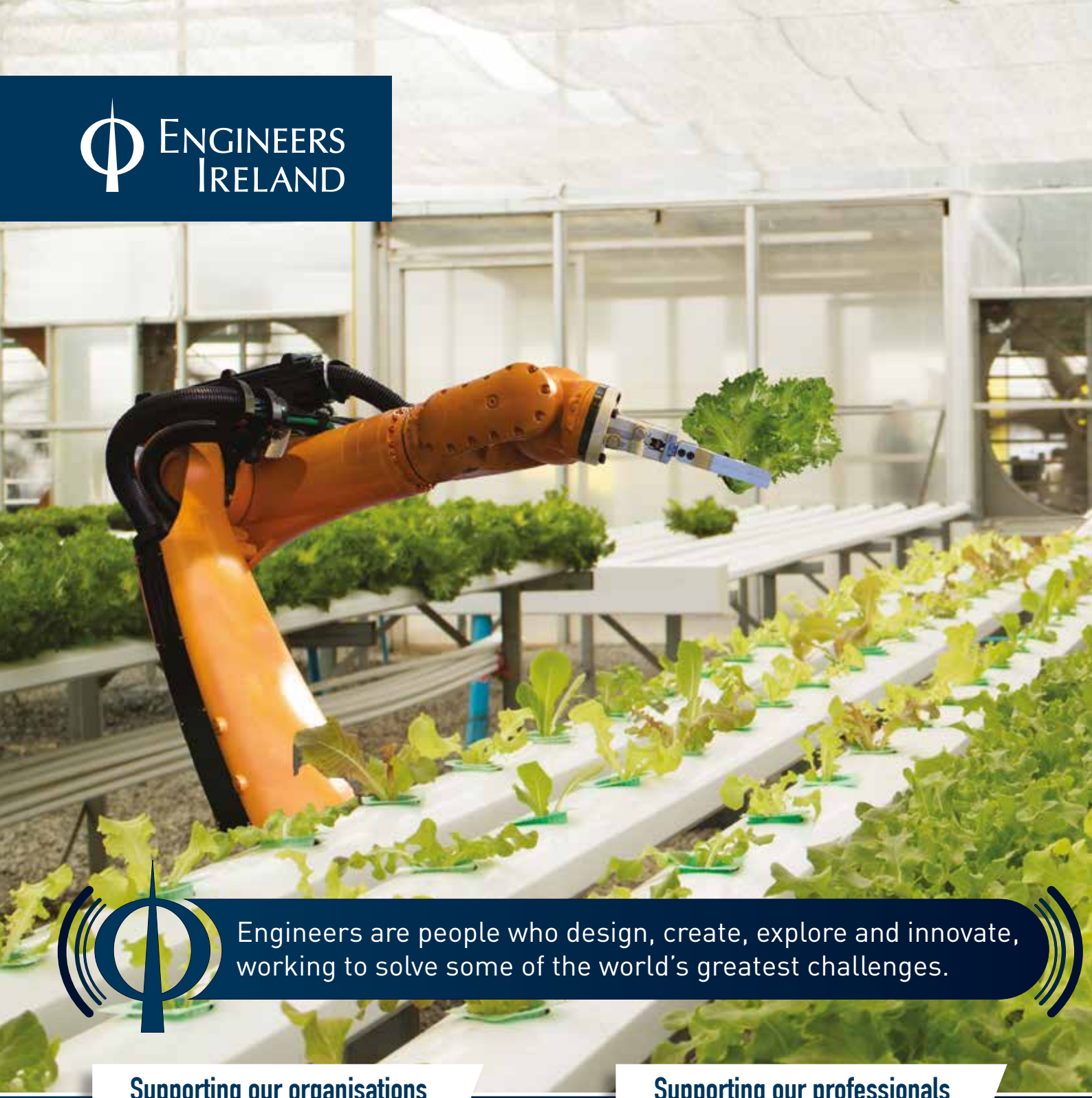
NUI Galway

The project method was adopted from studies by the Sustainable Development Solutions Network Australia/Pacific (SDSN Australia/Pacific, 2017) and an Austrian project on measuring research papers contribution towards the SDGs (Körfgen et al., 2018). The SDSN Australia/Pacific released a 'Guide for getting started with the SDGs in Universities' which provided extensive direction for this project. Once decided that a keyword search would be the approach taken, the first step was to build the tool. Microsoft Excel was chosen due to its versatility in data analysis and accessibility. The end goal of this tool is that it can be used by many universities across many disciplines. Through many relatively rudimentary excel functions, the tool was built in excel with the following outcomes:

- Be capable of analysing up to 500 Learning Outcomes of any given curriculum
- Produce easy-to-read results showing to extent to which each SDG is covered
- Have tools present for further in-depth analysis if required
- Have tools present to link a spreadsheet containing any given degree to another 'Master' spreadsheet, which can be used for broader, cross-discipline analysis.

Bibliography:

- KÖRFGEN, A. et al. (2018) It's a Hit! Mapping Austrian research contributions to the sustainable development goals. Sustainability (Switzerland), 10(9), pp. 1–13.
- MONASH UNIVERSITY (2017) Compiled-Keywords-for-SDG-Mapping_Final_17-05-10. [Online] Australia/Pacific Sustainable Development Solutions Network (SDSN). Available from: http://ap-unsdsn.org/wp-content/uploads/2017/04/Compiled-Keywords-for-SDGMapping_Final_17-05-10.xlsx [Accessed 03/02/20].
- SDSN AUSTRALIA/PACIFIC (2017) Getting started with the SDGs in universities: A guide for universities, higher education institutions, and the academic sector. Australia, New Zealand and Pacific Edition. Sustainable Development Solutions Network. Australia/Pacific -Melbourne.



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