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Nottingham Business School
Nottingham Trent University

Equality, diversity, and inclusivity in engineering, 2013 to 2022: a review

December 2023

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Royal Academy of Engineering
Prince Philip House, 3 Carlton House Terrace,
London SW1Y 5DG

Tel: 020 7766 0600

www.raeng.org.uk

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Nottingham Trent University
50 Shakespeare Street
Nottingham
NG1 4FQ

Tel: (0)115 848 2999

Email: enqiries@ntu.ac.uk

Equality, diversity, and inclusivity in engineering, 2013 to 2022: a review

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Report prepared by Nottingham Business School:

Dr Maranda Ridgway

Dr Louise Oldridge

Dr Michaela Edwards

Dr Nadia Kougiannou

Dr Sarah Pass

Dr Scott Lawley

Dr Val Caven

Royal Academy of Engineering

NBS Nottingham Business School
Nottingham Trent University

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Glossary

Discrimination	Unlawful discrimination under the Equality Act 2010 is the less favourable treatment of a person (for example, at work or in the provision of a service) because of a protected characteristic. This can be because the person discriminated against has that protected characteristic or is perceived to have it, and discrimination by association is also prohibited. The Equality Act includes direct and indirect discrimination, harassment and victimisation, discrimination arising from disability, and failure to make reasonable adjustments.
Diversity	A group or organisation is diverse when it includes people with various characteristics, backgrounds and experiences.
Equality	Equality is given different conceptual meanings by different people. It can refer to formal legal equality, non-discrimination, equality of opportunity, equality of outcome, and substantive equality. It can refer to equality between people with different protected characteristics, as well as to socio-economic equality. Equality is concerned with justice, the removal of barriers to fairness and the transformation of society so that all may participate. Social inequality arises from interpersonal prejudice and systemic, structural, and institutional bias.
Equity	Equity, like equality, is imbued with different conceptual meanings by different people. It usually frames Equality (of outcome) as the desired end state, with an equitable approach being required in order to reach that end state. Equity has a particular focus on recognising and rectifying systemic disparities, through targeted interventions aimed at levelling the playing field. Equity emphasises the need to ensure fair and just opportunities, outcomes, and treatment for individuals and groups, considering their unique circumstances, historical disadvantages, and intersecting identities.
Inclusion	The extent to which people feel valued for who they are (their personal and professional background, experience, and skills) and the extent to which people feel they belong or ‘fit’ in the engineering profession and their organisation, regardless of their protected characteristics.

Intersectionality	Intersectionality is a theory and metaphor deriving from Black feminist scholarship, which articulates how multiple and combined inequalities shape the experiences and outcomes of underrepresented groups.
Leaky pipeline	A metaphor for the fact that a proportion of individuals, typically from underrepresented groups, drop out or fail to progress at various stages of a career or educational pathway, resulting in a considerable loss of workforce talent and diversity.
Microaggressions	A microaggression is a brief, subtle, sometimes unintentional, behaviour or interaction that communicates a bias towards an individual from a marginalised group.
Social class	Social class refers to the stratification of society by social and economic status. Social class can be challenging to operationalise as a concept due to its many dimensions.
Social mobility	Social mobility refers to how individuals move between socioeconomic strata within one's lifetime and between generations. It relates to the extent to which our society is 'open' or 'fair'. Education plays a vital role in this process.
Protected characteristics	A person's characteristics identified in the Equality Act 2010: age, disability, gender reassignment (being transgender or trans), marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex, and sexual orientation. Among other things, individuals have a legal right not to be treated less favourably by their employer or a service provider because of a protected characteristic.
Science capital	This refers to individuals' knowledge, attitudes, experiences, and resources enabling them to engage with and participate in science-related activities, such as science education, careers, and informal learning opportunities. In addition, it includes various forms of cultural and social capital, such as access to information, networks, role models, experiences, confidence, interest, and identity as science learners or professionals.

Executive summary

This review summarises the literature on equality, diversity, and inclusivity (EDI) in engineering employment in the UK over the past 10 years. It identifies trends, issues, and the demonstrable impact of EDI research. In doing so, it uncovers under-researched areas and makes recommendations for future lines of inquiry. There were 506 documents included in the review across five literature source categories: 1) academic literature, 2) professional engineering institutions, 3) corporate organisations and trade unions, 4) not-for-profit and engineering magazines, and 5) policy.

Gender was the most prominent theme, with increased attention given to gender equality and inclusion in the engineering industry over the past decade and various organisations raising concerns about the lack of representation of women in engineering. Significantly, in 2021, only 16.5% of people in engineering roles were women.[1]
The literature also highlighted the 'leaky pipeline' phenomenon, where women leave their careers due to structural and systemic workplace barriers. Efforts to address gender disparities and create more inclusive environments have improved opportunities and representation for women in engineering. However, despite progress, women face various challenges and barriers in the industry, such as stereotyping, bias, and limited career advancement opportunities. These persistent issues highlight the need for ongoing efforts to ensure equal opportunities and representation for all genders in engineering.

While gender equality has received significant focus, other categories of difference, such as ethnicity, have not received the same attention and action. For example, categories such as age, religion, neurodiversity, and non-binary identities, were only briefly mentioned in a few reports.

The report's findings draw attention to the risk of systemic issues prevailing in the industry, emphasising the importance of considering EDI from an intersectional perspective. Recognising that individuals embody multiple social identities and face overlapping forms of discrimination is essential. Categories of difference rarely exist in isolation; they intersect and influence each other, shaping individuals' experiences and opportunities. Intersectionality describes overlapping categories of difference beyond its initial description of simultaneous racial and gender prejudice; for example, in the technology industry, Black women made up fewer than 1% of the technology workforce in 2020.

Stereotypes, bias, and discrimination create barriers to equality and diversity, and addressing these issues is essential to promote inclusion. The report outlines potentially promising practices to improve EDI performance within the sector, including:

- **Establishing equality communities**
- **Providing equitable career guidance**
- **Engaging with local community organisations**
- **Implementing conscious inclusion programmes**
- **Data collection and monitoring**
- **Promoting networking and social events**
- **Introducing diversity pay gap reporting**
- **Removing bureaucracy**
- **Implementing reciprocal mentoring and**
- **Returners programmes.**

The report highlights several research recommendations which are discussed in more detail and supported by indicative research questions in the report.

Recommendations

1. **The Royal Academy of Engineering should focus on comprehending and addressing systemic issues and barriers** encountered by underrepresented groups to dismantle such barriers to promote equitable opportunities and inclusive environments within the field.
2. **Future research should employ a longitudinal approach that examines the lived experiences and career trajectory of underrepresented groups**, uncovering the obstacles they encounter and enabling the development of targeted strategies to dismantle these barriers.
3. **Future research needs to explore all identity characteristics in depth.** This is because the literature review returned fewer documents relating to age, nationality, immigration or language, socioeconomic status, religion or belief, neurodiversity, non-binary identities, and maternity, paternity or family.
4. **A thorough evaluation of EDI interventions is crucial for creating diverse and inclusive environments**, providing valuable insights to develop evidence-based strategies that enhance diversity, foster inclusivity, and address systemic barriers.
5. **It is necessary to examine the intersections of gender, race, ethnicity, age, disability, socioeconomic status, and other characteristics**, using an intersectional approach to identify and dismantle the distinct barriers and opportunities faced by those who encounter multiple forms of disadvantage.
6. **The Academy should collaborate with community partners to benefit from their unique perspectives and expertise**, leading to a better understanding of barriers and opportunities within different communities and developing effective strategies to foster inclusion and diversity in engineering.

Background and approach

Research background and objectives

Background

Nottingham Business School (NBS), part of Nottingham Trent University, was commissioned by the Royal Academy of Engineering (the Academy) to conduct a literature review of equality, diversity, and inclusivity[i] (EDI) in engineering in the UK over the past 10 years.

Over the past fifteen years, the Academy has been at the forefront of efforts to incorporate diversity and inclusion principles into the field of engineering. Through a strategic blend of programmes, research initiatives, and analytical studies, the Academy has sought to systematically address the factors contributing to the underrepresentation of certain groups within the profession. This sustained commitment involves a comprehensive exploration of the challenges that hinder broader participation in engineering. The Academy's approach is marked by a pragmatic lens, seeking practical solutions to foster an inclusive environment within the engineering community.

There has been a marked increase in research and activities aimed at increasing EDI within the engineering profession, leading to an increasing amount of literature in this area over the past 10 years. This report seeks to develop the Academy's understanding and inform its diversity and inclusivity research programme. Therefore, this review reports on the themes, trends and issues related to EDI in engineering, focussing on research released over the past 10 years.

Objectives

The review aims to enable the Academy to judge what has been learned across the engineering profession in the context of employment and what has been acted upon in the past decade. Therefore, the objectives of this review are:

1. To identify and summarise the trends, issues, and demonstrable impacts of EDI research in employment over the past 10 years, particularly identifying what has been learned, acted upon, and what works.
2. Uncover neglected and under-researched areas in engineering employment and make recommendations for future lines of inquiry.
3. Help diversity and inclusion professionals working in engineering organisations, Chief Executive Officers and senior leaders, practitioners, policymakers, and researchers to focus on relevant questions to inform their research, practice, and impact in EDI.

The following research questions shaped the review:

- What are the critical lines of inquiry related to EDI in research and broader literature over the past 10 years?
- What are the central EDI themes and issues identified in the research and literature?
- What areas of EDI in the engineering profession are under-researched and why?
- What type of EDI interventions and actions are being researched, and how effective are their implementation and impact?
- Which underrepresented groups are the focus of research? Which groups are under-researched?
- To what extent is there an influence of research on policy and practice? Where are academics or policymakers most confident about 'what works' in creating change in EDI in engineering?

[i] The terms inclusivity and inclusion are used interchangeably in this report.

Overview of approach

The literature review followed two broad phases: literature search and analysis.

Literature search strategy

The search strategy was devised by organising literature search locations into five categories:

1) Academic literature

Web of Science was selected as a database to source relevant peer-reviewed academic journal articles.

2) Professional engineering institutions

All professional engineering institutions (PEIs) granted licences by the Engineering Council were included in the literature search. The complete list is detailed in Appendix 1.

3) Corporate organisations and trade unions

The complete list of EngineeringUK members, accessed from their website's 'our members' page, was used as a source of corporations. Additionally, searches were conducted on trade unions' websites that cover the engineering profession, namely Unite and Prospect. A complete list of the corporate organisations and trade unions used for the literature search is detailed in Appendix 2.

4) Not-for-profit and engineering magazines (further grey literature)

A complete list of the not-for-profit and engineering magazines used for the literature search is detailed in Appendix 3.

5) Policy (government and engineering sector bodies)

A complete list of the national policy and evaluation locations used for the literature search is detailed in Appendix 4.

Literature search criteria

Three levels of search terms were used:

1. At the top level, broad terms relating to EDI were used: equality, diversity, inclusion, inclusivity.
2. The second level used terms relevant to the protected characteristics outlined in the Equality Act (2010): ageism, disability, gender, trans, marriage, civil partnership, pregnancy, maternity, race, ethnicity, religion, sex, sexual orientation, LGBTQ+. Where relevant, updated terms to reflect current usage and understandings were used (for example, trans as well as gender reassignment).
3. The final level reflects terms not specified as protected characteristics in the Equality Act but felt relevant to a contemporary understanding of EDI: caste, socioeconomic status, social class, regionality, neurodiversity, non-binary, intersectionality, colourism, shadeism (prejudice based on skin colour, shade or tone, which can manifest within as well as between racial or ethnic groups).

Following a manual review to check for relevance, a total of 506 documents were included in the review.

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Analysis

All documents were converted into Portable Document Format (PDF) and uploaded to QSR NVIVO for analysis. Each document was categorised; the assigned categories form some of the structured section headings under the Review Findings.

Each document was also allocated to an overarching topic, as follows:

- Barriers to EDI
- Increasing EDI
- Closing pay gaps
- Measuring EDI
- Commitment to EDI
- Networks/allyship
- EDI policy
- Progression/deflection/retention
- EDI reporting
- Promoting awareness
- Equality guidance
- Role models
- External partnership
- Talent/skills development
- Impact of COVID-19
- Young/future engineers
- Importance of EDI

Each document was thematically coded against a coding framework which captured, for example, discipline, characteristics, barriers and good practice. Other codes emerged during the coding process, such as (but not limited to) data monitoring, returners (to the engineering profession) and mental health. Similarly, some codes were subsequently merged or consolidated for analytical clarity.

Where multiple documents (for example., EDI strategy, pay gap reports) from the same organisation referred to the same initiatives, duplicate coding was not used to avoid misrepresenting the content. Only the most recent reports on the same topic (for example, pay gap) were included.

This analytical approach helped provide a systematic framework for organising and structuring qualitative data. Through coding and categorisation, the data were organised and indexed. Thematic analysis helps to make sense of large volumes of data and identify common themes or patterns across different data sources. It allows for capturing the rich and nuanced aspects of the data, providing a more holistic understanding of the topic. This approach permitted prominent themes across the literature to emerge. Most of the report presents a more in-depth and detailed review of the most prominent themes.

Due to the complexity of the topic, it was also helpful to give more depth on some documents than others. For example, where an existing report directly addressed this report's purpose (for example, Atkins' Career Deflection Report [2]), it is discussed in more detail. Where multiple documents address the same topic, they are presented thematically (for example, barriers women face in engineering) rather than each document coded under this theme being summarised individually, as much of the content is similar and speaks to the same point.

In assessing the qualitative conclusions drawn from the different sources utilised in this report, it is essential to acknowledge the potential variability in their rigour and purpose. Different document types may vary in terms of their methodological robustness and the intended audience. Therefore, the authors or institutions involved, the level of peer review or editorial oversight, and the methodology employed in generating the information were carefully considered in assessing the quality and reliability of each source.

Over- and under-representation in research

As this report aims to uncover neglected and under-researched areas of EDI in engineering employment, it is helpful to consider how and why certain areas may become over- or under-represented in research by shedding light on some factors that may influence such trends. It is essential to recognise that the quantity of research conducted does not necessarily indicate the relative importance, size, or complexity of the issue being addressed.

Over-representation in research occurs when a topic receives greater attention and resources compared to other topics. Several factors can contribute to this phenomenon. For example, an influential piece of literature can highlight an important new issue or unlock a new way of thinking that ignites interest and prompts researchers to delve deeper into the subject. The prominence of such work can create a snowball effect, with subsequent studies building upon the original research, leading to a disproportionate emphasis on a particular area. External factors such as funding availability, media attention, and popular trends can also drive over-representation in research.

Conversely, under-representation in research occurs when a topic or issue of significant importance receives insufficient attention. Again, many factors can contribute to this phenomenon. One reason is the lack of awareness or limited understanding of the issue's significance, particularly among the academic community. Consequently, limited funding and resources are allocated to such areas, impeding further investigation. Additionally, complex or niche subjects that require interdisciplinary collaboration or specialised expertise may not be researched due to the limited availability of researchers with the necessary skills and knowledge. Furthermore, prevailing biases or societal norms can influence the prioritisation of research areas, inadvertently leading to the neglect of critical issues.

In sum, while the volume of literature on the different topics is discussed in this report, it is important to note that the quantity of research conducted does not always indicate the comparative size or complexity of the issue being addressed.

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Review findings

Equality, diversity, and inclusivity

Figure 1 shows the number of EDI-related publications over the past decade by year. Encouragingly, there is an upward trajectory with a growing number of topics covered. The most significant proportion of documents from the search fall within the umbrella category of EDI.

Within this category, there are three points of note:

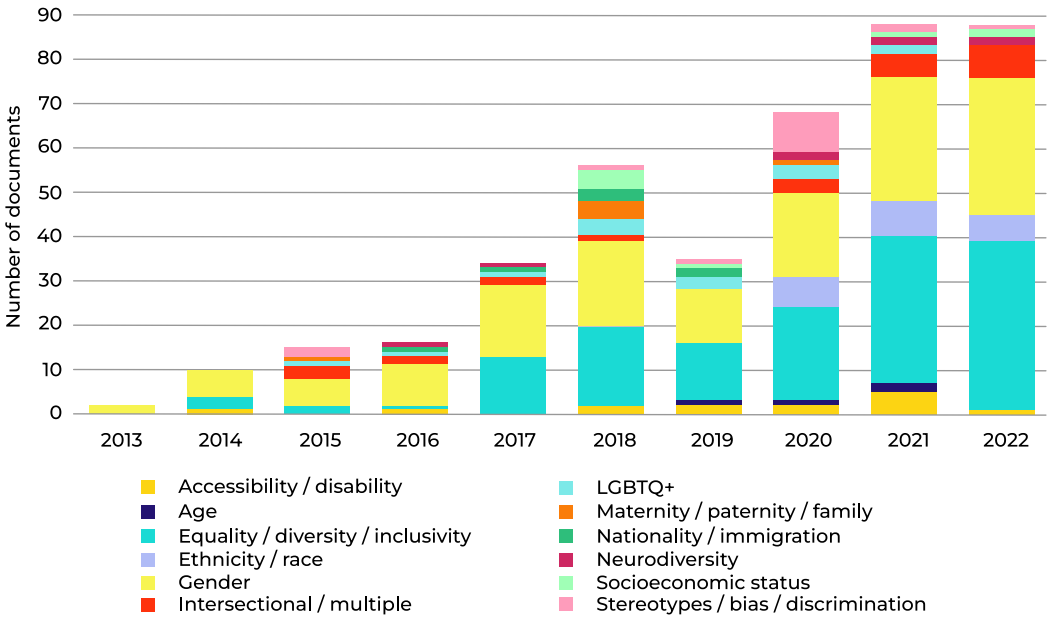
1. Use of the term 'equity' versus 'equality'; national policy sources (for example, All Party Parliamentary Groups (APPGs)) and others discuss equity, while most other documentation refers to equality.
2. Within this category, most documents focus on diversity.
3. The terms inclusion and inclusivity are used interchangeably.

In academic literature, 'stereotypes' appeared in 55.7% of documents, 'bias' in 49.2% and 'discrimination' in 47.5%. In the corporate literature, 'discrimination' appeared in 25% of documents and 'bias' in 23.9%. In the literature produced by trade unions, 'discrimination' appeared in 82.6% of the documents. The documents focussed on addressing stereotypes, bias, and discrimination to identify barriers to EDI and provide guidance towards equality.

A noteworthy development in engineering is the growing emphasis on EDI to tackle inequalities through inclusive design strategies. A prime example is Arup's partnership with the University of Liverpool and UNDP to establish Cities Alive, a gender-responsive project approach.[3] It is essential to recognise the positive nature of this shift in focus. Nonetheless, it is necessary to clarify that this report confines its scope to employment. Consequently, EDI in design has been deliberately excluded from the discussion.

It should be highlighted that data collection and monitoring are crucial to implementing successful EDI initiatives. However, in many cases, data collection

Figure 1: Document categories over time (documents without a date are excluded)



and tracking are lacking or have inconsistent categorisation. Furthermore, there is a lack of data about intersectional identities and a call to refine data collection to account for this. The Academy [4] highlights the importance of data and monitoring and offers detailed diversity monitoring guidelines.

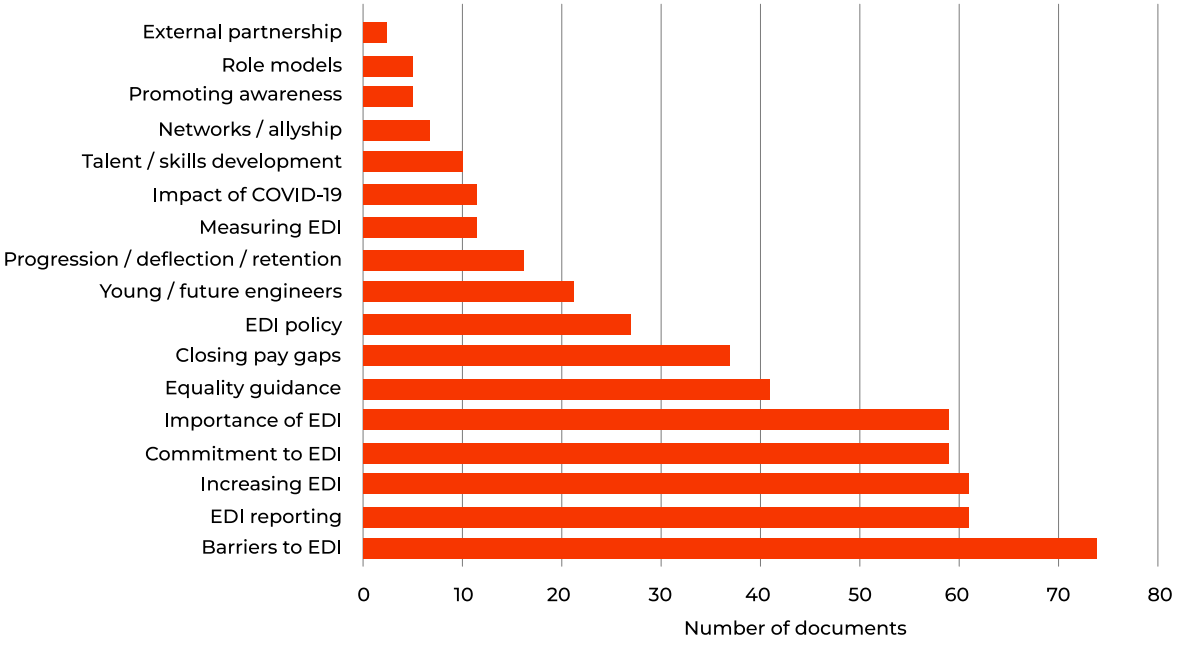
Figure 2 shows that a significant proportion of the literature has been categorised as the organisational commitment to EDI (such as strategies), progressing action on EDI (including toolkits) and reporting on EDI. Taken together, this proportion of the literature indicates that the intention to improve EDI supported by action and measurement has gained traction in the past decade.

Encouragingly, many organisations have published explicit initiatives and, in some cases, successful outcomes. However, when initiatives did not lead to positive results, these were not apparent or shared. At the same time, some organisations have investigated EDI to understand barriers (for example, entry into the profession or career progression within the profession) faced by different groups.

For example, the Institute of Physics' (IOP) [5] submission to the House of Commons Science and Technology Committee Inquiry into Diversity in STEM [ii] summarised the leading causes of underrepresentation in physics, including barriers to studying the subject. These barriers lead to fewer people from underrepresented groups progressing into the workforce and a lower attraction and retention rate among underrepresented groups in the workforce.

In the Chartered Institution of Highways and Transportation (CIHT) [6] survey of corporate partners, 46% of respondents said they do not have "enough diverse employees for us to use as role models to attract and inspire a more diverse workforce"(p10). In addition, a quarter of respondents claimed the physical work environment hampered an inclusive workforce,

Figure 2: Literature categorisation



[ii] science, technology, engineering, and mathematics

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and 21% of respondents recognised that their workplace culture could feel unwelcoming to some people from underrepresented groups.

Other points of note include organisations using awards or participation in events, for example, Pride, to demonstrate commitment to EDI. Furthermore, awareness weeks have provided a departure point in drawing attention to lesser-discussed issues. For example, the British Computer Society (BCS)[7] used awareness days/weeks to highlight invisible disabilities, such as dyslexia, attention deficit hyperactivity disorder (ADHD), and Asperger syndrome, to discuss neurological differences in the context of diversity. However, it is essential to note that other organisations have done little more than make generic statements.

Coupled with the intent to progress EDI is the need to address systemic issues. However, only a few documents address systemic problems (even if they do not use this terminology specifically), such as the division of domestic labour or the under-representation of Black pupils in science education. Notably, there is some crossover between systemic issues, intersectionality and science capital, which are discussed later in the report.

In some cases, the phrase 'systemic issues' is mentioned but not explored in more depth or is mentioned generally as an area worth more investigation; for example, the Government, Science and Engineering (GSE) Profession[8] state:

"Working collaboratively with the GSE Diversity and Inclusion Action Group (DIAG), we will drive the delivery of solutions and interventions to meet systematic challenges within science and engineering. DIAG is made up of members at all grades and roles from across the Profession and is an integral partner, ensuring that the Profession stays connected and aligned to its members' needs. DIAG's aim is to support growing a truly inclusive work environment to result in improved performance delivered through a confident workforce and strong, accountable leadership."

The Academy[9] goes further by recognising the link between systemic issues and broader societal dynamics:

"The inclusion challenges at play in engineering organisations are intrinsically linked to systemic inequality in wider society."

Finally, the BSA[33] presents an extensive analysis of how COVID-19 has exacerbated many existing structural inequalities in STEM and calls for longitudinal research into its ongoing effects.

Initiatives

The review identified many promising areas of practice, a few of which are highlighted in Table 1 as examples.

Table 1: Example EDI initiatives

The Engineering and Physical Sciences Research Council [10]	• Inclusion Matters programme: a collaboration between UK universities, businesses and learned societies consisting of 11 projects to accelerate culture change concerning EDI.
Ultra [11]	• Focus on actions, plans and culture rather than target numbers. • Rethink job design; not defaulting to old job descriptions and the previous incumbent's role, challenging the necessity of qualifications, face-to-face work, and specialist skills. • Review succession plans for the inclusion and progression of underrepresented people.
HS2 [12]	• Senior Leadership Team (SLT) development seats; top talent joins SLT for 12 months to develop relationships and project knowledge. • Staff network career development sessions to clarify various development opportunities and support resources. • Mentoring and reverse mentoring provide opportunities to develop relationships and skills by accessing expertise.
Jacobs [13]	• Establish Junior Leadership Teams and Shadow Leadership Teams to integrate creative thought into decision-making and provide development and internal network growth. • Staff attendance at McKinsey's Black Leadership Academy. • Implement a diverse mentoring scheme to accelerate career development, learning and networking opportunities for underrepresented employees. • Review succession planning for all director-level roles and above to enhance diverse representation in senior positions. • Trial a Science, Technology, Engineering, Arts and Mathematics (STEAM) Returners programme for experienced professionals returning to work after a career break. • Extend the STEAM Ambassadors programme to inspire future generations into STEAM careers.
Transport for London [14]	• Develop awareness and training of neurodiversity. • Embed equality and inclusion into onboarding material to ensure new colleagues understand commitments. • Review Diversity Dashboards to ensure they are intuitive, informative, and engaging for line managers. • Launch a coaching, mentoring and sponsorship strategy to upskill managers and develop their coaching capability. • Introduce an 'Our Time' development programme for women and employees from underrepresented groups. • Collaborate with Staff Network Groups to deliver career development and skills workshops.

HS2 [12] reports successful outcomes due to the initiatives, including consistent or increased promotions of underrepresented groups, women, LGBTQ+ and disabled staff.

Identity characteristics

This part of the report details the literature review, focussing on identity characteristics.

Age

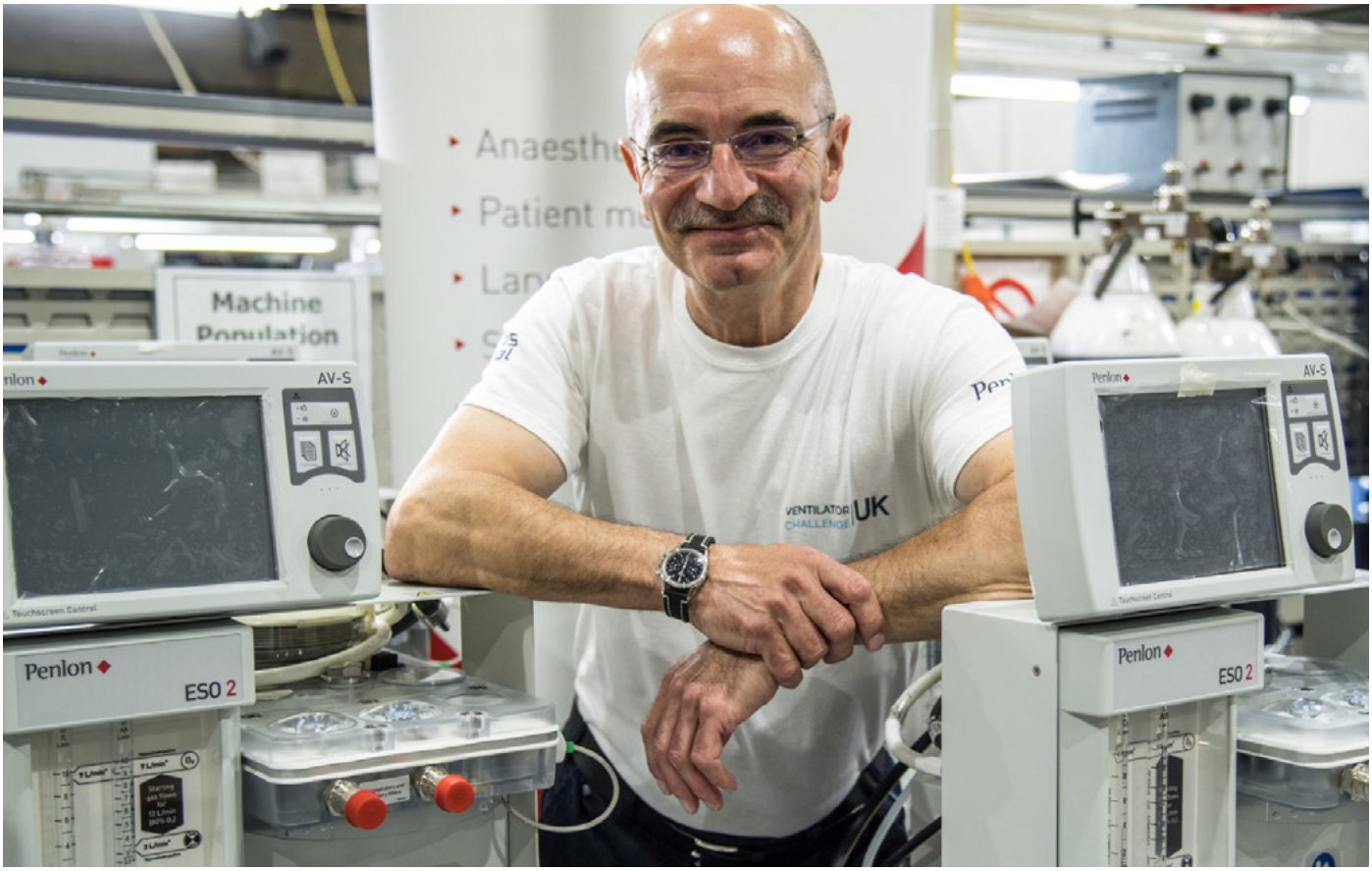
The literature focussing specifically on age-related topics was minimal. Six documents (~1% of the total) focussed on age; three specifically addressed the issue of ageism and the ageing workforce in the information technology (IT) and energy disciplines. BCS [1], the chartered institute for IT [5], states that the number of people over the age of 50 in the IT sector is increasing, leading to a skills shortfall and an ageism problem. More generally, the Campaign for Science and Engineering (CaSE) [16] pointed to the need for an ageing workforce strategy.

The other three documents focussed on initiatives encouraging young people into engineering and STEM careers. These documents explore young people's relationships with science education, including the impact of inequalities.

Disability

The literature on accessibility and disability is limited compared to other characteristics. Seventeen documents (3%) considered accessibility and disability at work. Five of these documents are guidelines to promote workplace accessibility, such as making documents more accessible and requesting reasonable adjustments. Furthermore, disability featured heavily in the literature produced by Trade Unions, with the term 'disabled' appearing in 72% of documents and 'disability' in 70%.

In engineering and technology undergraduate programmes, 10.5% of students had a known disability, compared to 15.1% in all subjects in 2020/21. For postgraduate study, these numbers dropped to 4.2% in taught programmes and 7.3%



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in research degrees. This compares to 9.8% and 12.3% of students studying all subjects on taught and research programmes respectively.[17] BCS [18] noted the underrepresentation of disabled people in IT, suggesting that if representation in IT were equal to the broader workforce, there would have been an additional 65,000 IT specialists in the UK. However, Atkins' Career Deflection Report [2] stated that retention rates for disabled individuals in engineering roles have improved and are now almost the same as those found for non-disabled individuals.

In the academic literature [19], a study found that attainment gaps prevail between STEM students who do and do not declare a disability. The study investigated the process of integrating inclusivity considerations into the development and design of new teaching and learning materials to ensure accessibility and inclusiveness for students with different needs.

Although there are frameworks available, such as guidance and templates, to aid in implementing inclusive practices, using these frameworks poses difficulties for faculty members, potentially affecting students' success. The study found that such frameworks are frequently unclear, and the process of navigating them is excessively complex and time-consuming. The study also found that neglecting inclusivity leads to more requests for "reasonable adjustments, consideration of special circumstances, complaints and lower attainment levels for disabled students"(p6).

Similarly, specific groups, notably women and disabled people, felt more excluded from the laboratory settings in an educational environment, affecting student engagement.[20] Findings suggest that making accommodations for disabled people is often regarded as time-consuming and challenging, especially if organisations lack an understanding of the difficulties faced by disabled individuals.

On a more positive note, commendably, two engineering organisations, Transport for London [21] and Network Rail [22], exceed the gender pay gap reporting requirements and publish reports on their respective disability pay gaps.

Gender

After EDI as an umbrella term, gender was the most prominent theme from the literature review, accounting for 33.2% of all documents. Here, the term 'gender' is used, but this section also includes any references to sex. The literature that has primarily been dominated by gender is encouraging because it demonstrates the increased attention that has been paid to women's under-representation in engineering. However, barriers remain to women's equal participation, and greater attention needs to be paid to other underrepresented groups. In the academic literature, the term 'gender' appeared in 91.8% of articles. In the corporate literature, it occurred in 77.2% of documents, and in the literature prepared by unions, 58.7%.

Government, Parliament, and campaigning organisations have been raising the profile of a lack of representation from specific groups, including women, in the STEM workforce for many years. For example, the Women's Engineering Society has been supporting diversity in engineering for over 100 years, and the Women in Science and Engineering Campaign (WISE) has been aiming to increase the participation of women in STEM since 1984.

While explicit bias against women in the engineering industry has decreased significantly over the last decades, implicit bias prevails.[2] In 2021, only 16.5% of those in engineering roles were women.[1] This underrepresentation is consistent across disciplines. For example, fewer than 10% of company board members in highways and transportation are women.[6] Furthermore, Atkins' Career Deflection Report [2] suggests that women will leave engineering at twice the rate of men.

Gender in higher education

The situation in the workplace is echoed in education. During the 2020/21 academic year, only 18.5% of women enrolled in engineering and technology undergraduate programmes, a significantly lower figure compared to the 56.5% of women students in all subjects. In postgraduate engineering and technology programmes there was an improvement in representation, with 25.8% of women in taught courses and 27.8% in research courses, however, this still fell short of the overall student population's gender balance.[17] Women comprise only 23% of engineering and physical science students, with a starker picture in mechanical engineering (11%) and civil engineering (12%)[24]. Between 2015 and 2018, only 15% of engineering and technology graduates were women.[25] A study [25] found that men who had participated had a well-defined sense of career identity as engineers, which they had developed from a young age, primarily due to paternal influence and early interest in cars and machines. In contrast, women in engineering faced more difficulty establishing themselves in this profession during university studies. A range of factors contributed to constraining their career identities, such as parental responsibilities, job opportunities, and gender biases (both implicit and explicit). The Society of Operations Engineers (SOE)[26] note:

> **"Engineering is seen as a dirty job: an engineer is seen as the man who comes to fix your boiler. We need to be explaining that an engineer designs your car."**

Gendered retention and the 'leaky pipeline'

The 'leaky pipeline' emerged as a solid academic and grey literature theme. The literature reports several contributing factors. The 'leaky pipeline' describes women leaving their engineering careers due to various structural and systematic workplace barriers, resulting in a lack of women in leadership roles.[27]

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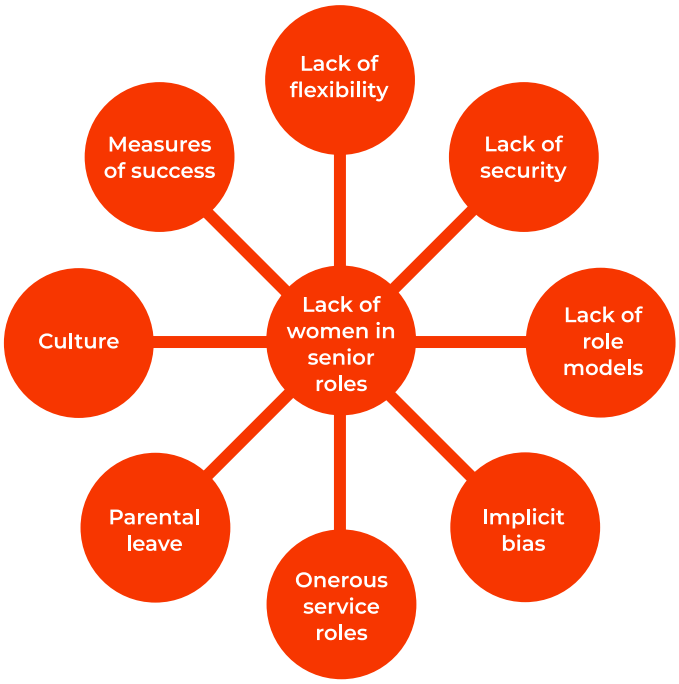
National policy documents focused on facilitating the re-entry of 'returners' to the profession after a period away and removing barriers which hinder this return, with the work of the Daphne Jackson Trust highlighted as an example of good practice. This charity provides support such as fellowships and mentoring to aid women returning to science and engineering research careers.

Research [28] found symbolic violence[iii] against women in engineering (both when studying and working), including denial of access to resources such as networking opportunities crucial to performance at work and university. Concerningly, where women have had access to networking opportunities, they sometimes attempt to neutralise any risk of interactions becoming sexualised by limiting their participation in social networking to avoid discomfort or embarrassment.[29] This problem calls for careful thought about such events to be more inclusive. Moreover, many STEM workplaces (industry and academia) often have gendered cultures that influence the recruitment practices and terms and conditions of work, by shaping expectations and biases regarding suitable roles and candidates. Stereotypes and societal norms can affect how job descriptions are framed, the assessment of candidates, and the opportunities offered to individuals. Consequently, gendered cultures can contribute to gender disparities in the workforce, limiting diversity. Conventional STEM career paths can also be hierarchical and linear, presenting potential barriers for women to return following any career breaks. Limitations in childcare and the availability of local or part-time job opportunities intensify these challenges.[30]

Women interviewed in one study [27] frequently discussed the character of their organisations' idealisations of a great worker, which consistently matched the same description. The 'ideal worker' was expected to work full-time, put in long hours, and be ready to travel without notice. This ideal worker was depicted as a man. Even when organisations state that their promotion processes are unbiased and equally available to women and men, the perception of the ideal worker creates a disadvantage for women, as they are less likely to conform to this ideal and, as a result, are less likely to be perceived as suitable candidates for promotion.

Figure 3: Systemic career barriers faced by women leading to a "leaky" pipeline [27](p774)



[iii] Bourdieu's concept of symbolic violence refers to imposing beliefs and principles to maintain and reproduce unequal power relations in society by constructing these relations as legitimate and natural.

Figure 3 summarises the systemic career barriers that women face. However, such factors are compounded by the underrepresentation of women in engineering, resulting in women individualising their negative experiences rather than perceiving the impact of gender.[28] Other publications have echoed this sentiment, stating that a problem "in the engineering industry is that women deny sexism, offering alternative counter-narratives to explain the discriminatory behaviour they see" [27] (p69).

In the literature produced by organisations and PEIs, there was an emphasis on closing the gender pay gaps. For example, in Atkins' 2021 gender pay gap report [30], they note:

> **"[t]he most significant challenge facing our industry when it comes to closing the gender pay gap is the disproportionate number of men to women across all levels of the career spectrum, particularly in senior roles."**

The Academy's [31] analysis of the gender pay gap focuses on structural issues within the profession and societal problems such as the domestic division of labour. The widening gender pay gap among engineers as they age could be attributed to how starting salaries are awarded to new hires. Graduate engineers who are women are typically offered lower starting salaries than men. Consequently, as engineers receive annual raises based on a percentage of their current salary, men receive larger absolute salary increases each year, resulting in a wider gender pay gap. Additionally, offering salaries to new hires based on their previous salaries exacerbates the issue as women fall behind within their current organisation and experience further relative pay losses when switching to new organisations.

The significant difference in progress rates between men and women in engineering can also be attributed to high attrition rates among women. Nearly half of the engineering graduates who are women securing engineering roles leave within five years. For those who remain in the field, the birth of a child is a critical turning point, as women in engineering are nearly twice as likely as men to switch fields, reduce their working hours to part-time, or leave engineering altogether. Statutory parental leave is not available to men and women on an equal basis. This and other ongoing systemic inequalities mean that caring for a child still typically falls on the mother. Therefore, a lack of family-friendly working arrangements significantly contributes to the attrition rate among women in engineering with children. Although UK law guarantees the right to request flexible working, engineering roles are among the least likely to be advertised as flexible.[32]

Gender and career progression

PEIs are offering insight into how a better gender balance can be achieved. For example, the Royal Aeronautical Society (RAeS) [34] suggest that women would be more likely to apply for jobs if they were encouraged, supported, and could see visible role models. The Royal Institution of Naval Architects (RINA) [35] suggest that formal networks provide a sense of belonging. Informal networks enable peer introductions and advocate the necessity of challenging inappropriate behaviour. Reflecting on the impact of COVID-19, BCS [36] argue the importance of gender equality as the workplace has witnessed enormous changes to working practices, with increased flexibility in time and place of work.

Table 2: Example initiatives to increase women's representation

Network Rail [37]	• Participating in the Women in Rail mentoring programme and Women in Transport's 'Lead' pilot programme.
Transport for London [38]	• Attracting more women by highlighting the careers on offer and showcasing the contributions women have made and continue to make. • Providing opportunities for personal development and progression at all levels. • Establishing an industry-wide network as a legacy of continued improvement and development by running inspirational and thought-provoking events.
Shell [39]	• Senior Women Connect (SWC) – a highly-interactive learning programme for senior women to share and address gender-specific leadership challenges through a series of peer group coaching sessions and providing opportunities to participate in external networking and speaking events. • Women's Career Development Programme (WCDP) – to support early-mid-career women to identify what they want from their professional and personal lives and achieve their full potential.
Ultra [40]	• 'Strategies for Success' aimed at unlocking the capability of senior and high-potential women to support progression. • Free menstrual products are to be rolled out at all major sites. • The dress code has been simplified to "dress appropriately". • Leadership 360 assessment process.

Initiatives

Significant effort is being invested in initiatives to increase women's representation and dismantle systemic barriers, a few of which are highlighted in Table 2 as examples.

In several cases, organisations reported on the success of initiatives to increase gender representation. For example, Atkins [30] notes that they are focused on increasing the number of women employed by the company. They also state that they offer development opportunities to enable employees who are women to progress to more senior positions. The company states it is working with the industry to achieve this goal, and they report their efforts have resulted in a five percentage-point increase in the proportion of engineering and technology undergraduates who are women in the UK between 2011 and 2021 in their organisation. Network Rail [37] reports that the number of women in leadership and management positions and women receiving secondment opportunities and promotions has increased in their organisation. It states that in 2013, women occupied 20.7% of leadership and management positions, rising to 29% in 2020. The Institute of Marine Engineering, Science and Technology (IMarEST) [41] reported on the success of the STEM Returners programme, which helps qualified and experienced workers return to employment after a career break through the provision of short-term placements. Since the scheme began in 2017, it suggests that more than 260 engineers have benefited from the scheme to return to work. Ultra [40] reported an increased internal hiring rate for women of 46.2% from their existing talent pool

of 37.9%. External candidates comprise 34.8% of applications from women, with 40% of all hires being women. Furthermore, in 2021, they reported that their senior leadership levels significantly increased in promotions among women (62%) versus men (38%).

Data considerations of gender representation

The above section presented a range of initiatives reported by various organisations to bolster gender representation. While these examples offer valuable insights, it is important to consider the degree of scrutiny and verification applied to the information. Some instances may provide well-documented and analysed data, while others might be presented more preliminarily or anecdotally.

Some factors to consider when evaluating the credibility of the presented initiatives are shown in Table 3.

It is important to note that while some examples may lack the depth of academic scrutiny typically found in research studies, they still provide valuable examples of real-world efforts which are taking place. Furthermore, where this lack of scrutiny may prevent accepting the examples at face value, it opens the door for further academic research to evaluate and scrutinise the effectiveness of such interventions. It is also important to note that this applies to EDI interventions more widely and is not just restricted to those which relate to gender representation. Therefore, this has been highlighted as an area for potential further research in the recommendations section.

Table 3: Data consideration evaluative factors

Factor	Description
Quantitative data	Initiatives backed by quantifiable data, statistical analysis, and specific metrics generally have higher credibility.
Longitudinal trends	Initiatives demonstrating progress over time provide a more robust understanding of their impact. Organisations that present data spanning multiple years enable a better assessment of the consistency and sustainability of their efforts.
Reporting transparency	Organisations that transparently outline their methodology for data collection, analysis, and reporting enhance the credibility of their initiatives. A clear description of how information was gathered and evaluated fosters greater trust.
Comparative context	Initiatives that benchmark their outcomes against industry standards or recognised benchmarks offer a more meaningful assessment. Such contextualisation helps gauge the significance of reported improvements.
Acknowledgement of limitations	Organisations that acknowledge the limitations of their data or potential biases demonstrate a commitment to honest reporting. Awareness of shortcomings adds a layer of authenticity.

LGBTQ+

This section, 'LGBTQ+', captures the searches for LGBT, trans and non-binary. The literature focussing on topics related to LGBTQ+ was minimal, totalling 18 documents (3.6%). Most commonly, literature related to advocating for LGBTQ+ inclusion and providing guidance on how to do so. In academic literature [42], it has been noted that there are difficulties finding reliable, sector-specific data on LGBTQ+ workers. Indeed, in the corporate literature, the term 'LGBT' appeared in fewer than 20% of documents.

Homophobia has specifically been found to be prevalent in the construction industry; many LGBTQ+ people have encountered homophobic comments at work, leading to higher levels of exclusion, harassment, and negative experiences.[42] These negative experiences and poor organisational responses can challenge those wishing to stay in the industry.

The IOP, Royal Astronomical Society (RAS), and Royal Society of Chemistry (RSC) [43] have collaborated to establish a support network for LGBTQ+ members and allies in the physical sciences community. They surveyed those working in the physical sciences in the UK and Ireland to investigate the workplace culture of LGBTQ+ workers. They reported that 28% of LGBTQ+ respondents had considered leaving the industry because of a hostile environment (that is, unwelcoming, unfriendly or unsupportive behaviour) or discrimination towards LGBTQ+ people. The report suggested that organisations in the physical sciences should increase the visibility of LGBTQ+ workers, create a welcoming community, review and enhance their EDI policies, and introduce or improve staff training related to EDI.

According to the report by IOP, RAS and RSC, 28% of LGBTQ+ respondents had contemplated resigning from work due to the unfavourable climate or discrimination towards the LGBTQ+ community. Both academic and industry respondents highlighted that working with people from cultures that are less accepting of the LGBTQ+ community can pose specific issues. These issues may involve colleagues and students within their workplace or clients outside their company or institution. The impact of being open about one's LGBTQ+ status is highly context-dependent, with varying consequences. While some individuals experienced minor discomfort, others risked losing clients and work that could have significant repercussions for their careers.

The IOP, RAS and RSC report's primary recommendations for enhancing LGBTQ+ inclusion were to:

1. Build a visible and welcoming community, championed and advocated by senior leaders and managers to speak out about LGBTQ+ issues.
2. Review and improve policies to ensure provision and protection for LGBTQ+ workers.
3. Introduce and improve the training that supports LGBTQ+ staff, including training on transgender inclusion, correct pronoun usage, and bystander training.

A few examples of good practice are highlighted in Table 4.

Table 4: Example initiatives to support LGBTQ+ inclusion

IOP [5]	• Gender-neutral toilets in the building. • Staff are encouraged to include pronouns in their signatures and have pronoun stickers at conferences, meetings, and events. • Pride-flag lanyards, badges, and pronoun pins are provided to staff and IOP have supported Pride events at their London office and across the regions, partnering and funding local campaigns and charities supporting LGBTQ+ inclusion.
Network Rail [37]	• An employee network for LGBTQ+ people and allies. Over the last two years, it has supported 1,000 members with events and training. • Gender-neutral toilets at headquarters. • LGBTQ+ pay gap reporting.

Ethnicity

After gender, race and ethnicity were the next most widely addressed topics with 26 documents (5.1%) – notably five times fewer documents than gender. Seventeen documents (3.4%) focused explicitly on stereotypes, bias, and discrimination.

EngineeringUK [17] report that engineering and technology programmes had a higher share of minority ethnic students, notably with a greater number of Asian students across all levels compared to other subjects. However, in highways and transportation, CIHT [6] report that Black, Asian or minority ethnic people make up less than 10% of the workforce (the national average is 14%), and white men occupy 90% or more management roles. The situation in the workplace is echoed in education, with Indian and Pakistani students – the two largest minority ethnic groups – comprising 7% and 4%, respectively.[24] Encouragingly, Atkins' Career Deflection report [2] summarised that retention rates for Black, Asian and minority ethnic groups in engineering roles have improved and are on par with those from white backgrounds.

In their 2022 ethnicity pay gap report, Rolls-Royce [44] claims their ethnicity pay gap is primarily driven by a relatively low representation of employees from underrepresented groups at senior levels and higher representation in junior professional and factory staff roles.

"Whether racial inequality takes the form of microaggressions or implicit and subtle discrimination via behaviour, policy or process, [the] recent focus on 'unconscious bias' and 'unintended discrimination' – both themselves contested terms – can make it difficult for racial inequalities to be challenged." [45]

According to a report commissioned by the Institution of Civil Engineers (ICE) [46], 80% of respondents (comprising ICE members of all ethnicities) acknowledged the presence of racism in engineering, for which the leading cause was unconscious bias. Almost 50% of the respondents mentioned gossiping as a common issue, while nearly 25% stated that face-to-face treatment was a problem. Additionally, 12% of the respondents believed that issues exist in how projects are designed and constructed. Individuals from minority ethnic groups, women and younger respondents had significantly higher levels of concern. However, younger respondents and women were more likely to challenge racist behaviours.

In a study exploring the experiences and challenges faced by minority ethnic women pursuing STEM higher education [45] (p367), research participants were asked about racism in the context of their university experiences:

"[s]everal [STEM] students, especially from [Black, Asian and minority ethnic] backgrounds, spoke of their acceptance of moderate racist behaviours and microaggressions as normal."

According to a report by ICE [46], almost all (99%) Black, Asian and minority ethnic respondents reported experiencing some form of racism in the broader society. In comparison, 81% said they experienced racism in the workplace and 73% within ICE. In contrast, 61% of white British respondents noted evidence of racism in the workplace, and the same proportion (two-thirds) saw evidence of racism within the ICE.

Respondents from minority ethnic groups stated they had been refused opportunities to advance and were not encouraged to pursue promotion. Black respondents were significantly affected, having encountered racist remarks and being victims of racism more frequently. In addition, older engineers from minority ethnic groups believed they had been deprived of progression opportunities.

In contrast to respondents from underrepresented groups, white respondents generally perceived

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their companies as dedicated to promoting EDI. However, minority ethnic groups, notably Black respondents, felt that race was not given the same level of importance as issues related to gender, LGBTQ+, and disability. Interestingly, older respondents from minority ethnic groups did not believe in their companies' commitment to EDI, nor did they believe that their company leaders would bring about change. A proportion of respondents (18%) believed that racial issues are not taken seriously, others (10%) felt a lack of management support, and 9% suggested that the way previous cases were handled led to mistrust.

On a positive note, although fewer companies reported their ethnicity pay gap, some companies have already taken steps in this area, and there are examples of good practices within the sector.

Eighty percent of Black, Asian and minority ethnic engineers would recommend civil engineering to others, but this is significantly lower than the 91% figure for white British engineers. Underrepresented groups strongly desired more support within the profession, but white engineers, particularly older ones, were less inclined to provide support. However, younger white engineers were found to be more supportive. About 32% of the open responses suggested that discrimination was more prevalent in this industry than in others, which poses a risk for both the industry and the profession.

The Hamilton Commission report [47] focussed on race, but from an intersectional and systemic perspective, with engineering portrayed as an industry dominated by white, middle-class men. The report highlighted obstacles within the industry and a general perception

from potential Black engineers that they did not feel they belonged in the profession, with systemic barriers encountered from education onwards. Some of these barriers include geography (most young Black people in England live in areas clustered around major cities while motorsport is typically situated in rural locations), self-identity (concerns about lack of belonging and not fitting in), entry criteria obstructing access to higher education as some teachers tend to underpredict the grades of high-achieving students from a disadvantaged background, and too few apprenticeship opportunities.

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Although ICE's report [46] and the Hamilton Commission [47] were limited to single engineering disciplines, the latest Academy's Inclusive Cultures [48] 2023 report echoed similar sentiments. For example, respondents reported racist comments about skin colour and comparisons to food items; being silenced; incorrect assumptions being made that underestimated their seniority; experiences of harassment about clothing or hair (particularly global majority clothing and hairstyles); and colleagues assuming they did not speak English or are not British.

Some references to race and ethnicity focus on how ingrained (that is, systemic) beliefs create a picture of who is a scientist (this links also with unconscious bias and perceptions, and also the idea of science capital). This topic is covered particularly in the Aspires report [49]:

"Science aspirations and science identity age 10-19 show patterns of inequalities... Inequalities in science identities and aspirations were evident in primary school and exacerbated through secondary school. Students identifying as Black expressed high levels of science aspiration and science self-concept, yet these do not seem to translate into post-16 science participation and/or intentions towards science careers."

The Hamilton Commission [47] has the most detail on systemic issues facing young Black people wishing to become engineers; it also links with science capital and some of the perceptions of who becomes an engineer. In addition, the Commission highlights concerns about the current shift towards stricter behaviour management policies in schools, which result in isolation units and temporary exclusions and disproportionately impact Black students.

Table 5: Example initiatives to tackle racial inequality

Shell [50; 51]	• Campaign to encourage ethnicity declaration to make ethnicity pay gap reporting more meaningful. • The Talent Accelerator – developed by the Black British Business Awards (BBBA) – allows participants to reflect, deliberate and develop, surrounded by peers and senior executive role models from underrepresented groups. • The Emerging Leaders Programme – developed by iNvolve, designed to build confidence, capability, and leadership skills to help diverse talent transition into more senior roles.
Jacobs [52]	• Partner with external organisations to provide leadership development programmes to accelerate advancement for Black employees to mid- and senior-level leadership. • Require senior leaders to sponsor and mentor two employees from diverse backgrounds, ensuring the global reach of mentoring opportunities and accountability for success. • Further strengthen the diversity of the Board of Directors, including Black representation.
Network Rail [53]	• Piloted a career development programme for Black middle management employees who aspire to senior leadership but might feel stuck in their current position. • Launched the Career Discovery Programme for more junior employees from underrepresented groups, focussing on developing their networking skills, building confidence, and learning about their strengths. • Grew the Cultural Fusion employee network for employees from under-represented groups and their allies from nearly 300 to 850 members.

Despite the stark view, several organisations proactively try to address racial inequality; a few examples are summarised in Table 5.

There are examples in the literature where organisations are trying to combat institutional racism. For example, Met Office [54] has a long-running scheme involving nine volunteers trained to provide a confidential and informal service for colleagues experiencing harassment or bullying by listening and signposting to sources of support and advice. Although unconscious bias training emerged several times within the review, there is mixed evidence of its effectiveness.

Encouragingly, some organisations, namely HS2 [12] and Jacobs [52], report they are trying to go beyond unconscious bias training by offering programmes in conscious inclusion. Whereas unconscious bias programmes primarily aim to raise awareness and understanding of the unconscious biases that individuals may hold, conscious inclusion programmes encompass a broader scope focussed on fostering an inclusive environment.

Maternity, paternity, and family

While some documentation focussing on gender also discussed maternity and family-related topics, the documents reported here are those dedicated to maternity, paternity, and family issues, of which there are only ten (2%).

Most of the documentation in the review presented policies on flexible working, maternity, paternity or shared parental leave, including adoption and surrogacy. The documents in the review covered policy and guidance reflecting the legal entitlement to paid leave and the related procedures for utilising leave. In some cases, documents outlined enhanced offerings beyond the statutory provision. However, a report by CIHT [6] found that only 48% of the 25 corporate partners who contributed to the survey used flexible working arrangements to attract and retain engineering talent. Indeed, WISE [55] report that over two-thirds of new parents who left their jobs felt their departure was preventable, with more than half identifying flexible working as a potential solution. Nearly half of those who returned to work credited flexible arrangements as a critical factor. These findings suggest that there is scope for organisations to promote flexible working and family-friendly policies.

Interestingly, a respondent to a study by the Infrastructure Client Group (ICG) [56] stated that their employer framed responses in a way that implied childcare is mainly the responsibility of working mothers. Although their comments were intended to support mothers in the workforce, the assumption that working fathers do not face the challenge of balancing childcare and work responsibilities is problematic. While data suggests that women are disproportionately impacted by additional unpaid work, organisations must be cautious not to assume this as their default position in their responses.

A report published by RaeS [57] found that airlines and training organisations typically do not offer the pilot trainer role part-time, despite preferences expressed by many men and women employed as trainers and pilots. Some departments also prohibit part-time pilot applications, citing a "full-time rule". Although some part-time work occurred during the pandemic, it is unclear whether training departments will recognise the benefits. Allowing part-time pilots to apply would increase women's representation and broaden the talent pool, leading to the inclusion of women who are primary caregivers or later in their careers.

A few examples of good practice are highlighted in Table 6.

Table 6: Example of family-friendly initiatives

Network Rail [37]	• Introduced "Everyone Matters" guides on supporting parents in the workplace, baby loss and fertility. • Launched a parental buddying programme which offers support to colleagues who are about to go on, are on or are returning from any parental leave. • Introduced the first room for parents to express milk in and rest if pregnant.
Ultra [40]	• Lactation spaces are to be rolled out at all major sites. • Priority parking for pregnancy near employee ingress points will be rolled out at all major sites. • Established a global minimum standard for maternity leave.

Nationality, migration, and language

Nationality, migration, and language topics appeared in seven documents (1.4%).

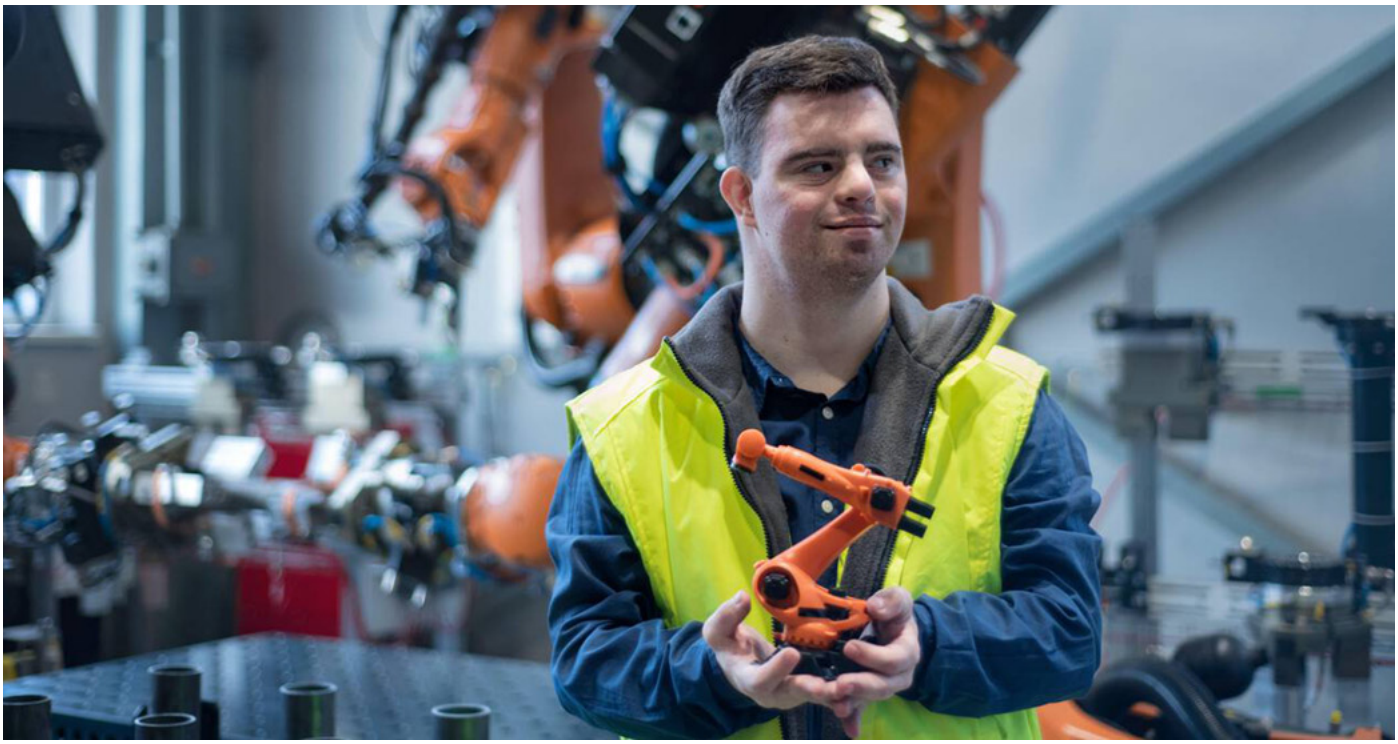
English as a lingua franca does not necessarily eliminate cross-cultural obstacles in business and workplace communication, despite being the common language among engineers worldwide. While using translation to communicate health and safety information to non-native English speakers may appear straightforward, it poses various difficulties. The primary challenge is that translators are typically not hired solely for translation duties but instead balance this responsibility with other tasks on the worksite.[58]

"[p]erceived barriers to qualified employment of migrant women in STEM are mostly related to technical language proficiency rather than the lack of qualified job vacancies for STEM specialists." [59 (p13)]

There is also some focus on nationality and immigration, usually framed around skills shortages in the industry and discussion around Tier 2 visas. This view of reform of visas to facilitate immigration is forwarded particularly by CaSE in numerous publications.

Neurodiversity

Neurodiversity was the central topic of 11 documents (2.2%). These documents focussed on educating about and explaining neurodiversity to readers. Trade unions [60] have compiled valuable resources to provide an understanding of neurodiversity. The British Institute of Non-Destructive Testing (BINDT) [61; 62] and EqualEngineers [63] have developed similar guidance. Encouragingly, the narrative centres around the strengths of neurodiverse individuals, as explained by BCS [64]:



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"Historically, we've focused on the deficits rather than the strengths of these conditions, and that's what we're really starting to do differently at the moment, that's the paradigm shift that we're in, that the strengths are becoming the focus as well as the struggles."

Neurodiversity appears to be gaining deserved attention; more than 15% of the UK population are neurodivergent.[65] For example, Ultra Tl has invited all managers to attend neurodiversity awareness workshops, whereas Stantec [66] has established a Neurodiversity UK Employee Resource Group.

Although there is a growing acknowledgement and awareness of neurodiversity, there is a lack of emphasis on evaluating and studying the prevalence of neurodiversity, specifically within engineering. There is insufficient investigation into the experiences and insights of neurodiverse individuals actively involved in engineering. It is essential for future research to address this gap and explore the firsthand perspectives of neurodiverse individuals engaged in engineering to gain a deeper understanding of their unique challenges, strengths, and contributions.

Religion or belief

In the corporate literature, the term 'religion' appeared in 16% of documents, and the term 'faith' in 8% of documents. However, no documents were dedicated to religion or belief as a topic.

There are some examples of good practice. For example, Transport for London's Diversity and Inclusion webpage [67] highlights their Faith Staff Network Group, which provides a space for colleagues of different faiths and those without faith to identify common issues to improve their working life at Transport for London. Emphasising the core focus, the website writes:

"Promoting understanding of faith and belief and respect for each other's practices is a central part of the Group's activity. The group invites everyone and excludes no one."

Similarly, Network Rail [68] has introduced prayer rooms and quiet spaces for contemplation within their larger offices, completed by a directory of facilities for each route.

However, the Academy's Inclusive Cultures [48] report found instances of employers questioning Muslim engineers' backgrounds, religious beliefs, and work events centred around alcohol consumption.

Socioeconomic status

Socioeconomic status was the focal topic of ten documents (2%). Although not protected under the Equality Act (2010), the IOP collects diversity data, including socioeconomic background, using proxy measures such as highest parental qualification. According to a report by The Bridge Group [69], Engineering professionals show more socio-economic diversity than most comparable sectors due to factors like job distribution, labour market demands, and individual perceptions of the field. Nevertheless, the report underscores challenges in the talent pipeline that hinder the entry and advancement of individuals from less privileged socio-economic backgrounds. For example, the split between vocational and academic paths in the profession creates a two-tier system tied to socio-economic differences.

These risks perpetuate the divide, as students of lower socioeconomic backgrounds often choose vocational routes with fewer advancement opportunities. In comparison, those from higher socio-economic backgrounds access academic paths with higher status and pay.

In the 2015 IOP [70] survey, 11% of respondents reported that their parents held no qualifications, while in 2019, that figure decreased to 7%. While not directly comparable, these figures reported by IOP survey respondents are significantly lower than those reported by the Office for National Statistics (ONS) 2011 census, that 27% of the UK population aged 16 and over achieved a Level 4 or higher qualification. However, the IOP acknowledges difficulties in accurately measuring socioeconomic background.

Socioeconomic status is an intersecting variable with other forms of disadvantage.

> **"[E]fforts to advance social mobility in engineering should consider how the complex interplay between class, gender and ethnicity may cause cumulative disadvantage."** [71 (p3)]

Additionally, there is often a lack of reporting or consistency in how data is recorded, making it difficult to track progress. Socioeconomic status is also related to educational attainment, as young people from minority ethnic groups often face barriers to academic success. Finally, it can be viewed as an aspect of 'science capital', encompassing a young person's social and cultural connection to science, including their background, experiences, and knowledge.

According to a report by EngineeringUK [71], only 11.4% of the engineering workforce is from an underrepresented ethnic group, as compared to 28.2% of the working population. There is evidence that social background has more of a bearing on women's labour market outcomes than men's, particularly for those from Black, Asian or other underrepresented ethnic heritages. Individuals from advantaged social backgrounds (defined using the POLAR4 methodology) are still 40% more likely to achieve an intermediate, managerial, or professional position later in life than their disadvantaged counterparts.

The Institution of Mechanical Engineers (IMechE) [72] suggests that personal connections in the engineering industry are a significant factor in determining success, and individuals from disadvantaged backgrounds are less likely to enter and advance in the field. To enhance the degree of socioeconomic diversity in the workforce, organisations should gather background information and take steps to recruit socio-economically disadvantaged young people.

Employers should also extend outreach efforts to students in areas with the greatest need. For example, despite only representing 45% of all applications, Russell Group students comprise 62% of successful candidates for engineering jobs. However, according to IMechE [72], selecting graduates from these universities does not necessarily lead to superior job performance, and they are also known for having the least socioeconomic diversity among students, making it less likely for employers to attract diverse talent.

Some action has been taken in this area; for example, in 2011, Airbus [73] stated it had signed a long-term agreement on social diversity, equal opportunities and preventing discrimination. It has also signed charters contributing to disadvantaged neighbourhoods' economic and social development. In addition, Network Rail [68] states it seeks to provide opportunities to people from socioeconomically disadvantaged backgrounds and understand what barriers exist to gaining employment in the sector.

Relationships between characteristics

Intersectionality

In the review, 28 documents (5.5%) addressed intersectionality explicitly or by naming an intersectional group, for example, Black women. The term 'intersectionality' was used in 27.9% of academic literature but not frequently elsewhere. Where it has been used, intersectionality often describes overlapping categories of difference beyond its initial description of simultaneous racial and gender prejudice.

Young people from underrepresented groups are often from minority communities and have less access to traditional scientific and cultural knowledge, which is often associated with higher social status.[74] This positioning highlights how inequalities intersect. Where underrepresented young people do not participate in informal science education (that is, learning outside of school, such as visiting a museum), it is often not due to a lack of interest but because of disadvantage, exclusion, and the effects of structural inequalities.

As the IOP[5] report illustrates, the technology industry is notorious for lacking diversity, with Black women only making up 0.7% of the technology workforce in 2020. The IOP encourages the publication of pay data for ethnicity and gender, focusing on intersectionality, to explore the marginalised groups that the data may not initially identify. Commendably, Network Rail[37] includes a section within its gender pay gap report which examines intersectionality specifically.

Notably, there have been calls for research into EDI in engineering to adopt an intersectional analysis; for example, the Academy[75] (p38) states:

> **"We would encourage all organisations to broaden the focus of their activity to include other under-represented groups, and in addition to take an intersectional approach to understand how (for instance) gender and ethnicity intersect to impact the lives of minority ethnic women in science and engineering."**

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Emergent topics

The following section of the report details findings from the literature review that focused on topics that do not explicitly address identity characteristics but still impact EDI.

Career guidance

Within the policy documents, it has been highlighted that to make science and engineering more inclusive, better careers education is crucial, as published by CaSE [76]:

"Under-representation in STEM is perpetuated by a lack of knowledge of career pathways, so careers education is vital to increasing diversity: this is the focus of one of the briefing's key recommendations for government."

Similarly, increased focus from the British Science Association (BSA) and CaSE has been given to apprenticeship from two angles:

1. Apprenticeships are a vehicle through which diversity in engineering can be improved (for example, through opening up vocational pathways into the profession or opening up the profession more generally to new entrants).
2. They focus on making apprenticeships more accessible depending on characteristics such as gender, race, disability and socioeconomic background.

Science capital

The concept of 'science capital' refers to the knowledge, attitudes, skills, and social connections that enable individuals to engage with and participate in science-related activities. It encompasses a wide range of factors influencing an individual's relationship with science, including their understanding of scientific concepts, confidence in their scientific abilities, interest in science, and sense of belonging in the scientific community. Importantly, it acknowledges that science is not limited to formal education or academic settings but is influenced by a person's background, social context, and cultural experiences.

By considering the broader context in which individuals engage with science, science capital seeks to promote inclusivity and diversity within the scientific community and make science more accessible and relevant to people from all backgrounds. Therefore, developing science capital is crucial for promoting science literacy, fostering scientific curiosity, and encouraging individuals to pursue careers in STEM fields. By recognising and nurturing the science capital of individuals, educators, policymakers, and institutions can work towards creating more equitable and inclusive opportunities for engagement with science and inspiring a broader range of individuals to participate in scientific endeavours.

In this review, science capital appears in some documents to capture the intersections of inequality and disadvantage that steer some people away from engineering and science careers (this also intersects with systemic barriers). The Aspires report [49] from University College London (UCL) states:

"Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (for example, knowing someone who works in a science-related job)."

There is an argument that STEM outreach programmes must strive for greater fairness. For example, young people from underserved groups, particularly those from underrepresented ethnic communities, were more likely to have lower levels of science capital and socioeconomic status. This observation emphasises the intersectionality of inequalities, where multiple forms of disadvantage intersect, including factors related to ethnicity, social background, and access to resources.[77]

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Findings by discipline, geography, and document type

In some cases, the targeted literature searchers did not return any relevant documents. There were several reasons this may have occurred: some websites did not have a search function, and a consequential manual search missed the relevant content; navigation was unclear, for example, the search returned irrelevant documents; site maintenance prevented access; and the documents found were dated outside the search period (that is, before 2013).

National policy

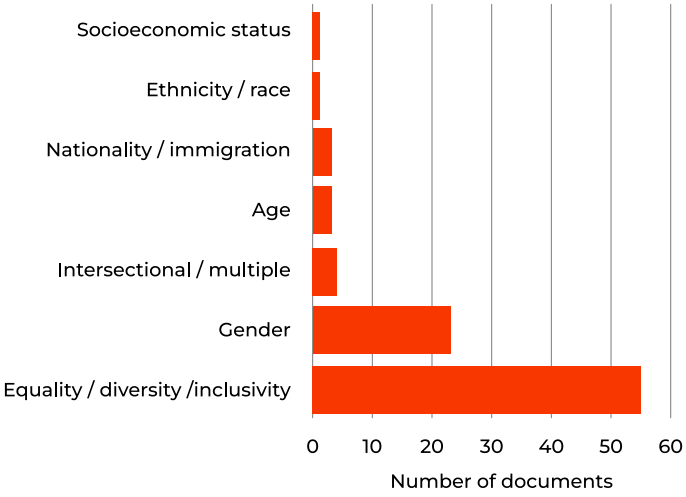
Figure 4 summarises the topical focus of documentation published by national policy sources (where more than one document has been published).

Within the policy publications, most documents are about engineering or STEM in general rather than specific engineering disciplines. Of the few documents that mention specific disciplines, many are Department for Business, Energy & Industrial Strategy (BEIS) sector deals.[iv] However, EDI is often only mentioned briefly, for example, in one or two short paragraphs. For instance, in the North Sea [78] sector deal:

> **"The sector recognises that it needs to tap into the largest pool of talent possible and better reflect modern society by having a diverse and inclusive workforce... [Accordingly], the sector will commit to local initiatives for including people with diverse backgrounds, perspectives and needs, which include age, ethnicity, education and other abilities, including assessing if any systemic issues prevent potential recruits from joining the sector and, if so, how these should be tackled."**

There is a focus on women in Aviation, primarily due to the aviation charter mentioned in the BEIS Aviation sector deal.[79] The aviation sector deal goes into more detail about the charter:

Figure 4: Summary of national policy documentation



> **"The Women in Aviation and Aerospace Charter was launched at Farnborough Airshow and pledges organisations and companies within the aviation and aerospace industry to work towards a more balanced and fair industry for women."**

The Hamilton Commission report [47] focuses on the automotive discipline, specifically on the motorsport industry, discussing engineering and STEM education and careers.

At national policy level, several guidelines, toolkits and strategies have been produced to facilitate the implementation of EDI by organisations within the engineering profession. For example, the Academy [4] produces guidelines relating to diversity monitoring and data collection, outlining 16 critical points for managers to implement EDI. The Academy also provided several toolkits and workshop facilitator guides around creating inclusive cultures. Meanwhile, the Academy and Government Science and Engineering (GSE) have current strategies for

[iv] Sector Deals are government-industry partnerships targeting sector-specific matters, aimed at fostering productivity, employment, innovation, and skills advancement.

increasing the diversity of the engineering professions. For the GSE, diversity and inclusion are also a part of its broader 'profession strategy' for developing the engineering professions.

Support for EDI at the policy level tends to be based on 'business case' explanations, emphasising the benefits of good EDI to business and the broader economy. This emphasis includes widening the skills and talent pipeline into engineering, improving research and development, increasing employee motivation, engagement and retention, and customer satisfaction. Only a few documents make the 'moral case' for EDI or, in the case of the Hamilton report [47], focus on the case for EDI from the perspective of employee experiences.

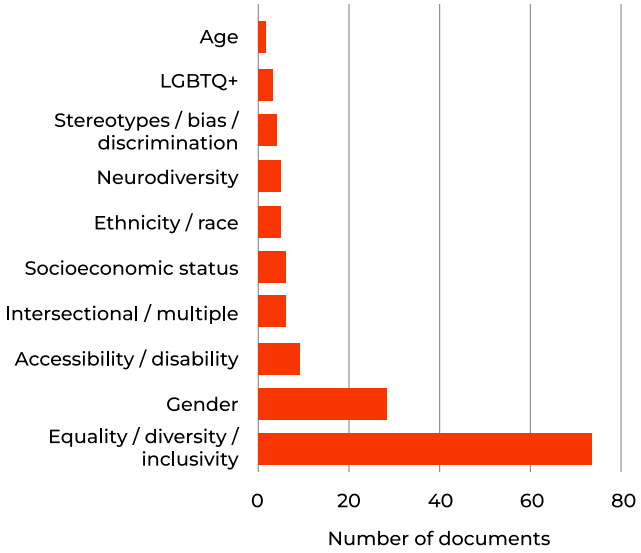
Professional engineering institutions

Figure 5 summarises the topical focus of documentation published by PEIs. EDI generally and gender were the dominant topics in corporate organisational documents. There were no documents which focussed on maternity / paternity / family nor nationality / immigration.

The review found that PEIs often focus on promoting gender equality within the engineering profession, addressing issues such as gender disparities in representation, pay equity, career advancement, and work-life balance.

Over half of all PEI documents in this review address EDI generally; therefore, there is an opportunity for attention to be paid to a broader range of topics in more detail. By broadening the discourse to include under-discussed topics, PEIs can enhance their commitment to EDI and promote a more inclusive and equitable engineering profession.

Figure 5: Summary of PEI documentation



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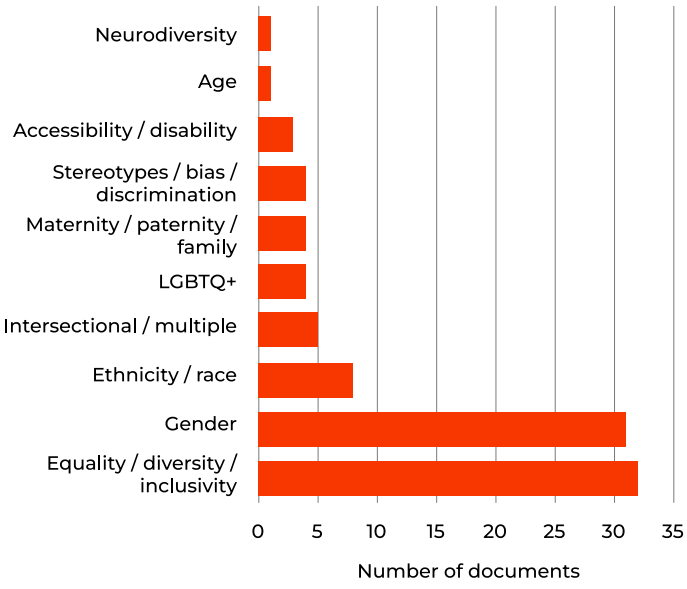
Corporate organisations

Figure 6 summarises the topical focus of documentation published by corporate organisations. EDI generally and gender were the dominant topics in corporate organisational documents. Ethnicity also featured proportionately more frequently than in other literature sources.

However, corporate organisations also have an opportunity to broaden the discourse (for example, no documents focussed on socioeconomic status nor nationality/immigration) to include under-discussed topics and further demonstrate specific diversity dimensions based on their internal priorities and external context.

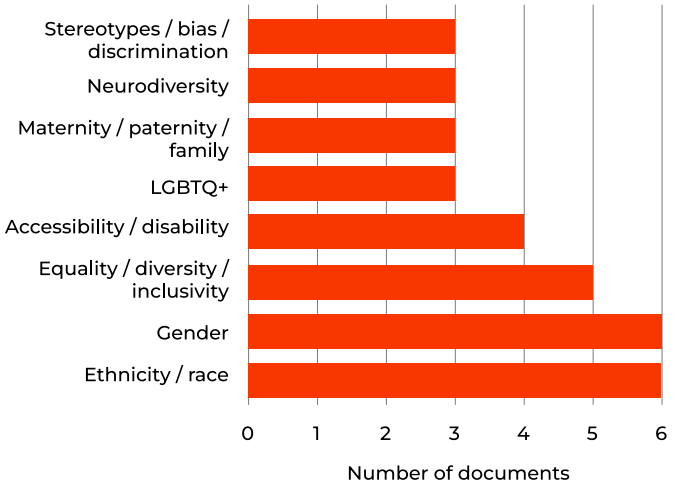
Figure 6: Summary of corporate organisation documentation



Trade Unions

Figure 7 summarises the topical focus of documentation published by the Trade Unions. Overall, there is a broader spread of topics addressed in the Trade Union documentation. However, none of the documents was focused on age, intersectional/multiple categories, nationality/immigration, or socioeconomic status.

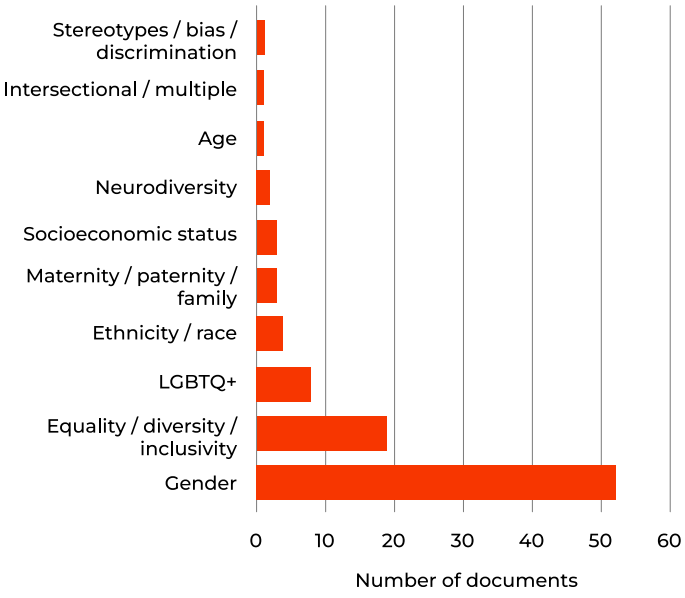
Figure 7: Summary of trade union documentation



Grey literature

Figure 8 summarises the topical focus of documentation published in grey literature sources (Appendix 3). While gender and EDI generally remain prominent, proportionately, more attention has been paid in this literature grouping to LGBTQ+.

Figure 8: Summary of grey literature documentation



Regional representation

Geographically, very little related to specific areas; most documents (95.4%) were assumed to relate to the UK overall as they did not explicitly state a specific geography. There were no apparent patterns of over-represented areas.

Discipline representation

Figure 9 shows the distribution of topics by discipline (after documents categorised as STEM have been removed).

Most EDI literature focuses on Computing and IT or is not aligned with a particular discipline. A high proportion of works focused on engineering students or academics rather than engineers in the industry. Furthermore, many disciplines are not represented, suggesting that a holistic understanding of the industry is needed.

Promising practices

In addition to recommendations for future research, this review revealed several promising practices. Although these practices are not presented as evidence of effective EDI interventions their potential value warrants mention here for consideration by the Academy and industry.

Equality communities, networking and social events

The review demonstrated the benefits of formal and informal networking events. However, to ensure these events achieve their maximum potential, guidance would be helpful to ensure they are inclusive. Across the review, there are many examples of successful and beneficial staff networks, including but not limited to culture and ethnicity, neurodiversity, LGBTQ+, women, faith and disability. Equality communities [48] aim to provide a safe and supportive space for marginalised individuals to speak up and share

their experiences. Allies may use their influence to advocate for policy changes and help create a more equitable workplace. Allies may not necessarily belong to marginalised groups but are committed to promoting equality, inclusion, and fairness in society.

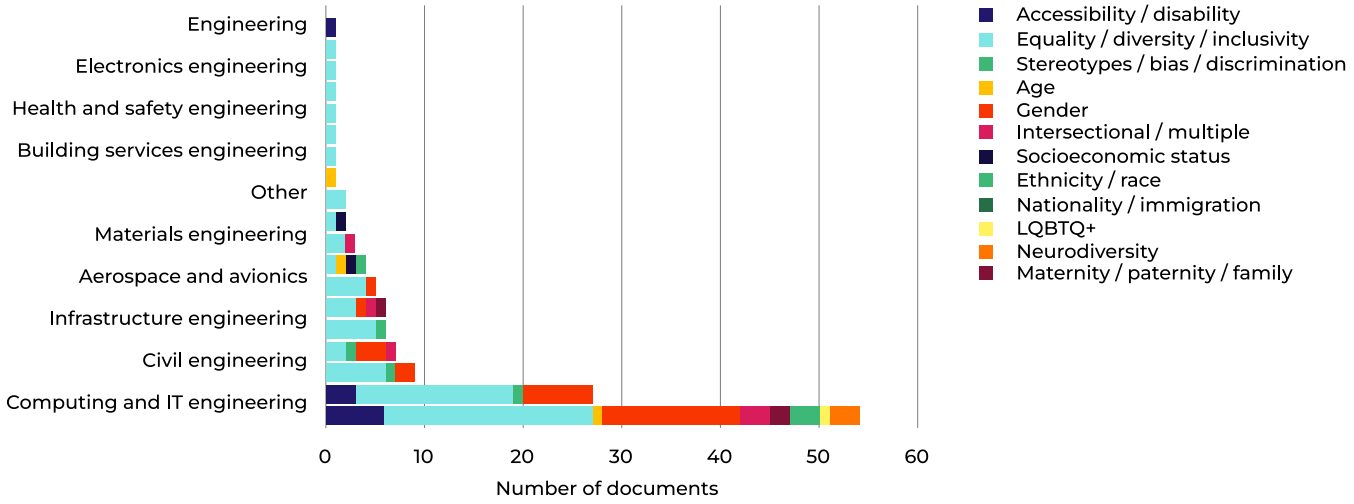
Carers, parents and guardians career guidance

Providing equitable career guidance from an early age is critical in promoting EDI within the engineering profession. For example, inclusive career assessments should capture diverse interests, strengths, and talents, ensuring that individuals feel represented and valued. Equitable career guidance recognises individuals face unique barriers and challenges in accessing and navigating career opportunities. This guidance aims to ensure that everyone, regardless of their background or circumstances, has equal access to the information, guidance, and opportunities necessary to make informed career choices. In addition, by encouraging students from diverse backgrounds to pursue careers in engineering and supporting them throughout their education, the profession can attract a broader range of talented individuals and address existing disparities.

Community engagement

Community engagement has been outlined as crucial to increasing research partnerships. Engaging with local community organisations such as mosques, childcare centres, and youth clubs is a valuable way of businesses becoming more connected to and understanding of the lived experiences of those they both serve and want to employ. Building relationships with these organisations can create collaboration opportunities towards shared goals. In addition, by partnering with community organisations, access to potential employees who may not have considered specific industries or job opportunities may be provided. This access can help to expand the talent pool and create a more diverse and inclusive workforce.

Figure 9: Summary of topics by discipline



Conscious inclusion programmes

Moving beyond unconscious bias training to focus on conscious inclusion programmes. These programmes offer a strategic approach to creating diverse and inclusive workplaces. They involve proactively identifying and addressing potential biases and barriers to inclusion in the workplace and ensuring that all employees feel valued and supported.

Data collection and monitoring

Equality monitoring should provide an accurate understanding of the current situation, enabling potential issues to be identified and addressed. It is crucial for evaluating the effectiveness of EDI interventions. Analysing the collected data should guide the development of a strategy and action plan. Additionally, publishing diversity data and representation will promote a sense of belonging among underrepresented groups.[48] Based on the findings of this review and Progression Framework Report [75], suggested categorisations include:

- Age
- Caring responsibility
- Disability
- Ethnicity
- Flexible working arrangements
- Gender
- Marital status
- Nationality
- Neurodivergence
- Religion
- Sexual orientation
- Socio-economic background
- Being transgender
- Working patterns

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Furthermore, there is a lack of data about intersectional identities and a call to refine data collection to account for this.

Pay gap reporting

Employers with 250 employees must report their gender pay gap annually. However, there are instances of organisations going beyond this requirement and applying the same methodology to voluntarily report on ethnicity, disability and other 'diversity' pay gaps. The Department for Business and Trade has published guidance for employers on ethnicity pay reporting. Some organisations also apply an intersectional lens in their pay gap reporting, providing greater insight into the issue.

Remove bureaucracy

Interrogate and revise 'Reasonable Adjustment' policies to minimise any disadvantage employees may face due to disability, neurodiversity, mental health, or changes in their circumstances. In addition, streamline the approval process for requests under such policies to reduce bureaucratic delays and simplify the process for everyone involved, ultimately leading to greater efficiency and better employee outcomes.

Reciprocal mentoring

Reciprocal mentoring involves pairing junior employees with senior leaders, with both taking on the roles of mentor and mentee.[48] The purpose is to provide leaders with insights and perspectives they may not have otherwise been aware of and encourage them to take action to provide more significant support. In turn, the junior employee benefits from the input of the senior leader.

Returners programme

Returners programmes are recommended to support individuals who have taken a career break and assist them in rejoining the workforce. These programmes should provide training and support to help update their skills and knowledge and facilitate a smooth transition back to work. Furthermore, employers can benefit from these programmes as they gain access to a valuable talent pool and promote diversity and inclusion.

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Recommendations

The review findings have been summarised in an evidence map (Figure 10) to provide representation of the types of finding, such as pay gaps, systemic barriers or underrepresentation, against different categories such as gender, race or disability. This evidence map does not capture all documents, instead it focuses on those documents in which the topic was a significant focus. The number reflects the volume of publications that intersects the topic and category and is colour coded for readability. This evidence map (figure 10) has helped guide the recommendations for research that follow.

Figure 10: Evidence map

	Age (16-24 or 50+)	Disabled people	Minority ethnic groups	Women	Intersectional groups	LGBTQ+ community	Parents or carers (mostly mothers)	Minority faith	Migrant workers	Neurodivergent individuals	Socioeconomically disadvantaged groups	Generally underrepresented groups
Difficulties accessing flexible working	0	0	1	3	0	0	0	0	0	0	0	0
Bias, bullying, harassment, discrimination	0	0	3	5	0	2	1	0	1	0	0	1
Career deflection	0	0	1	2	0	1	0	0	0	0	0	0
Barriers stemming from education	0	2	3	7	0	0	0	0	0	0	2	0
Unfair processes	0	0	1	0	0	0	0	0	0	0	0	0
Fewer grant applications or awards	1	2	2	2	0	0	0	0	0	0	0	0
Lack of career guidance or confidence	0	0	0	5	0	0	1	0	0	0	1	0
Limited reporting or data	0	3	2	1	1	2	0	1	0	0	1	0
Isolation or low inclusion / belonging	0	2	3	3	0	1	0	0	0	0	0	1
Greater likelihood of non-permanent work	0	0	0	0	0	0	0	0	0	0	0	1
Other systemic barriers	0	0	0	5	0	1	1	0	1	0	0	1
Pay gap	0	0	6	24	0	0	0	0	0	0	1	0
Underrepresentation (including in leadership)	3	4	5	16	3	1	0	1	0	0	1	0
	1	1	3	1	1	0	1	0	0	0	0	0

Recommendations for future research

A core objective of this review was to uncover neglected and under-researched areas and make recommendations for future lines of inquiry. This section outlines areas for future research, the sort of research that should be undertaken and what the focus should be. Guiding research questions are offered for each section.

Systemic issues

Future EDI research in engineering must seek to understand and address the systemic issues and barriers that underrepresented groups face. This report has already highlighted examples of how such systemic issues can affect women (for example, the domestic division of labour, lack of flexible and part-time work and barriers to returning to the profession after a period of absence).

The report also highlighted systemic issues affecting young Black people in education, as highlighted in the Hamilton [47] and Aspires [49] report, which inhibit the acquisition of sufficient science capital necessary to enter the engineering profession or even to view oneself as a potential engineer.

Simply focusing on individual-level interventions may not be sufficient in addressing the root causes of inequality and marginalisation. Instead, efforts should be contextualised within the broader social, cultural, and institutional systems that contribute to excluding underrepresented groups. By acknowledging and actively working to dismantle systemic barriers, research can be more effective in promoting equitable opportunities and creating inclusive environments for under-represented groups in engineering. Key research questions which could be addressed include:

- What systemic issues face different underrepresented and marginalised groups within the engineering profession?
- How do these issues intersect between different groups?
- How well does existing data monitoring and evaluation capture these systemic issues?
- How has COVID-19 reflected and exacerbated existing systemic issues?

Key examples of where systemic barriers could be (further) examined are shown in Table 7.

Table 7: Suggested research topics

Topic	Description
Bias in organisational policies	Investigating biased policies that perpetuate inequities and hinder the advancement of underrepresented groups within engineering organisations.
Design and accessibility	Analysing how designs, such as PPE (Personal Protective Equipment), can exclude certain groups due to lack of inclusivity in their design.
Flexible and part-time work	Exploring how the absence of flexible work arrangements affects underrepresented groups, particularly those who require a work-life balance due to caregiving responsibilities or other commitments.

Experiences of engineers in work

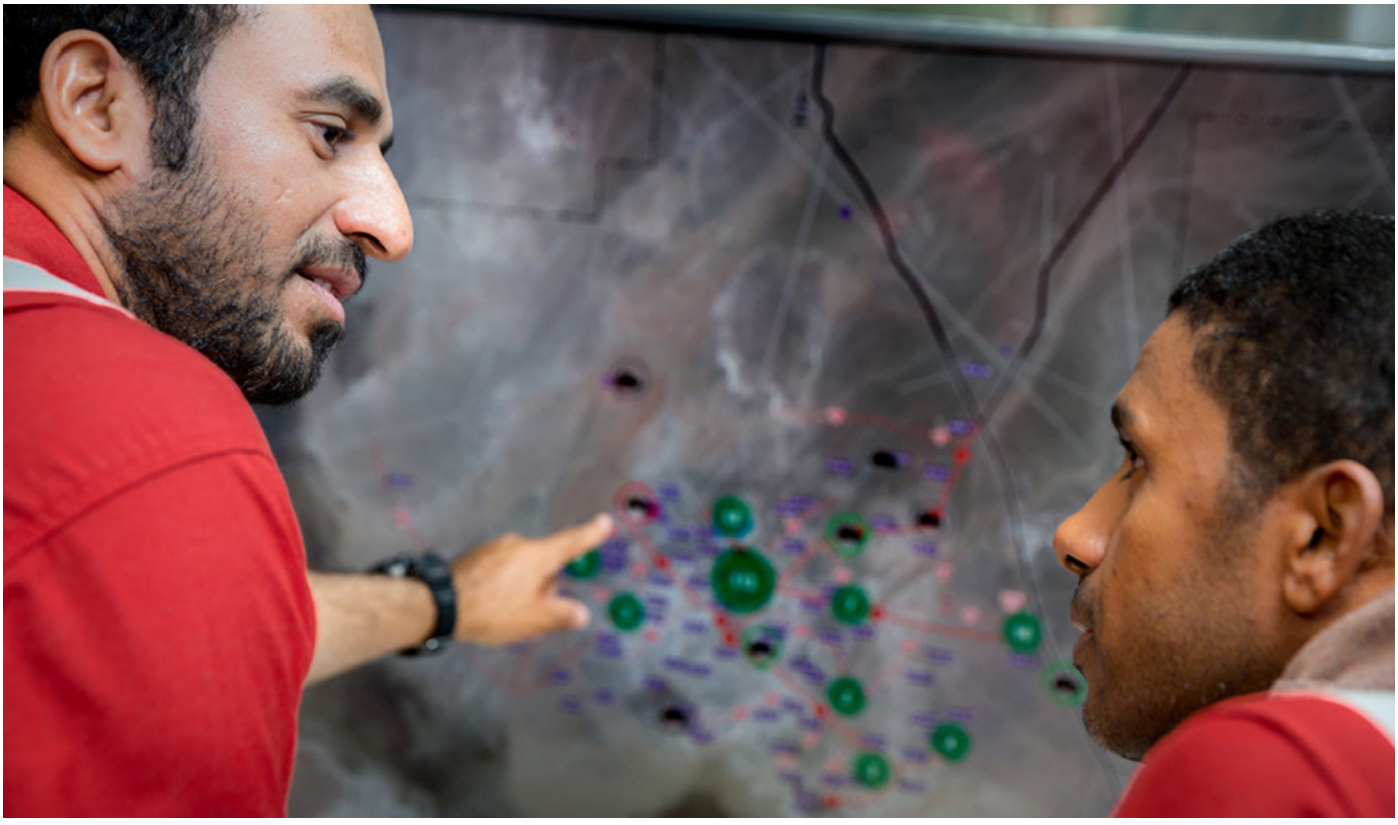
The report underscores a critical issue that demands immediate action: the neglected experiences of individuals, particularly from underrepresented groups, once they have secured employment. While the culture of the engineering profession has been robustly explored by the Academy's Inclusive Cultures 2023 Commentary, that survey uncovered clear examples of differential experiences of those from underrepresented groups, giving rise to further questions.

While some of these questions were explored in the Inclusive Cultures reports through qualitative focus groups, future research must adopt a longitudinal approach that delves into the career trajectory of underrepresented groups, shedding light on the barriers they face in advancing their careers. By investigating the factors impeding their progress, targeted strategies can be developed to dismantle these barriers and foster a more inclusive and diverse engineering workforce.

Comparative studies analysing the career trajectories of underrepresented groups and their counterparts from over-represented backgrounds can uncover disparities and illuminate marginalised engineers' challenges.

To guide this research, several questions could be explored:

- How do career trajectories differ between underrepresented groups and their more over-represented counterparts?
- What barriers hinder career progression for underrepresented engineers, including factors such as bias or limited resource access?
- How can organisational policies and practices be enhanced to support the advancement of underrepresented groups?



Under-researched groups

The original search terms for this report drew on the protected characteristics outlined in the Equality Act (2010). However, they were also expanded to encompass language changes used (such as trans/transgender in addition to gender reassignment) and to capture additional aspects of identity and disadvantage.

From the original search terms, the following only appeared briefly: age; nationality, immigration or language; socioeconomic status; religion or belief; and maternity, paternity or family. The following did not appear at all: colourism, shadeism and regionality. These gaps indicate the need for research to understand the nuances of these identity characteristics.

Although some areas have received significant attention, for example, gender, the perpetual gender inequality in engineering indicates that the large volume of research does not mean there is no more need for future research.

It is worth noting that characteristics of the distinct groups outlined here often intersect with other identities, which should also be examined in future research, as reiterated in the section related to intersectional approaches to research.

While it is difficult to prioritise one group over another, suggestions for immediate attention are outlined below:

LGBTQ+ community

There is a scarcity of comprehensive research focusing on the experiences of LGBTQ+ individuals in engineering. To bridge this gap, research must delve deeper into the connections between LGBTQ+ identities and career experiences in engineering. Some potential research questions to explore include:

- How does an individual's sexual orientation impact their career choices and opportunities in engineering? Do issues around science capital and the self-identification of what is an engineer also apply to LGBTQ+ people?
- What are the specific challenges and barriers faced by LGBTQ+ engineers in the workplace?
- Are there any aspects of the engineering workplace culture which create career and progression barriers or have a negative impact on the experiences of LGBTQ+ engineers?
- What specific organisational policies address barriers faced by LGBTQ+ engineers? To what degree do these impact the lived experiences of LGBTQ+ engineers?

People from socio-economically disadvantaged backgrounds

Research on the lived experiences of individuals from less advantaged socio-economic backgrounds remains limited. Focused research is crucial to identify and address the specific challenges faced by these individuals. Some potential research questions to explore include:

- What barriers do individuals from less advantaged socio-economic backgrounds face in accessing science capital, engineering education and career opportunities?
- How do socio-economic disparities impact engineers' career progression and advancement?
- What interventions and support systems effectively promote the inclusion and success of individuals from socio-economically disadvantaged backgrounds in engineering?

Neurodiversity

Although there is a growing awareness of neurodiversity, there is little evidence of a focus on this within the engineering field. Future research should prioritise examining the firsthand perspectives of neurodiverse individuals engaged in engineering. Some potential research questions to explore include:

- What are the particular strengths and challenges of neurodivergent individuals in engineering roles?
- How does workplace culture and organisational support impact the experiences of neurodiverse engineers?
- What practices can foster an inclusive environment for neurodivergent engineers?

Ethnicity in engineering

Despite some progress, there's a notable gap in research concerning the experiences of individuals from diverse ethnic backgrounds in engineering. To foster inclusivity and equal opportunities, future research should explore the intersections of ethnicity and engineering careers. Some potential research questions include:

- How does ethnicity impact career trajectories and choices within engineering?
- What are the unique challenges faced by engineers from different ethnic backgrounds, and how do these challenges vary across ethnic backgrounds and different engineering disciplines?
- To what extent do organisational structures and workplace cultures contribute to or mitigate ethnic disparities in engineering?
- How can mentorship programmes and organisational policies be tailored to address the specific needs and aspirations of engineers from diverse ethnic backgrounds?

Disability

While there is some progress in providing workplace guidance, gaps remain in addressing accessibility and disability in engineering. Notably, the experiences of disabled individuals remain under-researched. There is an opportunity to better understand accessibility and disability at work in engineering. Suggested research questions include:

- What specific challenges do disabled individuals face in engineering and technology education and the workplace, and how can these challenges be addressed?
- How do the representation and retention rates of disabled individuals in engineering compare to the broader workforce, and what factors contribute to these disparities?
- What is the influence of workplace culture and organisational support on the experiences of disabled individuals in engineering?

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Evaluation of diversity interventions

To create diverse and inclusive environments in engineering, it is essential to evaluate the effectiveness of EDI interventions. By conducting thorough evaluations, valuable insights into the impact of these interventions can be gained to develop evidence-based strategies to enhance diversity, foster inclusivity, and address systemic barriers within the industry.

A comprehensive range of research methodologies should be employed to initiate this critical evaluation. Quantitative approaches can help measure the outcomes and effectiveness of diversity interventions, such as assessing changes in representation, diversity training outcomes, and employee satisfaction and engagement. These data-driven insights can inform decision-making processes and guide the development of effective interventions.

In addition, qualitative methods, such as interviews, focus groups, and case studies, are essential to capture individuals' lived experiences and perspectives participating in diversity interventions. These qualitative insights can shed light on the nuances of individual experiences, the effectiveness of support systems, and the organisational factors that facilitate or hinder inclusive practices.

The commitment to EDI needs to go beyond the business case. Evaluation is about more than how these interventions help recruitment, retention, research and development. There is an ethical and moral imperative to promote equality and inclusivity for all individuals. Considering the societal impact of EDI interventions allows organisations to assess how their practices contribute to social progress and address systemic inequalities.

Research efforts should focus on evaluating EDI interventions to answer key research questions, such as:

- How do EDI interventions impact the experiences of underrepresented groups in engineering? What are the perceived benefits and challenges?
- What strategies and interventions most effectively create inclusive and supportive environments for diverse individuals within engineering organisations?
- What barriers and opportunities exist for implementing and sustaining successful diversity interventions within engineering organisations?

Researchers, organisations, and stakeholders are urged to collaborate and prioritise evaluating interventions across all dimensions of EDI. By rigorously assessing their social and organisational impact, good practices can be identified, gaps addressed, and strategies refined to create inclusive environments.

Intersectional approaches to research

This report highlights that gender has been the predominant consideration within EDI publications in engineering. While addressing gender inequality remains crucial, the research lens must be expanded to consider other protected characteristics, as well as taking an intersectional approach. By acknowledging and studying the interconnected nature of multiple dimensions of identity, a deeper understanding of the complex challenges faced by underrepresented groups in the engineering industry can be gained.

The intersections of gender, ethnicity, age, disability, socioeconomic status, and other characteristics must be explored to reveal the nuanced experiences of individuals within the

engineering field. By adopting an intersectional lens, the unique barriers and opportunities faced by individuals who navigate multiple forms of discrimination and disadvantage can be identified and dismantled.

Some potential research questions and areas of focus may include:

- How do various dimensions of diversity intersect and influence the experiences of individuals in engineering? What are the specific challenges individuals face at the intersections of gender, race, disability, and other intersecting identities?
- How well does existing data collection and monitoring capture intersectional identities?
- How does combining different characteristics impact career advancement, access to opportunities, and inclusion within the engineering profession? What strategies can address the barriers individuals face with intersecting identities?
- How do organisational policies, practices, and cultures either support or hinder the experiences of individuals from diverse backgrounds? What are good practices for fostering inclusive environments that recognise and value intersectionality?
- How can intersectional research approaches inform the development of comprehensive and practical EDI initiatives within engineering organisations?

Increase research partnerships

The review has underscored the significance of community engagement in forging strong relationships and working towards achieving EDI goals, particularly within the employment realm. This insight should serve as a call to action for future research endeavours. By collaborating with community partners, their unique perspectives and experiences can be utilised to leverage expertise to advance the profile of engineering among a diverse and burgeoning talent pool.

To catalyse meaningful change, research should be prioritised that embraces community engagement as a guiding principle. Community partners, including underrepresented groups, professional organisations, advocacy groups, and educational institutions, possess invaluable knowledge that can shape research agendas and inform policies and practices. Their contributions can foster a deeper understanding of individuals' barriers and opportunities within different communities while providing practical insights for developing effective strategies to drive inclusion and diversity in engineering.

Some potential research questions and areas of focus may include:

- How can community engagement enhance the recruitment and retention of underrepresented individuals in engineering? What strategies and initiatives have been successful in attracting diverse talent?
- What are the unique challenges and barriers faced by individuals from different communities (such as minority ethnic groups, LGBTQ+ individuals, and disabled individuals) in pursuing engineering careers? How can community-driven research shed light on these challenges and inform targeted interventions?
- How do community-driven initiatives and programmes foster a sense of belonging and empowerment among underrepresented groups in engineering?
- How can community partnerships inform the development of educational curricula and training programmes that promote EDI in engineering? What are the most effective strategies for equipping engineering students and professionals with the skills and knowledge to address intersectional challenges?

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Conclusion

This report aimed to culminate the key themes and issues relating to EDI across the profession limited to research regarding the workforce. It has examined the diversity profile and demographics of the profession as portrayed in industry and academic literature.

The increased attention given to gender equality in the engineering industry in the past decade is undoubtedly a positive development. Efforts to address gender disparities and create more inclusive environments have improved opportunities and representation for women in engineering, to an extent. However, it is crucial to acknowledge that significant work is still needed. Despite progress, women continue to be vastly underrepresented in engineering and face challenges and barriers in the industry, including stereotypes, bias, and limited career advancement opportunities. Continued efforts are needed to break down these barriers and create an equitable and inclusive engineering sector.

While gender equality has received significant research focus, it is essential to recognise that other categories of difference, such as ethnicity, have not received the same attention and action. The report's findings shed light on the risk of systemic issues prevailing in the industry and the need for a more comprehensive approach to diversity and inclusion. Intersectionality, the recognition that various categories of difference intersect and overlap, is crucial in addressing these imbalances. Considering the intersection of gender, ethnicity, and other characteristics is essential to fully understand and address the unique challenges faced by individuals who belong to multiple marginalised groups. Adopting an inclusive framework that acknowledges and actively works to dismantle barriers individuals face at the intersections of different identities is imperative.

Overall, the approach to EDI in engineering is generally functional or utilitarian. It is primarily based on statistical data and stresses a business case for diversity to emphasise the advantages of EDI. Many interventions regarding careers, training and education (individual progression and career attainment rather than lived experience) are framed. While part of this literature addresses issues such as culture, lived experience and systemic issues, this is smaller compared to that which takes a more functional approach.

More could be done to ensure that the engineering profession's EDI efforts are comprehensive and inclusive. By addressing the systemic issues that prevail and extending the focus beyond gender to encompass other dimensions of diversity, the engineering industry can create a more equitable and welcoming environment for all. This approach involves implementing policies and practices that challenge bias, foster inclusive cultures, and actively support the career advancement of individuals from all underrepresented groups. This will advance the aim of evolving engineering to become a more diverse and inclusive sector where all individuals, regardless of their gender, ethnicity, or other identities, have equal opportunities to thrive and contribute.

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Appendix 1

List of Professional Engineering Institutions used as search locations

Abbreviation	Professional Engineering Institutions
BCS	The Chartered Institute for IT
BINDT	British Institute of Non-Destructive Testing
CABE	Chartered Association of Building Engineers
CIBSE	Chartered Institution of Building Services Engineers
CICES	Chartered Institution of Civil Engineering Surveyors
CIHT	Chartered Institution of Highways & Transportation
CIPHE	Chartered Institute of Plumbing and Heating Engineering
CIWEM	Chartered Institution of Water and Environmental Management
EI	Energy Institute
IAgrE	Institution of Agricultural Engineers
ICE	Institution of Civil Engineers
IChemE	Institution of Chemical Engineers
IED	Institution of Engineering Designers
IET	Institution of Engineering and Technology
IExpE	Institute of Explosives Engineers
IFE	Institution of Fire Engineers
IGEM	Institution of Gas Engineers and Managers
IHE	Institute of Highway Engineers
IHEEM	Institute of Healthcare Engineering and Estate Management
ILP	Institution of Lighting Professionals
IMarEST	Institute of Marine Engineering, Science & Technology
IMechE	Institution of Mechanical Engineers
InstMC	Institute of Measurement and Control
InstRE	Institution of Royal Engineers
IOA	Institute of Acoustics
IOM3	Institute of Materials, Minerals and Mining

IOP	Institute of Physics
IPEM	Institute of Physics and Engineering in Medicine
IRSE	Institution of Railway Signal Engineers
IStructE	Institution of Structural Engineers
IOW	Institute of Water
INCOSE	The UK Chapter of the International Council on Systems Engineering
NI	Nuclear Institute
PWI	Permanent Way Institution
RAeS	Royal Aeronautical Society (RAeS)
RINA	Royal Institution of Naval Architects SaRS Safety and Reliability Society
SOE	The Society of Operations Engineers
TWI	The Welding Institute

Appendix 2

List of corporate organisations and trade unions used as search locations

Airbus Group
Anglo American
Arm
Atkins
City and Guilds
Drax
EDF
HS2
ITM Power
Jacobs
Laing O'Rourke
Leonardo
Met Office
National Grid
National Skills Academy for Nuclear
Network Rail
Nuclear Industry Association
North East Automotive Alliance
Northern Railway
Orsted
Pearson
Prospect
Radioactive Waste Management
Rolls Royce
R2 Factory
Sellafield Ltd
Shell
Siemens
Small Business Charter
Stantec
Thales
Transport for London
UK Power Networks
Ultra
Unite
Wave
WSP

Appendix 3

List of not-for-profit organisations and engineering magazines used as search locations

Association for BME Engineers

Engineering magazine

Engineering Update

EngineeringUK

EqualEngineers

Eureka!

InterEngineering

Lloyd's Register Foundation

The Engineer

UK Research and Innovation

Women's Engineering Society

Appendix 4

List of national policy and evaluation sites used as search locations

British Science Association

Civil Service Careers

Department for Business, Energy and Industrial Strategy [v]

Engineering Council

Parliamentary Science and Technology Committee

Royal Academy of Engineering

Science Campaign

[v] BEIS existed until 2023 when it was split to form the Department for Business and Trade (DBT), the Department for Energy Security and Net Zero (DESNZ) and the Department for Science, Innovation and Technology (DSIT). Responsibility for national security and investment policy has gone to the Cabinet Office.

Royal Academy
of Engineering

Nottingham
Business School
Nottingham Trent University