

# **Literature review on engineering education and skills policy**

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## Executive summary

The Royal Academy of Engineering is looking to the future skills needs of the engineering profession. These skills needs are increasingly shaped by present and emerging challenges facing modern society, from digitisation and the ubiquitous applications of AI, innovation and crucially the climate emergency, compounded by the long-standing and on-going shortage in engineering skills.

To achieve notable progress in reframing the engineering practices we need for a rapidly developing and complex world, systematic change must be carried out across the entire education and skills ecosystems. This includes, of course, the entry point to the profession (in schools, colleges, universities, or early-stage apprenticeships) to the arguably more important 6.8 million practising and active engineers already in the workforce.

To support the development of an inclusive skills policy focused on qualified and practising professionals – and engaged with green, sustainable, and net zero thinking and behaviour – the Academy commissioned RDAM Consulting Limited to carry out a review of UK-focused skills policy over the past ten years. This review sought to bring together ideas about ways by which to overcome barriers to participation in training and development from across the four nations and a wide range of disciplines. It was principally concerned with the training and development that takes place beyond school and tertiary education. Where possible, it also looked at examples of practice that were directly related to engineering or science, technology, engineering, and mathematics (STEM).

The review drew upon almost 250 sources and identified a coherent set of barriers to and enablers of participation in education and training. These were, unsurprisingly, closely related: enabling participation was often a way of identifying a barrier and then planning how to address this.

The most typical barriers and enablers were:

- **A diverse and responsive skills ecosystem**
- Collaboration (including with trade unions)
- **Culture of lifelong learning (inclusive)**
- **Financial support**
- **Flexible/accessible learning**
- **Information**
- **Leadership/strategic vision includes skills.**
- Pre-existing initial qualifications
- High self-worth
- Top-down/local flexibility
- Reliable/relevant qualifications
- System complexity
- Teachers/lecturers who are well-trained
- Transferable learning

The above are characteristics that, were they absent or not functioning, would be barriers. However, if they are present and active features of programmes or approaches, then they will act to enable individuals to access training and development. The barriers and enablers in bold are those that feature most regularly in the material reviewed.

Many of these barriers and enablers have been consistently identified over a long period and can act at both systemic and individual levels. However, understanding these and how to address them should provide a solid platform for appraising existing engineering skills interventions, as well as developing new ones.

There has been and continues to be considerable policy churn concerning skills development across the UK. In some ways, while the issues are persistent and recognised, the accumulation of reliable evidence regarding the addressing of these issues is less well-developed. This absence of helpful approaches to impact evaluation places some limits on

how much confidence there can be in learning from previous (and, indeed, current) attempts to improve training and development uptake. Nevertheless, the range of experiential evidence can offer insights into the characteristics that effective interventions should adopt: for example, encouraging managers and organisations to develop inclusive and lifelong learning skills strategies addressing some common barriers to uptake.

The review also looked for examples of training and development in engineering disciplines related to green skills. One of the foremost challenges in this area is to define what is meant by a “green skill” and how this differs from, say, a green job. Several organisations are examining this: an agreed understanding of the skills involved (beyond the adoption of technical solutions) will help to establish meaningful ways in which to address skills gaps through upskilling or reskilling. From this perspective – and looking across to previous work carried out by the Academy – there are at least three aspects to embedding green skills in engineering. As mentioned above, adopting new technologies is one element of this. Additionally, it may be desirable to complement this with changes in both professional behaviour and thinking that are systematically geared towards green, sustainable, and net zero solutions. Like engineering habits of mind, this change arguably sits at the heart of being a 21<sup>st</sup>-century engineer, and it may take time to identify how to bring about this change for existing professionals. However, there are ways (for example, using the Visiting Professors' programme) to develop and test curricula and teaching approaches to help to build sustained professional development that creates positive and meaningful change.

This review highlighted, as others also have, the existence of a complex skills ecosystem with which the Academy will need to engage to effect real change in how the existing workforce develops. This indicates that, while the Academy and strategic partners may identify at a national level what they are seeking to achieve through a diverse and inclusive skill development initiative, successfully embedded solutions will need to reflect local/regional collaborations, demands and strengths. This may see the Academy widening the range of stakeholders with which it engages as it develops its workstream into future skills, including trade unions, local authorities, and employer bodies.

The evidence examined for this review suggests several challenges and developments with which the Academy may wish to engage, summarised in four evidence-informed and practical recommendations:

- **Recommendation 1:** The Academy should highlight and encourage collaborations between employers, unions and skills bodies (among others) to promote participation in training and development among UK employees.
- **Recommendation 2:** The Academy should work with, for example, professional engineering institution (PEI) and partner organisations with local industries to identify localised approaches to skills development that, at least, show early signs of promise and that may be seen as testbeds to support the evidence base for effective interventions.
- **Recommendation 3:** The Academy should ensure that any new programmes it commissions or pilots that are connected to skills development are designed to yield useful evaluative information about impact over a sustained period. Equally, existing programmes may need to be re-designed to allow for better evidence of impact on primary beneficiaries – such as professionals, learners, and employees – to be gathered.
- **Recommendation 4:** The Academy should set out a best current (or working) definition of green skills (distinct from “green jobs”) in order to support reviews of existing programmes, as well as the development of new ones, to ensure there is clarity about the effectiveness and focus of interventions.

- **Recommendation 5:** The Academy should continue to highlight and champion the central importance of creating a more inclusive and equitable engineering profession and sector, as a key factor in attracting the widest possible range of diverse talent into engineering, which will help to address the skills shortage.

As a central convening power, the Academy occupies a strong convening space to bring together views and expertise to underpin this inclusive and green-focused approach to skills development. Importantly, this approach must be accessible to all in the engineering workforce and must embody the principles, characteristics and mindset that are more than just about technical solutions to climate change.

This approach may include using the evidence about barriers and enablers to evaluate and adapt existing programmes as well as generating new ones embodying these principles from the outset. The Academy may also look to the communities with which it works – educators, training providers, employers, the professional engineering institutions, and related professional associations, for instance – to improve the evidence base (including well-structured case studies) concerning skills transformation and to work with the ecosystem to spread good and effective practice that is amenable to local demands and collaborations. Finally, and perhaps critically, it could very usefully support the establishment of a green skills definition that can guide training and development in the engineering ecosystem.

**'...with 80% of the 2030 workforce already in the workforce today, re-skilling the existing workforce will be the major challenge between now and 2030.' (1)**

## Introduction

The Royal Academy of Engineering (RAEng) has commissioned a wide-ranging literature review to help inform its thinking about re-skilling and upskilling existing engineering professionals. This is an ambitious goal both qualitatively and quantitatively.

The Academy wants to see existing and qualified engineers equipped with ways of thinking and working to help them tackle the skill challenges of the 21<sup>st</sup> century, which importantly include addressing climate change, thinking and acting to address green issues and sustainability and making responsible contributions to society. These skills primarily address tackling problems – something that is a critical element of engineering thinking (2). However, turning engineering skills towards net zero or sustainability, or the less well-defined “green jobs”, is partly about technology (what tools can be used); more importantly, however, it is about ways of thinking and working. Changing habits of mind and behaviour will be a bigger challenge than introducing and using new tools.

The scale of the challenge is notable and the target audience is diffuse (there are estimated to be 6.8 million engineering roles in the UK workforce (3) and over 8 million in the engineering economy (4)). So, while it may be important and tractable to focus, for example, on ensuring that the UK's c. 40,000 engineering graduates enter the profession equipped with the latest ways of thinking and working, there is a much bigger job to be done to shift the thinking and behaviours of the existing engineering workforce as a whole.

This review looks back over ten years of skills policy and research in the UK to identify where there is scope for bringing about positive change in re-skilling and upskilling active engineers. Where possible, it looks into matters that specifically relate to STEM as a whole, and engineering discretely. It does so while offering some views as to how to address skills needed by engineers to address pressing immediate and future challenges.

This work looks at post-secondary education and training. Annexe A sets out the approach taken to this focused review and, in the following sections, references are selected from the literature to illustrate key points.

## What the literature tells us about barriers to and enablers of skills development

In a 2014 review of skills policy, City & Guilds struck a plaintive note observing that, after three decades of policy development regarding skills for those in work, “not much is new under the sun” (5). However, as much as there has been inconsistency and churn in policy-making to support in-work training and development, there has been as much consistency in the recognition and description of barriers to the uptake of skills (whether this is upskilling or re-skilling).

*Upskilling or re-skilling – the same or different?*

The two terms are often used in close proximity in the discussion of skills policy, to the extent that it is possible to regard them as synonymous. Most of the literature reviewed here takes that approach; however, the terms are better seen as distinct. [The Scottish Council for Development and Industry](#) (SCDI) has set out a useful differentiating definition (6):

**Re-skilling:** Learning new skills typically applied to a new job, often in the context of a new career. Reskilling is a means of facilitating a transition to new employment opportunities, perhaps in response to the threat of technological unemployment, sector decline, redundancy or skills gaps.

**Upskilling:** Learning new skills typically applied to an individual's career progression, enhancing their capabilities and enabling the individual to apply these new skills at a higher level of a likely similar profile – often, but not necessarily, within the same organisation. Upskilling is a means of progressing individuals up the workplace value chain and increasing their productivity.

Looking across the literature, there are around 14 commonly mentioned barriers to the uptake of training and development in the workplace. Some of these operate at the individual level, some at the employer level and some at what could broadly be described as “the system” level (organisations and institutions, including government and government agencies). The variety of barriers and enablers and the extent to which they interact makes it hard to separate the direct or differential impact of, say, an absence of information regarding courses, course quality and access to financial support.

In the materials reviewed, the most regularly cited barriers and enablers to training and development in work were:

- **A diverse and responsive skills ecosystem**
- Collaboration (including with trade unions)
- **Culture of lifelong learning (inclusive)**
- **Financial support**
- **Flexible/accessible learning**
- **Information**
- **Leadership/strategic vision includes skills**
- Initial qualifications
- High self-worth
- Top-down/local flexibility
- Reliable/relevant qualifications
- System complexity
- Teachers/lecturers who are well-trained
- Transferable learning

The above are characteristics that, were they absent or not functioning, would be barriers. However, if they are present and active features of programmes or approaches, then they will act to enable individuals to access training and development. The barriers and enablers in bold are those that feature most regularly in the material reviewed.

From this assessment, it is clear that several systematic elements may be inhibitors for individuals and employers, and that governments have long recognised the need to overcome the reluctance of both employers and individuals to become involved with skills development. This has led to many different interventions, often with the aim of securing access to skills development for potentially disadvantaged groups (7).

Overcoming any **financial barriers** (and not simply about finding appropriate government support) either to pay for or to develop or provide training is the most frequently cited

obstacle by all groups. This may be due, for example, to complex system design (8) or the array of different stakeholders involved (9). This issue of **system complexity** may also relate to the absence of accessible or versatile learning opportunities. For instance, one commentator drew attention to the focus on apprenticeships as a preferred model for developing the workforce, noting that many training needs were not necessarily as involved as an apprenticeship (8 *ibid*) and that there is a place for smaller learning units. However, it is important to note that some employer needs may be so niche that training developers are reluctant to commit to creating opportunities for skill development (10). It is also noted that in addition to financial barriers, and implicitly related the **time** to undertake additional activities within busy schedules is a key barrier for today's engineering professionals.

**Lack of or poor information** concerning training and development opportunities is also a well-documented barrier to participation. This information gap, which is often a result of businesses and education and training providers having notably different ways of articulating skill needs, can concern the availability of opportunities or more persuasive intelligence concerning the benefits of training both to individuals and employees (11, 12, 13).

It is also difficult to support employer development if, for example, employers do not have a **vision for growth that includes staff development**, with some employers sensing that their staff are fully skilled (14). Over 60% may have that view; it is one that potentially traps businesses and employees in a "low skills equilibrium" (11, *ibid*), thereby limiting opportunities for change and innovation.

The reluctance of employers and employees to take up training and development may also result from a backdrop to education and training that does **not support or value a culture of inclusive lifelong learning**, which is vital to support employee retention in the workforce, as well as productivity (11, *ibid*). With as many as one-in-four employees stating that there is nothing preventing them from taking up training and development opportunities, this is a cultural, structural and systemic matter (14).

Another small set of barriers, which operate at a very personal level, can be clustered together: **low self-esteem** (15), possessing **poor levels of qualifications** and basic skills (16) and having a previous **poor experience of education** personally or within the family (17). Some of the latter may result from needing help to access training and education opportunities supported by motivated, well-qualified teachers and lecturers (18). Adults with any level of disadvantage (whether this is related to, for example, socioeconomic status, educational experience, ethnicity, sex or gender or an intersection of these) are more likely than others to have a negative disposition towards education and training (19).

Some general points about support are related to the previous set of barriers and cutting across the issue of financial barriers. This may relate to (for example) the availability of **flexible development opportunities** that can fit around existing care and work responsibilities (20) and a tendency to focus on initiatives (publicly funded or otherwise) focusing on young people in schools rather than adults in the workplace (21). The notion of flexible access is also pertinent to employees in small and medium-sized enterprises (SMEs) and rural or isolated communities (22).

One commentator has observed that, while the supply of and demand for training and its uptake has occupied many researchers over many years and there have been many and varied interventions, there remains a longstanding "acceptance of a need for better policy, [and] it remains an unsolved and contentious area" (15, *ibid*). It has also been noted that, although financial barriers are cited regularly, they may not be the principal or most critical barrier (16, *ibid*). Rather, it may be that they are part of an interacting mix, which may contribute to an overall lack of engagement by employees or those in training and

development. It is unlikely, in other words, that a single-focus policy intervention will result in any or all of these barriers being overturned.

Given the close relationship between barriers and enablers, looking at ways to develop positive uptake and engagement with skills often identifies activities that aim to confront and turnover known barriers. The two most regularly cited enabling factors concerning engagement with training and development are potentially linked. It is a regular theme of the Employer Skills Surveys (ESS) that **managers are critical to shaping organisations' attitudes to and engagement in training**, yet are the least likely group to undergo training at work (23). This role for managers has also been noted by the Industrial Strategy Council (18, *ibid*). Both characteristics may be exemplified by employers adopting '[High-performance workplace](#)' strategies (24) or through a commitment to structured approaches to employee development, such as [Investors in People](#) (IiP) (5, *ibid*); that is, working with a policy that **encourages lifelong learning**.

A **flexible approach to training and development within a diverse and responsive skills sector** may also be linked to facets that combine to support engagement with skills development (19, *ibid* and 25). These characteristics relate to the presence or absence of accessible (often local) skills provision that may involve further education, higher education and/or private training providers, trade unions and employers. Ideally either collaborative or managed in nature, this diverse set of providers should be accompanied by a capacity to react to new or anticipated skill needs and demands. This flexibility and accessibility orients some control concerning the access to and uptake of training towards the individual, making the conditions that otherwise prohibit development less intractable (26). However, flexible learning must still be high quality, relevant, accessible and funded and it is not an end in itself. For example, the recent Short Courses in a higher education pilot in England attracted only 12 applicants to 103 courses from 22 providers (27).

**Collaboration** is a further theme appearing to make notable contributions to promoting engagement with training and development. This can work at the level of employer-employee interaction or be triangulated usefully between employers, employees and social partnership stakeholders, such as trade unions (28) or sector skills councils (7, *ibid*). The development of employer networks is another example of a collaborative and supportive means by which to increase engagement in skills development (29).

A further dimension of collaboration involves organisations and bodies that form part of the ecosystem (providers, funders, awarding organisations) **acting together in a "skills ecosystem"** (30) to bring clarity to what is available to anyone wanting to upskill/re-skill. This also applies at a strategic level, with skills being such a "horizontal" policy issue that touches on many government departments; there is a need to approach policy formation in a cross-government way (9, *ibid*, 30, *ibid*, 31). In such an ecosystem, however, it is challenging to identify ways to overcome barriers when so many are linked and there is, therefore, the risk of resolving one issue while making others worse.

### *Skills ecosystems*

Anderson and Warhurst (32) describe a skills ecosystem as a dynamic way to understand the many interconnected elements concerned with developing and implementing skills policies. They contrast this with 20<sup>th</sup>-century economic human capital thinking, which saw skills and skill development as relatively fixed variables. These tended towards states of equilibrium and, in the past, driven approaches to skills development that were responsive to the supply of education and training opportunities. Skills ecosystems thinking is more active, complex and (as the authors note) “messy”. However, it arguably reflects reality much better and could prevent governments from making their “episodic reactive interventions and encourage a sustained change” in how skills policies develop.

Naturally, this feeds through into ideas about **improved and simpler information** that conveys the importance of skill development, how to support it and what courses/validation steps are available. Access to such information that can be relied upon and is accessible is another key enabler (8, *ibid*).

The extent to which collaboration concerning skills development is seen as so critical could imply that there is a need to avoid top-down, centralised skills policies (33). Therefore, the need to **be locally flexible** is almost a consequence of the diverse natures of local economies and the complex range of partners in the local skills ecosystem.

### *In brief*

The barriers to participation in training and development have been known for some time. They operate at the system, business and individual levels. Skills ecosystems are complex and have many elements that will likely be different and engaged in different ways at local levels, where real change can happen – in contrast to nationally driven approaches.

There is rarely a single reason for low participation in lifelong learning; the inhibiting factors may be intersectional and compounding. Financial barriers form part of the mix but may not be the most critical element in overcoming a reluctance to upskill/re-skill for employers or employees. Management, leadership and collaboration are required to make interventions successful, particularly concerning creating a culture of inclusive lifelong learning.

## Examples of interventions from across the UK

Bringing about changes in the way employers and employees engage with skill development will be challenging. The need to do so is clear, but it comes against a background of reducing employer investment in skills over the last ten years (34) and some evidence that many employers (two out of every three manufacturers surveyed) do not make plans for their workforce (35). A recent Public Accounts Committee report covering England describes in detail the worrying reduction in employer spending and employee participation in training and development (36). This report also identifies many of the barriers highlighted above, noting in particular how this loss of skills development – so important for economic prosperity – is compounded by the complexity of the skills system.

Nevertheless, having examined the enablers and barriers to the uptake of training and development across the UK, this section of the report will look at interventions that have been implemented to both underpin the enabling factors and overturn the barriers. However, this review (as others have (37)) is limited in terms of direct evidence of

effectiveness regarding interventions. For example, in 2015, the Organisation for Economic Cooperation and Development (OECD) (38) review noted that only around 10% of education policies it examined had been evaluated for impact. Equally, looking at efforts to improve the uptake and awareness of STEM study and career options, the UK National Audit Office drew attention to the lack of good evaluation evidence to support the understanding of intervention and related spending impact (39). This means that what follows is often illustrative of a mixture of interesting approaches rather than demonstrably proven and effective measures. However, the examples also serve to illustrate the complexity of the skills ecosystem and help to show how difficult it can be to introduce national or one-size-fits-all skills policies.

## The skills ecosystem

Interventions that feature some degree of focus on the skills ecosystem predominate over the period covered by the review. However, this is rarely the exclusive focus, which mirrors the observation that single-focus policy intervention is unlikely to improve uptake and engagement in training and development successfully. Some examples of this approach are set out below.

Several critical changes have occurred in Scotland to set up a more joined-up skills ecosystem. This has operated at several levels. For example, post-school education funding, whether in further or higher education (including apprenticeships), came under the responsibility of one funding organisation (the [Scottish Further and Higher Education Funding Council](#) – SFC) in 2005. In addition, Scotland appears to be moving from a supply-side skills model to one that seeks to drive and respond to demand and skills utilisation (32, *ibid*). Several developments have supported this shift, including creating sector-level Skills Investment Plans (SIP) (40). These are developed at national and regional levels (41), allowing for flexibility that can accommodate a wide range of partners (including unions and sector skills councils) and be responsive to local needs. These changes overlapped with a drive to rationalise the college sector (bringing some greater clarity to the ecosystem) and the development of skills utilisation policies built on pilots and their evaluation (42). The direct impact of the changes in Scotland has yet to be fully understood. Still, Audit Scotland has urged the Scottish Government, [Skills Development Scotland](#) and the SFC to collaborate to make the impact of their joint approach to skills planning (43).

Similar approaches are evolving in other parts of the UK. For example, in Northern Ireland and Wales, similar programmes to bring colleges together have been implemented (44). Area-based reviews of college provision have also been taken forward in England. However, these were primarily due to financial viability concerns rather than an overt attempt to simplify and streamline the ecosystem (45).

The same authors (44, *ibid*) suggest that England is still pursuing a market-led approach to skills policy while the other nations are more centrally directed. This is not altogether the case, however, as the Department for Education has introduced new players into the skills ecosystem that have a direct bearing on engineering skills. For instance, [National Colleges](#) (of which, five have been created) and [Institutes of Technology](#) (there are plans for 21 to be initiated), both of which aim to address sectoral skills concerns with a drive to establish greater collaboration between partners at a regional level, including Local Enterprise Partnerships (LEP) and local authorities. A further development of this involves the moves to generate [local skills improvement plans](#) (LSIP) in collaboration with [Employer Representative Bodies](#) (ERB).

University Technical Colleges in England could also be seen as an attempt to diversify the supply of skills, but these are unlikely to operate at a sufficient scale to make a notable difference in the supply of skills (46).

#### *T levels and skills development*

One of the major developments in England focusing on technical skills has been the creation of T levels. These are qualifications aimed at post-16 students in school or further education equivalent to three A levels, resulting from the Sainsbury review of technical education. The Government sees them as valued qualifications that are a notable development from the previous Tomlinson 14-19 reforms (47).

They have been developed with a wide range of employer engagement and require up to 45 days of authentic and meaningful work experience. T levels also form part of the Government's lifelong learning approach.

The first three T levels were introduced in 2020 and saw the first students assessed in 2022. Three more waves of subjects (2021, 2022 and, finally, 2023) will ultimately see 23 in place. None of the other three nations has taken similar steps to introduce such full workplace-oriented qualifications into their post-16 stages of education, although developments such as the Scottish Qualifications Authority [National Progression Awards](#) are increasingly taken up in school and further education.

Aside from the 2022 attainment outcomes for the first three T levels, there is yet to be evidence of the impact of these new awards, and that is unlikely to change in the near future. To date, the appraisal of the awards has been largely about the process of implementation (48). However, there has been some criticism of their introduction, particularly as they have resulted in existing qualifications being set aside and some employers suggesting they are a poor substitute for those [qualifications they will replace](#).

In Northern Ireland, there are plans to encourage universities to collaborate with colleges to support [Regulated Qualifications Framework](#) (RQF) level 4/5 skills provision (49). They are also introducing a Flexible Skills Fund ([SkillUp](#)) to support upskilling and re-skilling in digital skills and green technologies via the further and higher education sectors.

In England, there have been additional developments that look similar to the introduction of SIP in Scotland. Initially, [Skills Advisory Panels](#) (SAP) were introduced in 2020 at LEP level, bringing key local actors together to produce regionally coherent and visible skills plans. However, these SAP have now been superseded by [Employer Representative Bodies](#) (ERB), charged with developing collaborative "direct and dynamic" relationships between employers and training providers via [Local skills improvement plans](#) (LSIP).

In England, the Department for Education has also pledged to make RQF level 3 qualifications free to anyone who has yet to achieve that level of qualification. This [Lifetime Skills Guarantee](#) has been in place since 2021 and is expected to springboard further individual skill development.

In Wales, from 2023, funding for FE, HE, adult education, and adult community learning, apprenticeships and training will come under the auspices of the [Commission for Tertiary Education and Research](#) (CTER). Some additional changes have been mooted, such as a new Master apprentice route to pass skills from older to younger workers or to adopt the idea of progression agreements (50). The Welsh Government has previously indicated that skills strategy should be predicated on individuals taking "responsibility for improving the value of their skills within the economy" (51). The 2018 establishment of a [Fair Work](#)

[Commission](#) has been cited as a good example of positive system change that helps to bring employers, employees and social partners together to agree on, among other things, skills policy (52). Fair work (sometimes referred to as good work) policies are in place in all four UK nations (53) and often include access to education and training (54).

### Leadership and management of skills

Closely related to ecosystem changes, and perhaps implicit in such changes, is the role that effective leadership and management can play in developing positive attitudes to and the uptake of learning opportunities. It is also a strong component of setting an organisational approach to lifelong learning; it is worth recalling that, as an employee group, managers are the least likely to undergo any training and development (15, *ibid*). Organisations and their leadership can see the skills system as complex and unstable, which can inhibit or prevent attempts to engage with it (55). Clearly, this is an issue to be tackled.

It would not be exaggerating to say that leadership and management involvement in shaping skills demand through engagement with SIP or SAP or fair work activities is critical (as noted above). Involvement in programmes such as IiP was seen as a key way in which to positively shift employer perceptions regarding training and development (5, *ibid*). Equally, the importance of understanding and evaluating skill needs in developing an individual and organisational approach to training and development cannot be overstated (56).

Managers and leaders have the potential to influence how organisations contribute to shaping the skills ecosystem. This is evident in some older and newer examples of initiatives and interventions. For example, the Burnley Borough Council employee progression model was identified as an example of organisation-led effective practice in 2016 (33, *ibid*). More recently, and potentially more significant, the [National Manufacturing Institute Scotland](#) (NMIS) (57) and the [High-Value Manufacturing Catapult's](#) "Skills Value Chain" (a prototype, innovation-centred and rapid way of developing courses to meet employer needs) have taken collaborative, system-change approaches to skills supply at a regional level to a new level of development.

### Learning from evaluation and pilots

It has already been noted that evaluation and outcome measurement in policy realms (especially around STEM policy) needs to be more developed. This is important as, with good evaluation, it is easier to learn lessons from what has been effective and be able to build upon previous failures.

A small number of the papers reviewed in this report mentioned learning from past examples of intervention, and a subset of these can point to good quality evaluation findings, with many more indicating a desire to see evaluation better embedded into policy.

The pilots that paralleled the development of the SIPs in Scotland are well-regarded (42, *ibid*) and the extent to which learning from the National Retraining Partnerships in England (58) has been acquired is laudable. This may have informed its movement under the [National Skills Fund](#), which focused on RQF level 3 qualifications and support for skills boot camps (that is, targeting those with low existing skillsets and skills in high demand from employers). The interest in RQF level 3 qualifications in England is now brigaded under the [Skills for Life](#) programme, which includes skills boot camps and many engineering qualifications. In addition, the programme includes wraparound support for childcare and travel costs.

It is equally important to learn from what has not been effective in terms of skills development. Although just outwith the scope of this review, the Government's Train to Gain programme in England was widely seen as "unrealistically ambitious" and not delivering value for money (59). Programmes such as Learndirect (60) and support in the form of Individual Learning Accounts (ILA) (61) have primarily been seen as failures, although the former made notable inroads in increasing diverse uptake of basic skills (26, *ibid*), and the learning from the former has helped other nations develop their own programmes directed at upskilling and re-skilling (particularly for those with low levels of existing qualifications). Northern Ireland's Department for the Economy sensibly suggests that new policies should be developed only once the current ones have been reviewed (62).

### Addressing financial barriers

Perhaps as it is, in some regards, more straightforward to achieve, the provision of funding to support skills development is a relatively regular approach to interventions. The unhappy experience of ILAs in England in the 2000s was predicated on the idea of eliminating the financial barrier to anyone wanting to upskill or re-skill. Although the scheme was closed in England, the lessons taken from this experience have been absorbed and used to develop Scotland's [Individual Training Account](#) approach (63).

The UKCES noted in 2011 (64) that this moving from a skill supply model of thinking to one that was more about stimulating employer demand (and utilisation) may need to be driven by giving employers a greater stake in shaping the skills system. One way of doing so was to align employer funding with government funding, leading to the creation of the Apprenticeship levy in 2017. All UK employers whose pay bill exceeds £3 million per year contribute 0.5% of the value of that pay bill per financial year. Smaller employers, who do not pay the levy, can access levy funds to support 90% of the training costs and almost ¼ of the Apprenticeship levy in England has been unspent in the past four years and returned to the Treasury (65).

As education and training is a devolved matter, how this UK-derived levy is distributed and used varies across the four nations. In England, the mandate has been to support apprenticeships, with the three other nations taking a more flexible approach.

The English levy approach has led to some unintended outcomes. Much of the emphasis appears to have focused on supporting higher education-based apprenticeships, arguably to the benefit of already highly skilled individuals, rather than entry-level skills or degree apprenticeships. Support for RQF levels 4-5 Apprenticeships has yet to benefit from this support. The impact of more flexible levy use, as part of the block grant to each nation, in Northern Ireland, Scotland (for example, via the [Flexible Workforce Development Fund](#)) and Wales may merit some examination to understand whether it has helped engineering SMEs in particular.

The 2012 Richard Review of Apprenticeships (9, *ibid*) noted that not every qualification or development of skills was an apprenticeship and that flexibility was a desirable quality of any skills system. Hodgson *et al.* (66) noted that a benefit of devolution in terms of further education and skills was that the UK now represented a policy laboratory with the potential for all nations to watch, learn and adapt from each other's approach. A key issue warranting on-going attention for apprenticeships is completion, something that prompted the current Minister for Skills in England to [write to providers in the spring of 2023](#).

## Other interventions

There are several other areas in which there have been attempts to secure demand for training and development from employers and employees. One example concerns improving the quality of training on offer; ensuring it is accessible and fit for purpose (which may be a role for the Professional Engineering Institution). In one example, the authors point to the relationship between employers, employees and work councils in Germany. This collaborative approach concentrates on anticipating future skill needs and is developed from the basis of doing things “better, not cheaper” (56, *ibid*). The Welsh Government have also observed that high-quality work experience can both develop desirable skills at an early stage and simultaneously create an appetite for lifelong learning (51, *ibid*). Additionally, in relation to skills for a green economy, it appears that skills and knowledge are more likely to engage and support learners if they are embedded and contextually relevant (67), which has implications for curriculum design, pedagogy and the development of teachers and lecturers.

Other authors have noted (perhaps taking a lead from the idea that “policy development around vocational education and training (VET) might benefit from being less ambitious” (55, *ibid*)) that it may be better to have a targeted and focused approach to policy and interventions. This could be in terms of geography, for example, changing Job Centres into locally appropriate “Jobs and skills hubs” (68). This may also suggest that training is less about completing entire courses but about acquiring skills in a flexible and relevant way either to meet current needs or to be in a good position regarding future skill needs (see, for example, [Digital Bootcamps](#)).

The recent Skills Imperative 2035 report (21, *ibid*) draws attention to the relative absence of well-targeted approaches to engage and inspire adults in the workforce to look for and undertake enhancement or extension activities. This, they note, is in stark contrast to the school sector, where interventions abound. Indeed, the authors state that “many countries have adult learning systems that are generally underprepared to address the skills needs of the future”, which is clearly a risk for growth (sustainable or otherwise). However, some good and focused models could be adapted, whether these are boot camps, tools such as [Skillsbuilder](#) and the [Skills Discovery Tool](#) or the [Barclays Lifeskills](#) model to help focus individuals on ways to become lifelong learners.

### *In brief*

The variety and range of interventions that have aimed at overcoming barriers to engagement in work-based training and development are extensive. There has been a gradual move over the decade from supply-based skills policies to ones focusing on skill utilisation and encouraging the demand for skills. The roles of SIPs and LSIPs appear to be important in establishing collaboration and ownership of skills development, as does developing a coherent approach to further and higher education, particularly at a local/regional level.

Having managers and leaders who value skills and see their development as strategically important will contribute to greater engagement with training and development.

There needs to be more evidence of developing effective, innovative and creative approaches to re-skilling/upskilling engagement for those already in the workforce. However, the (NMIS) and the [High-Value Manufacturing Catapult's](#) Skills Value Chain may represent a change in that perspective.

A continued issue for this area of policy development is the need for more suitable and reliable evaluation measures that allow programmes to be appraised and learning to be shared.

## Skills policies: interventions and EDI

Whether it affects skills broadly, STEM skills more generally or engineering skills in particular, the landscape of skills policy and activity faces a number of EDI challenges. The STEM and engineering fields in particular have had a continuing focus on the participation and retention of women and girls in a number of STEM disciplines while also working within (in higher education) a need to work towards greater socioeconomic diversity. Programmes and policies generally have to balance several inclusion features at any one time and may have to address what are longstanding biases. For example, one author observed that both the quality of training and skills development and its uptake is "skewed in favour of already advantaged education groups" (69).

There are, of course, legal requirements in place to ensure that employers and training providers do not discriminate against individuals (including access to training and development opportunities). Within the workplace, employers and employees are (within the definitions of protected characteristics) guided by advice from the [Equality and Human Rights Commission](#) (EHRC) regarding rights and responsibilities. Equally, training providers and regulators are also instructed to foreground EDI and to act if they feel these principles are not being observed (see, for example, the accreditation guidance from [Ofqual](#) and the [SQA](#)). Similar approaches attend to higher education and private training providers.

However, while the legislative frameworks may be in place as a means of protection when things go wrong, there may be other factors (as outlined in the discussion of barriers and enablers above) that prevent individuals from taking up opportunities they might be entitled to; or benefiting from those opportunities to the same extent as advantaged groups. For example, there have been, for many years, concerns about the diversity of young people taking up STEM qualifications at school and beyond. These concerns have become more nuanced over time to include, in particular, the social and economic circumstances of individuals, their ethnicity, their sex and the impact these characteristics have on access to qualifications and attainment. Many interventions to ameliorate or counter these effects have been in place in some cases for decades. However, as several authors have pointed out, there needs to be more evidence that they are achieving their goals (39, *ibid*). For

example, the absence of sound and reliable evidence of impact, particularly concerning EDI, was highlighted by the APPG on D&I in STEM (70) and the Hamilton Commission (71). This review examined literature from the wider skills domain but looked within this for examples of effective practice in relation to skills and EDI. The material reviewed suggests that, in common with the APPG and Hamilton reports, the evidence base is underdeveloped.

The APPG also looked at the STEM workforce through an equity lens (72) and noted that the intersectional barriers that had taken hold in school rolled forward into the world of work. They called for long-term and independent evaluations to support the identification of good practices in terms of interventions to overcome barriers. This review, like the APPG report, has also identified very few examples of approaches that are deliberately geared towards tackling diversity (although the NMIS has an explicit and welcome approach to promoting [diversity in manufacturing](#)). [Equate Scotland](#), which has a direct focus on increasing the number of women studying, working and remaining working in STEM, has produced a best practice guide for engineering employers that highlights training for staff and managers (73). The [STEM Returners programme](#) has been developed to support individuals and employers to return to STEM careers when they have taken a career break (for any number of reasons, some related to the barriers identified above). This programme, supported by the [Women's Engineering Society](#), strongly focuses on diversity. The [Association for Black and Minority Ethnic Engineers](#) (AFBE UK) also offers training and development for organisations and mentoring for professionals to support the retention and progression of professionals from ethnic minority backgrounds.

## How is the engineering profession addressing the EDI challenges?

For some time, the Academy has been actively promoting and supporting attempts to increase diversity and inclusiveness in the engineering profession, create greater equity about access to the professions, and create greater retention and progression within them). The 2017 benchmarking report (74) established the current state of EDI development across the professions, as well as a baseline against which progress can be reviewed (as it was in 2021 (75)).

A subsequent review of inclusion in engineering further underpinned the Academy's desire to support engineering stakeholders to create a more inclusive future for engineers that embraces, develops and retains the talents of all (76). The seven recommendations from the 2018 report (76, *ibid*) map well onto the enabling steps identified by this literature review, particularly creating a culture that values inclusive lifelong learning. This focus on culture change was also taken up in the 2020 Diversity and Inclusion Action Plan (77) and, while the work on [inclusive cultures](#) has not been explicitly about training and development of new skills for engineers, it has set a tone that opportunities in engineering (including skills progression) should be open to all. The [Institution of Engineering and Technology](#) (IET) has also explicitly recognised this as a means by which to address skills shortages in its 2019 EDI Strategy (78).

Many of the stakeholder bodies engaged with engineering – from the [Engineering Council](#) to [EngineeringUK](#) and the 39 PEIs – actively promote and champion diversity. The PEIs and the [Engineering Council](#) may have scope to flex their membership/recognition activities to encourage diversity and support the goals of a diverse profession. [EngineeringUK](#) is, through programmes like [NEON](#) and [Tomorrow's Engineers](#), acting creatively and using evidence to find ways to encourage young people to engage positively with engineering.

In terms of activity to support inclusive engagement with skill development as a subset of being part of the professional community of engineers, there are some examples of work

being undertaken that appear to be actively addressing the barriers to engagement with opportunities to upskill and re-skill. Many seem to focus on bringing key players together to coordinate and plan activities, as well as creating a sense of inclusivity by role modelling through advocates and commitments. Several of these have been mentioned earlier in the review, for example, the [High-Value Manufacturing Catapult's](#) "Skills Value Chain" or the [National Manufacturing Institute Scotland](#) (NMIS), focusing on collaboration or setting a culture of inclusion and lifelong learning. Other initiatives, such as those led by the [Women's Engineering Society](#) or the [Association for Black and Minority Ethnic Engineers](#) (AFBE UK), clearly focus on increasing engineering diversity.

Other examples include:

- The [Skills for Life](#) programme, which offers free access to notable numbers of engineering and digital RQF level 3 qualifications, with support for travel and childcare to enhance accessibility and inclusion. The programme targets individuals who have yet to achieve a level 3 qualification.
- The [Office for Students](#), with higher education partners and industry, has created targeted programmes for under-represented groups to support their development as artificial intelligence specialists.
- Targeted at undergraduates, Rolls Royce has created the [Technology and Engineering I Accelerator](#) to encourage black and ethnic minority STEM students to pursue a career related to engineering or technology.

These examples are not intended to be exhaustive and, in many cases, need some additional time to yield valuable and reliable outcome evidence. One next step from this review may be to engage with the PEI and engineering stakeholders to help identify more interventions that characterise the best qualities of inclusive skills support – particularly those that are determinedly attempting to demonstrate impact.

If the barriers highlighted in this report are addressed well in policy and practice, these programmes may support uptake of training and development (and, conversely, could inhibit uptake if not tackled or the barriers are reinforced). In terms of positive approaches, this may include:

- Targeting policies to address diversity and evaluating these so that they may be continuously improved.
- Promotion of internships/work experience to under-represented groups.
- Better monitoring of equity issues when reviewing interventions, ensuring they are underpinned by a theory of change and effective monitoring plans.

Failing to understand and account for intersectional interests (and not, for example, sex, ethnicity, disability and socioeconomic status as standalone matters) can contribute to reducing diversity in training and development (79). This was highlighted in recent work by [Equate Scotland](#) (80). Another example, with a particular focus on women in STEM, has been produced by the [Women in Science and Engineering \(WISE\)](#) network. Their "ten steps" approach – mapping on to issues identified above, such as flexible learning, collaboration and culture change – appears to be supported by evidence of a positive impact on organisation culture.

## Sustainability, green skills and climate change

There is a strong consensus that green jobs will be in demand (67, *ibid* and 81). The same authors note a need to embed sustainable development principles fully into higher education teaching and learning so that its impact was felt beyond the minority of students who may opt to study it directly or through an additional module. Indeed, this report suggests that:

*It is rather that sustainable development is something that any good engineer, architect etc should be expected to know about. There are already professional bodies such as the Royal Academy of Engineering that recognise this. (67)*

In parallel with some of the findings above regarding enablers for skills development, this paper sees progress being a result of collaboration between the government, learned societies, trade unions, employers and others.

**One of the elementary challenges for this area of skills development is defining what they are.** The Green Alliance (81, *ibid*) has attempted to shed some light on this and also draw attention to the challenges the Office for National Statistics highlighted when they attempted to examine “green jobs” (82). LinkedIn has also looked at this area and developed a “green skill taxonomy” (83), a mixture of roles, occupations and skills that draws attention to roles that need “greening” (which may have some parallels with the need to re-skill/upskill employees in existing roles that need to adapt). Recent work by Rubio and colleagues (84) examined this area and also identified a need to “develop and maintain” a taxonomy that covers green skills.

Much writing about the green economy refers to **green jobs and skills as almost synonymous**. However, Sofroniou and Anderson (85) begin to unpack this a little and identify “green enhanced skills” occupations that require employees to adapt how they work to the demands of a green economy, ranging from knowledge of legislative change to new materials. In addition, the Centre for Skills, Knowledge and Organisational Performance (SKOPE) is currently working on a project (due to end in 2022) looking at [green skills in the construction sector](#).

Recent work from the [Edge Foundation](#) looked at skill gaps across the UK economy (86). Considering the interest in and demand for green skills, they noted that young women were more likely than men to be interested in developing these skills. However, the same group identified a lack of information about jobs and skills as a key feature limiting their interest in green occupations (or occupations in which green skills could be utilised). The green skills agenda could be a notable way to diversify several STEM areas in which women are underrepresented.

The role of trade unions and sector representative bodies in promoting skills development and forging productive alliances between employers, social actors and employees has already been noted. [Unionlearn](#), the learning and skills element of the Trades Union Congress (TUC), has begun to develop some resources targeted at supporting the growth in green jobs (and skills) (87). These include some helpful case studies that reflect the earlier discussion of enabling factors by showcasing local responses (for example, the [Yorkshire & The Humber TUC](#) programme to support transitions to green jobs and skills). [MakeUK](#) (looking at digital skills for a green economy) identified a need for more RQF level 4+/SCQF level 7+ skills for the manufacturing sector in the UK and noted that ‘a green future goes hand in hand with a digital future’ (88). They also noted the urgency of forging responsive partnerships with the education and training sectors to meet this demand (88, *ibid*).

The [Unionlearn](#) activities and many of the explorations of green jobs often focus on adopting new technologies or technical approaches to becoming more sustainable. This is one part of the transition to creating a greener economy and more sustainable growth. For

example, the Green Alliance (81, *ibid*) highlights this in relation to agriculture and the readiness of Governments to subscribe to physical capital/machinery-based interventions in this domain.

Arguably the bigger prize lies in **equipping employees with the thinking skills to see their work and endeavours through a green/sustainable lens**. As Microsoft has noted:

*Sustainability also has a behavioral shift in thinking. We are asking people to change from how they used to function. It's not just technical, it's behavioral.*  
(89)

This parallels the efforts the Academy expended to explore and change how engineers think about their discipline. The resulting "Thinking like an engineer" project report identified six engineering "habits of mind" (closely related to those in mathematics and science and not far from the 21<sup>st</sup>-century skills identified by the World Economic Forum (90)) or the meta-skills approach advocated by [Skills Development Scotland](#). The Engineering Habits of Mind report, meanwhile, was largely aimed at teachers working in the primary sector and arguably contained lessons for anyone involved with the teaching and learning related to engineering. **Supporting learners to develop new ways of thinking, rather than acquiring technical skills or knowledge retention, is challenging**. However, there is good evidence from various sectors that transferable/non-cognitive skills can be successfully fostered (91, 92, 93) and should be familiar to, for example, those involved in developing the "[knowledge, skills and behaviours](#)" embedded in Apprenticeships. Another way of approaching this change in thinking and acting has been developed concerning software engineering, based on [eight principles](#), but its impact and reach have yet to be tested.

This step may require **considerable re-thinking of curricula with parallel changes and adaptation of teaching**. The report cited above (90, *ibid*) notes that, in relation to critical thinking, the challenge is "to convince all educators, especially those associated with higher education, to embrace these constructs and target them as learning outcomes in their courses". The same challenge will face those wishing to embed sustainable and green thinking in engineering education. Writing about VET, the European Centre for the Development of Vocational Training (CEDEFOP) has recently commented on the lack of initiatives across the EU to "prepare VET teachers and trainers for the integration of the green dimension in VET" (94).

It may be possible to achieve some effective changes in partnership with higher education through focused development of, for example, the Academy's [Visiting Professors](#) programme (with a parallel effort to examine the impact of such an approach). Equally, organisations such as [Enginuity](#) appear to be making some headway in identifying new and data-driven ways of identifying skill needs. Their innovative task-focused approach and understanding more about the way(s) this helps to upskill and re-skill employees may be helpful in terms of training and development design.

There is an increasing amount of interest in establishing ways to develop green skills (however these are described – and the [Construction Leadership Council](#) (CLC) has indicated it is also undertaking work to show what these are (95)). Some additional examples of green skills-focused activities relating to engineering are:

- The CLC "[Green Construction Board](#)" is a collaborative venture at a strategic level to bring Government and industry together, including a clear focus on future skills.
- The [Construction Industry Council](#) (CIC) is drawing sector partners together to develop [occupational standards](#) targeted at tackling climate change.
- [The Engineering Construction Industry Training Board](#) (ECITB) is establishing partnership-led approaches to supporting professionals via their [Train to Retain](#) and

[Graduate Development Grant](#) programmes. These programmes are re-skilling/upskilling initiatives that encourage individuals to acquire skills to support net-zero productivity.

One final note on ways to drive the re-skilling/upskilling agenda is the role of regulation. This may be seen as a fairly direct way in which to mandate a change in how individuals approach their work. Still, it may have a supporting role to play (96, 97) and there is evidence of it having a direct impact on professional practice (98). While engineering is not a protected professional title (and, therefore, does not have the mandatory element of meeting particular standards to register and practice), the professional standards for engineering set out by the Engineering Council (99) may have a role to play in this regard. This may concern amending the standards or revising how they are used to drive particular practices. This may also pertain to the membership standards set out by each PEI and there may be merit in revisiting the Academy's 2017 benchmarking study with this focus (74, *ibid*).

*In brief*

Direct interventions to produce a change in engineering practice to become more green or sustainable are more apparent in discussions about roles and technical approaches rather than the (arguably more difficult) ways of changing how engineers or others alter their thinking and behaviour.

The desire to have engineers whose thinking and actions are embedded in an understanding of green, sustainable, low-carbon and responsible approaches may require notable embedding of new approaches to teaching and learning about becoming and developing as an engineer.

## Stakeholders and partners for the future

**As previously noted, the range of stakeholders invested in skills development across the ecosystem is extensive** and covers those acting at a strategic and policy-focused level to more regional and local actors. This will require some degree of prioritisation as the Academy develops its view on how it wishes to re-orient skills development for engineers towards a more green and sustainable growth basis.

This may see the Academy engaging with a set of **organisations that it has yet to work with to develop nationally and locally coherent approaches** to meet skills demands; for example, the TUC and the Confederation of British Industry (CBI). The previous section drew attention to the regional Unionlearn activities on green jobs and skills and the CBI has also been active at regional levels to promote low-carbon economic transition (see, for example, the work of the [Humber Cluster](#)). It is likely that local [Chambers of Commerce](#) will also have a stake in developing the demand for upskilling and re-skilling.

Local authorities also play many roles in supporting local skills development. Taking forward a regionally sensitive approach to developing an effective green engineering skills ecosystem would probably benefit from establishing links with the relevant national bodies (the [Local Government Association](#) (LGA), the [Northern Ireland Local Government Association](#) (NILGA) and the [Convention of Scottish Local Authorities](#) (COSLA)).

Equally, identifying opportunities to work with and shape the demand for skills locally will need to see some interaction with those involved with SIP and SAP development ([Skills](#)

[Development Scotland](#), [Employer Representative Bodies](#) and [Skills Advisory Panels](#), for example).

Of course, the Academy may want to engage with the national levels of organisations such as the [CBI](#), the [British Chambers of Commerce](#) or Unionlearn. For instance, this level of activity may help efforts to bring flexibility to the funding for skills development or to help develop collaborative approaches that make it easier for organisations or individuals to engage with upskilling and re-skilling.

The role of the PEI linked to the Academy should also be considered. For example, working with clear, well-defined goals around increasing the demand for and uptake of training and development focused on sustainability may benefit from PEI support and be piloted with specific engineering disciplines. This targeted approach to establishing new ways of working and ready access to active members could help in the speedy establishment of local collaborative pilots.

Ultimately, the decisions over stakeholders and engagement rest on developing two strands of strategic thinking. The first of these is the clear definition of what outcomes are being sought from green/sustainability skills development. The second is the intended scale of change. Clarity over these matters will allow the resources of the Academy to focus on developing interventions that build on the evidence presented here and that can have their impact assessed to support future initiatives.

*In brief*

The range of stakeholders involved in skills development is extensive and likely to vary in scope and intensity in different regions. Being clear about what sort of change the Academy wishes to bring about and at what scale will be an essential factor in deciding which partners to work with and whether that is on a strategic or operational level. A focus on local initiatives to develop and test skills ecosystem improvements in the demand for, uptake and deployment of green/sustainable skills is a desirable goal.

## Implications for future skills policy at the Academy

Looking across the range of evidence reviewed, several possible developments present themselves for consideration as a new approach to developing the engineering workforce; one that sees them thinking and acting in green, low-carbon and sustainable ways.

From the perspective of ways to support engagement with upskilling and re-skilling, it would appear that any intervention needs to consider **the many elements that may affect an individual's decision to participate in training and development**. This needs parallel changes in how managers and leaders set a vision for demonstrably inclusive employee development (perhaps even modelling the desired changes themselves) in an organisational culture that promotes lifelong learning. Such changes may require **additional effort by employers to collaborate** with learning providers to help shape the training on offer and other partners, such as unions and sector skills bodies, to promote uptake among staff.

*Recommendation 1:* The Academy should highlight and encourage collaborations between employers, unions and skills bodies (among others) to promote participation in training and development among UK employees.

**Local skill needs and engineering sectors may be so distinct as to rule out top-down approaches**, so locally planned and agreed approaches to driving skill demands are likely to have a greater impact. This may be an argument for quite **focused collaborative pilot projects** that include sufficient time to see changes embedded and for **evidence about the impact** to accrue. This review may act as a stimulus to the sector to work with the Academy to identify existing and **promising local solutions** that can be drawn upon to help spread effective practice.

*Recommendation 2:* The Academy should work with, for example, PEIs, partner organisations and with local industries to identify localised approaches to skills development that at least show early signs of promise and that may be seen as testbeds to support the evidence base for effective interventions.

The desirable skills may be as much about ways of thinking and behaving as about adopting new technologies. A change of this nature will require **some degree of repeated engagement with learning designed to support learners in changing how they think and act**. Creating good evidence to support the wide adoption of such approaches will be abetted by carefully designed and evaluated pilots. There are **opportunities to take this forward using existing programmes** managed by the Academy: the Visiting Professors scheme, for example, could accommodate innovative work to support the embedding of green thinking/behaviour both in undergraduates and active professionals.

*Recommendation 3:* The Academy should ensure that any new programmes it commissions or pilots that are connected to skills development are designed to yield useful evaluative information about impact over a sustained period. Equally, existing programmes may need to be re-designed to allow better evidence of impact on primary beneficiaries such as professionals, learners and employees to be gathered.

Any or all of these recommendations will be aided by the establishment of clear or best current working definitions of key areas of interest. This is particularly the case for terms such as green skills and how to develop both green technical skills and ways of thinking and acting.

*Recommendation 4:* The Academy should set out a best current or working definition of green skills (distinct from "green jobs") to support the development of new and review of existing programmes to ensure that there is clarity about the effectiveness and focus of interventions.

The desire to shift thinking about workforce skills development in this direction is ambitious. However, it will require patient accumulation of evidence to ensure that policy and practice changes are not "episodic reactive interventions" (56, *ibid*). The Academy could play an important role in creating and sharing examples of good intervention design and evidence of effectiveness.

Nevertheless, it is arguable that enough is known about what characterises good practice in inclusive skills development to design interventions with the characteristics of effectiveness embedded, which can underpin new work and evaluate existing programmes. The principal

challenge will be settling on a shared vision of what thinking and behavioural skills are required and how to develop these effectively in and beyond the workplace.

*Recommendation 5:* The Academy should continue to highlight and champion the central importance of creating a more inclusive and equitable engineering profession and sector, as a key factor in attracting the widest possible range of diverse talent into engineering, which will help to address the skills shortage.

The skills agenda for engineering will fail to be sustainable or fair unless it is considered through an EDI lens, ensuring that nobody is excluded from engineering due to a protected characteristic or their socioeconomic background.

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## Annexe A: Identifying relevant material

The project inception meeting informed how the literature review would be framed. In addition, the discussion yielded greater clarity over the definition of 'skills' embedded in the literature search and indicated a desire to start with a broad definition, narrowing to STEM and engineering where possible. It was also agreed that the review's primary focus would concern further and higher education and workplace-based skills approaches. The inception meeting also noted that the review should identify engaged stakeholders for possible follow-up work.

Whilst much of the policy-facing work has originated in the grey literature (that is, publications outwith academic journals), this has been complemented by drawing on a considerable amount of reflective and informative work around skills policy arising from academic study. Both sources feature in this review, and gaps in the evidence base are highlighted where possible.

The initial list of search terms applied to the search is set out below, and these have been used in various combinations (where '\*' is a wildcard):

Skills search terms		
Emp* training	Skill* demand	Training incent*
Engineering	Skill* policy	UK
England	Skill* strategy	Upskilling
Northern Ireland	STEM	Vocational training
Retraining	Training barrier*	Wales
Scotland	Training facilitat*	

The search was also constrained by time (from 2012 to current), English language articles/writing, and UK-based work. However, exceptions that have an international dimension have been included where they are authoritative, offer insights or (from a scale perspective) reinforce UK-based work.

Any or all of the search terms used in combination yielded (Google Scholar) upwards of 400,000 items to review. To make the volume manageable, the strategy adopted has been to review the 100 most relevant and 100 most recent publications under each search combination to identify useful material. This was complemented by examining the references within documents selected for review and extending the selection of documents accordingly. This approach yielded over 230 items for deeper examination, which are set out in the spreadsheet ([here](#)).

Table 1 shows the national spread of documents reviewed.

**Table 1 UK coverage of documents reviewed**

	Number of documents
UK	82
England	65
Northern Ireland	18
Scotland	34
Wales	28

*A small number had an international focus*

Table 2 shows the representation of documents across the decade reviewed.

**Table 2 – Documents by year, 2012-2022**

	<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>18</b>	<b>19</b>	<b>20</b>	<b>21</b>	<b>22</b>
Documents	8	10	17	8	22	21	17	24	29	28	41

The documents reviewed have a relatively representative spread across the four individual nations in the UK. However, there also appears to have been a notable upturn in skills-related policy and research publications since 2016, possibly due to increasing concerns over skills supply post-Brexit.