



APPG on
Diversity and
Inclusion in STEM

Inquiry on Equity in STEM education

Final report



JUNE 2020

Secretariat:



BRITISH
SCIENCE
ASSOCIATION

About the APPG

The All-Party Parliamentary Group (APPG) on Diversity and Inclusion in Science, Technology, Engineering and Maths (STEM) was established in 2018 and aims to promote the inclusion and progression of people from underrepresented backgrounds in STEM, and to encourage government, parliamentarians, academics, businesses and other stakeholders to work towards a STEM sector that is representative of the UK population. We also want to consider and influence changes in policy that will lead to this outcome.

The British Science Association acts as Secretariat to the Group. The Group is made up of Members of Parliament and Lords and is a focus for collaboration with businesses and other organisations in the STEM sector. The Officers of the APPG are:

- Chair Chi Onwurah MP (Labour)
- Officers Baroness Benjamin (Liberal Democrat)
- Baroness Brown (Crossbench)
- Baroness Grey-Thompson (Crossbench)
- Lord Lucas (Conservative)
- Stephen Metcalfe MP (Conservative)
- Carol Monaghan MP (Scottish National Party)
- Alex Norris MP (Labour, Co-op)
- Lord Sheikh (Conservative)

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With thanks to the Royal Society for their help and support in setting up the inquiry.

Equity in STEM education

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The views expressed in this report are those of the All-Party Parliamentary Group on Diversity and Inclusion in STEM. The report does not necessarily represent the views of any of the sponsors, witnesses, contributors and reviewers, unless stated.

This report was compiled by the British Science Association who provide the Secretariat to the APPG. The information in this report, including reference to policies and Government status on issues, is correct at the time of writing (June 2020).

The Secretariat would like to thank Clio Heslop, Fembe Nanji-Rowe, Jon Fitzmaurice, Louis Stupple-Harris and Peter Trevitt for their contribution towards producing this report.

Foreword

Equity in STEM education is more important now than ever before.



When we started this inquiry in 2019, we could never have imagined that we would launch the final report in 2020 against the backdrop of blanket school closures and an enforced government lockdown to stop the spread of COVID-19. This Coronavirus has – temporarily – changed the way we live our lives in the UK and across the globe, and the role of science, technology, engineering and maths (STEM) has never been more important to society.

In 2019, the APPG on Diversity and Inclusion in STEM believed that equity in STEM education was vital for the UK to prosper in the 21st century. Arguably it is more important than ever before and we have taken the decision, despite the ongoing global crisis, that we must put forward our findings and recommendations to ensure the UK has a STEM education system that works for all young people of all backgrounds who will be able to tackle future global challenges, such as climate change – whether they are working in science or not.

While we rightly herald our health workers, scientists and engineers for their outstanding response to this crisis there are many unsung heroes such as cleaners, delivery drivers and supermarket staff who are keeping the UK going. The life skills learnt through a high quality STEM education – such as critical thinking, analysis and communication – are important to all of us in these challenging times.

Even before the COVID-19 crisis, science and technology were increasingly shaping our daily lives. Yet the STEM professionals who designed the computer or phone you are reading this report on, tested the medicine you take or stress tested the bridge that lorries use to transport vital supplies are still far too likely to be male, white and middle class.

When I started my Electrical Engineering degree at Imperial College London in the 1980s, I was one of only two females on my course. After graduating and starting work as an engineer I was often the only Black person in the room, the only woman, the only working-class person and the only Northerner.

Fast forward to 2020 and I am disappointed that the UK – as a country with a STEM skills gap – is still not tapping into the talent of those from traditionally under-represented groups who could become the scientists, engineers and technicians of the future. We are missing out on talent and those forced out of STEM are missing out on the invaluable experiences a STEM education, at any level, imparts as well as the exciting, high-skilled, green jobs of the future.

As a society we have been discussing the challenges of getting under-represented groups into STEM careers for over 30 years, yet the dial has hardly moved. If I was to start as a STEM apprenticeship or degree course today, I would still feel in the minority.

I am delighted to present this first inquiry report of the APPG on Diversity and Inclusion in STEM and hopefully it is the start of real change. It is encouraging that so many Parliamentarians across different parties – and individuals and organisations in and beyond STEM – believe that equity in STEM education is an issue that we must take forward to challenge Parliament and the Government with new ideas and solutions.

It is my hope that the evidence and recommendations in this report help make STEM education more equitable for current and future generations. Greater equity could help young people have the skills and aspirations to fill the UK's STEM skills gap and bring the diversity of thought that allows the UK to continue being a leader in scientific and technological innovation, as well as well as creating citizens that are engaged with science whether they work in STEM or not.

Chi Onwurah MP.

Chair, APPG on Diversity and Inclusion in STEM

Executive Summary

This report seeks to outline the evidence on whether schools and the education system provide equity in learning opportunities of science, technology, engineering and maths education to all students (3-19) in England. While there have been many reports and inquiries into the STEM skills gap in England, the All-Party Parliamentary Group on Diversity and Inclusion in STEM believed there was a lack of up-to-date evidence and reporting on equity within STEM education.

This report is based on written evidence received from 20 organisations, two oral evidence sessions with key stakeholders, over 20 expert interviews and a literature review of over 80 relevant sources.

The inquiry aimed to understand whether young people are provided with equitable learning opportunities within STEM education, regardless of their background, and provide recommendations to resolve inequities that may be present within the current system. This report provides evidence and recommendations on STEM education policy in England, as education is a devolved policy area in the UK. It also includes background information from Scotland, Wales and Northern Ireland to provide insight into how equity is tackled in their national education systems.

Young people are not the problem

Equity in STEM education cannot be considered in isolation from equity in other parts of the education system or society as a whole. Where there is inequity, this report found that the systems or processes need to change – not the young people in the system.

There are many factors that determine young peoples' perceptions, aspirations and attitudes, and the ways this causes or worsens inequity can be complex. The educational pathways leading to STEM fields – and to the wider pool of occupations for which a STEM education is useful – are made up of a series of transitions and stages that need to be understood to fully identify how inequity is caused.

The inquiry found that inequity in the workplace could be linked with a wide variety of factors in education, from timing of initially starting school, to parental influence to narrow and stereotypical role models. It was notable that issues earlier in education are more widely experienced, while as educational pathways increasingly diverge as students get older there is greater variation in the challenges and problems encountered, underlining the importance of acting early.

The report brings together five key findings, which inform six recommendations for the UK Government and its agencies, the STEM sector and educators. The findings are:

- There is a need for a more joined-up approach by Government to tackle the causes of inequity in STEM education
- Inequity cannot just be seen through the lens of gender, economic disadvantage or ethnicity
- Strengthening teaching will lead to positive outcomes for young people
- Wider access to good careers education has the potential to raise aspirations around STEM and reduce inequity
- Schools' role in GCSE option selection is leading to inequity, especially in the most disadvantaged areas.

Recommendations



1 There should be a minister responsible for addressing inequity within the education system and widening participation within higher and further education to prepare young people for the future.

- We recommend this portfolio sits within the Department for Education, and supports cross-departmental co-ordination on related policy areas for the future skills for young people, whether or not they go on to work in a STEM field.
- We call for this Minister to set up a Commission for Future STEM Skills to set a clear strategy to improve Britain's productivity and enable all citizens to fulfil their potential.¹
- Government should conduct an in-depth review of each stage of education pathways to identify policies and measures to reduce inequity and loss of opportunity.²

2 STEM education should be more relevant to the lives of all young people, appeal to a wider cross section of young people and do more to create the conditions to enable students to experience STEM as inclusive and 'for me'.

- We ask that equity is given greater weight when monitoring and reviewing STEM education and barriers to the participation of students, particularly in relation to low aspirations and links between grading and perceptions of difficulty.
- Steps should be taken to ensure that all teaching and learning approaches and resources are broad and inclusive in the knowledge and practices that they represent and that they do not reproduce normative ideas of who does STEM.
- We call for the Government to improve the capturing and sharing of information on the effectiveness of interventions that reduce misperceptions and raise aspirations.³
- We recommend that an organisation is chosen or a coalition is created that can work with the Careers and Enterprise Company, STEM Learning, employers and the full range of providers of cost-effective, high quality STEM enrichment in order to provide an easily accessible and user-friendly mechanism by which schools and teachers can connect with them.⁴

3 There should be more action to address teacher shortages in STEM subjects and more support for teachers to access to specialist skills and knowledge linked to improving equity.

- Recognising that Government policy is supportive, we call for more resources to strengthen the recruitment and retention of specialist STEM teachers in schools/colleges in disadvantaged areas, with a particular focus on physical sciences, maths and computing.⁵
- We call for the Department of Education to update Initial teacher education (ITE) and continuing professional development (including within the Early Career Framework courses) for all teachers to better prepare them to tackle inequity in the classroom.⁶

4 Changes to careers support and guidance suggested by the Careers Strategy for England (2017) must be fully implemented and followed up to ensure it is consistent across all schools and reaching all young people.

- Government should ensure that support for implementing new arrangements is speeded up, any gaps in delivery are urgently identified, and additional support is provided to schools if needed.
- Robust evaluation, monitoring and reporting is needed to ensure that the changes are reaching those that need it most and are effective in reducing inequity.⁷

5 The Government should take steps to address the existing inequalities in provision of Double Award and Triple Science at GCSE.

- We recommend the Government identifies what further support is needed by schools in England that are currently not offering Triple Science at GCSE to enable them to do so, and take steps to ensure that this is provided without delay.
- We request Government considers what policy changes or other measures are necessary to ensure that decisions about whether individual students take Double Award or Triple Science are most appropriate to the individual student as a matter of urgency.⁸
- We ask the Government to ensure schools' public reporting includes annual uptake of Triple Science and Double Award compared to overall pupil characteristics.⁹

6 There should be a review of fundamental changes to STEM GCSEs which considers equity issues, providing findings to those preparing the next round of reforms.

We recommend that Government initiates a review addressing the following issues that involves key stakeholders, builds on prior evidence, and commissions new research and evaluation where necessary:

- The possibility of a revised common single route of study in the sciences up to the age of 16 that is accessible to all learners.¹⁰
- The role that students' practical work plays in equity and how they perceive science, including the content of practical work, how it is assessed and how it is resourced in all schools.
- Potential interventions or policy changes that could reduce the growing and acute gender divide in computer science.¹¹
- Changes that may help ensure computer science is offered in all schools, including the possibility of adjusting the qualification and/or training arrangements so as to broaden the pool of teachers who can deliver it to a good standard.

Notes

1. The Commission should address all forms of inequity and all stages of the STEM education pipe-line, including pathways that lead to STEM occupations and non-STEM occupations that require STEM skills.
2. We recommend that this review should;
 - Consider STEM occupations and occupations where STEM qualifications are an enabler
 - Focus on occupational pathways where inequity may be causing unfairness of opportunity
 - Focus on occupational pathways where inequity may be exacerbating labour shortages
 - Take an intersectional approach, moving away from a narrower focus e.g. on gender or economic disadvantage
 - Include early years and school education, with a particular focus on how inequity starts and develops
 - Looks closely at stages when choices are being made and at factors influencing those choices including perceptions of different routes and occupations
 - Gathers more information about inequity within routes into 16-19 and between post-19 education and the factors that lead to it
 - Make full use of existing evidence of equity and inequity in STEM education.
3. An external evaluator could develop a best practice code for publicly funded STEM enrichment activities in relation to equity. This could be informed by recent development of the Inspiring Engineers Code of Practice.
4. This organisation/coalition would work with existing leaders in this area including the Careers and Enterprise Company, STEM Learning, employers and the full range of providers of cost-effective, high quality STEM enrichment.
5. Incentives could include continuing professional development, sabbaticals, or increased pay.
6. Training should include special educational needs and disability (SEND) training, bias training, awareness of intersectionality (Crenshaw 1989), and understanding of issues faced by students for whom English is an additional language.
7. The monitoring process could make it a statutory requirement to adopt the Baker clause and Gatsby Benchmarks by all schools by 2020 and review the support needed to achieve this.
8. This should include the provision of information to students and those that guide them, involvement of students themselves, and proper consideration of what is most appropriate for each student.
9. Demographics should include gender, disability, ethnicity, pupil premium eligibility.
10. This element of the review should be given particularly high priority if the goals set out in Recommendation 5 have not been achieved in full.
11. Teacher support could involve continuing the National Computing initiative with British Computer Society and STEM Learning.

Introduction



The APPG for Diversity and Inclusion in STEM agreed to conduct an inquiry into equity in STEM education after over 70 ideas were submitted to an open call for inquiry ideas issued by the Secretariat. Equity in STEM education has been a common theme since the first meeting of the APPG in May 2018.

The inquiry started in March 2019 and included a call for evidence, evidence sessions, a roundtable and expert interviews. The inquiry report was delayed due to the General Election in December 2019 and the dissolution of Parliament in November, and the outbreak of COVID-19 in the UK in March 2020.

It was agreed that the inquiry would take a broad overview of the challenges and opportunities of equity in STEM education, and its implications for society. We are grateful to our Secretariat (the British Science Association) and everyone who contributed to this inquiry.

Definition of STEM

STEM is the acronym for science, technology, engineering and mathematics.

In education, it means the study of these subjects. In secondary schools, other subjects sit under these terms including biology, chemistry, physics, statistics, computer science and design and technology.

Outside of education, STEM refers to sectors of employment and industry which use the specialised skills associated with science, technology, engineering, and maths, rather than just subject knowledge. This is a broader definition, for example construction, defence, finance, planning, product design, are all examples of STEM jobs which don't link directly to a school subject.

In this report, we usually use the definition of STEM associated with education, whilst recognising that it is linked to a much wider set of skills and experiences in the workplace and careers. This report notes that there is no commonly agreed definition in either education or employment.

Why equity?

Equity and equality are two approaches used to try to create fairness. This report defines equity as a needs-based approach to ensure people with different needs can be equally as successful, and equality as treating everyone the same.

The inquiry chose to use equity as many studies state that treating everyone equally within education provides unequal outcomes, as it assumes all young people begin in similar circumstances. This report uses the Organisation for Economic Co-operation and Development's (OECD) 2018 definition of equity in education:

“Equity in education means that schools and education systems provide equal learning opportunities to all students. As a result, during their education, students of different socio-economic status, gender or immigrant and family background achieve similar levels of academic performance in key cognitive domains, such as reading, mathematics and science, and similar levels of social and emotional well-being in areas such as life satisfaction, self-confidence and social integration. Equity does not mean that all students obtain equal education outcomes, but rather that differences in students' outcomes are unrelated to their background or to economic and social circumstances over which students have no control.”

Background

The question of underrepresentation of certain demographics within STEM industries and academia is one that has challenged policy-makers, businesses, civil society and campaigners for many years. Tapping into missing talent and reducing the numbers of children who experience inequity is vital to meeting the skills challenges of the future, from technician level to science research, as well as in the many non-STEM occupations where STEM skills are important. The evidence suggests there is a mismatch between the STEM skills needed and those available in the UK (National Audit Office, 2018) and the shortage of STEM skills in a number of important sectors has been estimated to cost businesses £1.5bn per year (STEM Learning, 2018).

In the context of historically weak productivity, the UK's recent departure from the EU, environmental challenges and the COVID-19 pandemic, there is a clear need to make better use of the whole talent pool by improving diversity within the pipeline of STEM candidates. Increasing the numbers of traditionally under-represented groups involved in STEM in the workplace could make a substantial contribution to reducing skills shortages (Broughton, 2013). While some limited progress has been made, further improvements would help alleviate what many see as one of the UK's key economic problems (National Audit Office, 2018).

In addition to economic factors, there are wider societal and ethical reasons that underpin the need for equity in STEM education: fairness and equality of opportunity; greater diversity of thought and experience, and a citizenship better able to make sense of scientific information and act on it.

Not a new crusade

Government, Parliament and campaigning organisations have been raising the profile of this for many years. For example, the Women's Engineering Society has been supporting diversity and 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. More recently, other groups aiming to challenge the lack of representation in STEM have emerged such as the STEMM Disability Advisory Committee (STEMM-DAC), the Black British Professionals in STEM (BBSTEM), or InterEngineering which aims to connect and empower LGBT+ engineers.

Within Parliament, the House of Commons Education Committee published its report on science education from 7-14 in 1995, and the House of Commons Science and Technology Committee reported in 2002 about the challenges within STEM subjects around gender and ethnicity for students aged 16-19.

Successive governments since the early 2000s have been concerned with improving the take-up of STEM subjects in schools and its impact on the numbers of students that go onto study those subjects in higher education. In 2017, the Government launched the paper 'Industrial Strategy: Building a Britain fit for the future' where it called for the need to '...to tackle particular shortages of STEM skills. These skills are important for a range of industries from manufacturing to the arts' (HM Government, 2017).

The Department for Education (DfE) is responsible for coordinating Government STEM interventions with a range of other government departments. The Department for Business, Energy & Industrial Strategy (BEIS) has a cross-cutting role setting the national framework for science and technology with its agency, UK Research and Innovation (UKRI) leading on STEM inspiration and investment in postgraduate education. Other departments, including the Department for Digital, Culture, Media & Sport, Department for Transport (who led 2018 Year of Engineering) and the Ministry of Defence run STEM-related programmes and initiatives. In 2016, the Royal Academy of Engineering reported that there are over 600 non-governmental providers of STEM skills interventions. Further inquiries have been undertaken into the STEM skills gaps by the National Audit Office (2018) and the House of Commons Public Accounts Committee (2018).

While some in Government, Parliament and campaign groups see STEM education as a pipeline for future scientists and engineers, this inquiry has a wider remit. The purpose of STEM education cannot be solely be focussed on those that go on to work in STEM careers since it has relevance to many other occupations and to wider personal and social well-being.

Lines of inquiry

The APPG on Diversity and Inclusion in STEM decided to focus the inquiry on the current state of equity in STEM education, as this is an area that has not been covered by previous reports undertaken by Government departments, Parliamentary committees, and organisations from the STEM and education sectors. This inquiry aimed to address this gap to enable a better conversation about the role of equity within the STEM education system and how it impacts on the STEM skills gap and other societal issues.

This report brings together evidence submitted by a wide variety of organisations as well as further supporting research. This report provides evidence and recommendations on STEM education policy in England, as education is a devolved policy area in the UK. The APPG consists of members of the House of Commons and the House of Lords who scrutinise the work of the UK Government, which is responsible for education policy in England. The report also includes background information from Scotland, Wales and Northern Ireland to provide an insight into how equity is tackled in their national education systems.

The inquiry aimed to address the following questions:

- Where is there inequity across different protected characteristics within the STEM education system in England, at any age?
- What can we learn from approaches in other countries or across the devolved nations?
- What policy change could alleviate this inequity?
- What other implications could a change in policy have, and who would be affected?

The recommendations in this report have evolved through discussion with policy experts from across the STEM and education sectors. These create a starting point for discussion of the changes we must make if the STEM education system in England is to provide a level playing field for all its participants.

8 March - 3 June 2019

Call for evidence

19 March 2019

Evidence session on GCSEs,
Houses of Parliament

20 May 2019

Expert roundtable, Houses of
Parliament

July – October 2019

Expert interviews: round one

6 November – 12 December 2019

Dissolution of Parliament

12 December 2019

General Election 2019

January – February 2020

Expert interviews: round two

June 2020

Final report published

Key findings



1 There is a need for a more joined-up approach by Government to tackle the causes of inequity in STEM education.

The inquiry found clear evidence of inequity at each stage of the education journey from early years to the workplace, becoming more pronounced at GCSE and beyond. A levels are generally taken by more advantaged students while gender imbalances are heavily skewed in many STEM subjects with males outnumbering females in STEM apprenticeships by 9:1. At university level there are heavy gender imbalances in STEM subjects; students from well-off families are strongly over-represented and there is inequity in outcomes for those from disadvantaged communities.

Research has enabled a better understanding of the causes and challenges of gender inequity, particularly in areas such as engineering or physics, but too few studies take a broad, longitudinal perspective as exemplified by the SPIRES research (Archer et al, 2020). Research into the relationship between economic disadvantage and educational outcomes is helpful but is often not specific to STEM. There is a need for more studies that take an intersectional view and focus on the real issues faced by young people who often experience multiple barriers. Additional Government funding for research has recently been made available in some areas, such as that looking at gender balance in computing, and this is welcome if it can contribute to a more joined up, intersectional approach.

Systemic changes affecting STEM education have been made in recent years, but the impact on inequity has been limited and inadequate. The updating of GCSEs in England in 2018 addressed some concerns but did not change the inequity of the main dual route system for science which many of the submissions to this inquiry highlighted. Measures concerning careers education in the 2017 Careers Strategy has many helpful features but its implementation is patchy and incomplete, and it is unclear whether the plans will meet their targets, particularly in disadvantaged schools.

Initiatives to attract more girls into physics and computing have received Government support which is welcome but have yet to make a significant difference in these subjects at GCSE or A level. Reviews by Ofqual of grading standards in A levels in physics, chemistry, biology have acknowledged legitimate concerns but no changes have been made and concerns remain about the continuing impact on student choice. The newly introduced reformed maths A level has so far seen a decrease in the proportion of girls taking the subject. The inquiry heard that other changes such as the decoupling of AS levels, demise of Applied Science A level, and reductions in the range of Level 3 post-16 Vocational qualifications offered in many sixth forms and colleges may be increasing inequity.

Progress with reform of post-16 qualifications and major changes in college and employment-based training, including changes to apprenticeships, has been mixed. It is encouraging that there has been an increase in interest in apprenticeships amongst school students, and announcements concerning additional support for the introduction of T levels is welcome. However there are a range of concerns about unintended consequences and reduced opportunities, especially in regions with skills shortages. These include: fewer options for mid-attaining students to study STEM at Level 3; low numbers of under 25s starting apprenticeship programmes; inequity in uptake of higher level apprenticeships; slow speed of qualification reform, and shortages of teachers for STEM-specific T levels. The reforms will need close monitoring of further implementation and evaluation to assess their impact on inequity.

At higher education (HE) level, initiatives to improve access to underrepresented groups have been welcome and the role of Athena SWAN charter is seen as positive, particularly in supporting gender equity initiatives, but patterns of inequity in HE remain largely unaltered.

There is a recognition amongst stakeholders that working in isolation is not going to lead to solutions unless the bigger picture is taken into account (Institute of Physics, 2017) and more progress is needed requiring Government to take action that is more coherent and effective in tackling inequity. This should encompass wider societal issues and the whole educational STEM journey, take a broader intersectional approach, and focus on deliverability while guarding against the risk of improving equity for one group at the expense of another.

Where there are gaps in research, policy makers must ensure that they are commissioning and supporting well-designed longitudinal studies and work with the sector to ensure that terms such as socially disadvantaged, higher-attaining, cultural capital and STEM itself are uniformly defined.

Government must listen to and take on board the views of experts and practitioners and plan policy more holistically, recognising that piecemeal or short term interventions can have limited effect and being more alert to the potential for unintended consequences.

2 Inequity cannot be seen just through the lenses of gender, economic disadvantage or ethnicity.

The Government and the STEM sector have traditionally looked at inequity through three key lenses – gender, economic disadvantage and ethnicity, with gender receiving particular attention in recent years. This is an over-simplification and although all three considerations remain important, they omit others. Those with special educational needs and disabilities represent some 15% of all pupils on roll in schools and mental health is cited by young people as one of the top five barriers to employment (Youth Employment UK, 2019). Many of those in the groups listed below can experience inequity for which the inquiry could not form a clear picture from the evidence available and where further research is needed:

- SEND students. Includes sensory impairment, physical and mental health, personal care support, communication or autism, learning difficulties
- Looked after children
- Gender identity and sexual orientation, LGBT+
- Geography
- Language and vocabulary (e.g. children with English as an additional language)
- Mature learners
- Young carers
- Young people Not in Education, Employment, or Training (NEETS)
- Religion and belief
- Summer born children.

It is also vital to recognise that individual students will often experience compounded effects (UCL, 2019) and that these do not necessarily combine in a simple additive fashion (The Sutton Trust, 2015).

From a very early age, the design of toys, attitudes of family and friends, role models and many other factors can reinforce unhelpful stereotypes. For example, research shows children's job preferences are already gendered by the age of seven and that holding gender-biased assumptions can influence the amount of academic effort young people put in (Kashefpakdel et al, 2019). These unhelpful societal influences continue as students move through education and the misconceptions they give rise to are a major cause of inequity and loss of talent.

Adopting an intersectional approach to equality research (for example, looking at data for students who are disabled and from a particular ethnic background, or sexual orientation etc) provides an understanding of the issues that is closer to the lived experiences of the affected groups (Equality Challenge Unit, 2017).





3 Improving teaching will lead to positive outcomes for young people.

Within STEM education and in wider society it is important to do more to counter perceptions of STEM that adversely influence students by broadening how we teach, learn, practice and represent STEM and by placing equity issues as central concerns. There are already a wide range of interventions that seek to tackle this but for many there is a need for better targeting and better evaluation of the results.

Quality of teaching has the greatest school-based impact on pupil outcomes (Coe et al, 2014, and LSE Growth Commission, 2013) and evidence shows that issues such as recruitment and retention, teacher training and deployment all have a significant impact on equity in STEM (Ainscow, 2010). It is also unhelpful that most teachers in primary schools are not STEM specialists.

Government targets for training science teachers have not been reached in recent years (The Gatsby Charitable Foundation, 2020) and schools in disadvantaged areas often struggle to recruit and retain experienced STEM qualified teachers (Liverpool John Moores University, 2019). A shortage of science teachers results in teachers being required to teach outside their specialist subjects in situations where this is not the most appropriate approach, a further problem that occurs more frequently in these schools.

There are gaps in teacher training and professional development, both for new teachers and for the existing workforce, which leaves teachers ill-prepared to tackle inequity in the classroom. Initial teacher education (ITE) does not adequately cover SEND training, bias training, awareness of intersectionality. It is notable that professional development also plays a role in retaining science teachers (Wellcome Trust, 2017).

Many teachers are not equipped to know how to support students to avoid an 'it's not for me' mentality and find a meaningful connection with STEM. This is not down to a lack of interest or will to tackle the issues, but a lack of time, resource, and support for continuing professional development.

There are concerns that setting and streaming of students reinforces inequity – for example higher sets are more likely to be allocated highly qualified and experienced teachers, whereas lower sets are less likely to be taught by a subject specialist (Francis et al, 2017).

4 Wider access to good careers education has the potential to raise aspirations around STEM and reduce inequity.

There is a disconnect between young people's career aspirations and jobs (Chambers et al, 2020). Lack of awareness of the breadth of career options that are enabled by STEM qualifications results in many young people feeling there is no point studying STEM unless they want to become a scientist or a doctor (Archer & DeWitt, 2017).

Evidence suggests that effective and impartial careers provision is particularly important for students from working class backgrounds, yet students from disadvantaged groups and those who are unsure of their aspirations have been shown to be the least likely to receive careers guidance (Department for Education, 2017). There is also evidence that girls experience additional barriers (Youth Employment UK, 2019).

The present availability of good careers education is patchy, inadequate or provided too late, and this is exacerbating inequity. Initiatives that are beginning to reverse this problem are welcome, however barriers to implementation need to be overcome more rapidly. For example, requirements for careers leads in schools is helpful but there is a need to ensure that all those in advisory roles are adequately trained to address inequity in STEM education.

Direct experience of the workplace by young people can play an important role in changing perceptions and raising aspirations around STEM but more and better opportunities are needed. Proposals made by those contributing to the inquiry included more help for those from lower socio-economic areas to access quality work experience and internships, bringing primary schools into the work experience co-ordination network and providing funding to enable schools to help students get suitable work experience (UCL, 2019).

Employers have an important contribution to make in improving the supply of skilled labour, particularly following Brexit, and should be encouraged to do more to reduce lost talent. Lack of diversity in their own workforce sends unhelpful signals to young people that can have a negative impact on their choices and aspirations. Organisational cultures that are excluding or lack diversity constrain opportunities and chances for progression and have also been shown to limit organisational performance (Campaign for Science and Engineering, 2018). More needs to be done to address these issues.

Recent increases in young people's awareness of environmental issues represents an important opportunity to interest more young people in STEM. Careers education should shape this vision showing how young people could make a difference as well as providing practical information about salaries and labour markets.

5 Schools' role in GCSE option selection is leading to inequity, especially in the most disadvantaged areas.

In England there are currently two main routes to studying science at GCSE: Combined Science (often referred to as Double Award) or a route where students take individual GCSEs in biology, physics and chemistry (often referred to as Triple Science). The existence of these two routes, retained following extensive updating in 2016, is intended to provide more choice and enable higher attaining students to study science in greater depth and breadth. However the inquiry found a range of concerns about its impact on equity and the consequences for young people's education. For example, some schools refuse to allow pupils who have taken Double Award science to take A level science, making access to these courses more difficult for students from disadvantaged backgrounds due to patterns of attainment at GCSE (Royal Society of Chemistry, 2019 / Lauchlan, 2018). Of particular concern is that approximately 8% of schools in England, mostly situated in disadvantaged areas, do not enter any students for Triple Science. This fails to deliver government policy, is wasting talent, limiting opportunity and should be urgently corrected.

The inquiry also found that where both the Double Award and Triple Science routes are offered there are concerns about timetabling and teacher allocation which favour one of the two routes. There is also evidence that students are not being properly informed or involved in the decision-making process on which route to follow. This is leading to serious inequity, figures showing that just 53% of the highly able FSM6 pupils are taking Triple Science compared to 69% of those not in the FSM6¹² category (The Sutton Trust, 2015). This needs to be corrected and backed up with robust monitoring.

Even if both options are available and the allocation of students to each route is equitable, there are still important concerns linking the current system to inequity, particularly for those taking the Double Award. Research found that those studying Double Award science are more likely to receive lower quality teaching than Triple Science students (Lauchlan, 2018). Triple Science was likely to be prioritised in decisions regarding staffing. For example, more teachers with more experience and discipline expertise are allocated to Triple Science. The Double Award route was commonly under-resourced and thought to be less in need of disciplinary experts due to lower levels of content as well as the likelihood that students with lower prior attainment are allocated to these classes.

The inquiry received calls for the present dual route in science at GCSE in England to be replaced by a common single route of some kind, however it was also acknowledged that although the original aims of the dual route policy do not appear to be being achieved, change on this scale is potentially disruptive. Further work on what form a common single route might take is needed.

There are also concerns that GCSE computer science is not offered in 38% of schools, significantly limiting the choices of students in those schools. It is suggested that the best way for governments to increase the proportion of disadvantaged pupils taking computing may be to ensure that more schools in disadvantaged areas offer computer science (Royal Society, 2017). The subject is also only taken by a minority of girls and recent investment by the Government in the National Centre for Computing Education, and specifically in funding for research into gender balance in the subject, will be helpful if it leads to policies that increase the take up of the subject by girls.

12. Free Schools Meals 6 refers to those who are eligible for the pupil premium because they have received free school meals in any of the previous six years, known as the 'ever 6' model. The Government use this measurement to provide extra funding to schools for pupils who are from disadvantaged households. This report notes that some authors, including Ilie et al (2017), suggest that this measure can be problematic as a measure of pupil socio-economic deprivation since there are many circumstances in which eligible young people do not claim the meal allowance.

Analysis of evidence

Introduction

The inquiry found clear evidence of inequity occurring throughout the STEM education pipeline, from pre-school to post-16. There has rightly been a strong research focus on gender equity in science education in recent years which has produced valuable insights. There have also been many good research studies looking at the complex effects of disadvantage in education and some data on educational inequity in relation to ethnicity but relatively little that focused on STEM education specifically. Other forms of inequity also occur for which there is comparatively little relevant research, for example in relation to mental health, disability, LGBT+ and other minority groups.

The review sought to consider the evidence from the point of view of individual students as it is actually experienced as far as possible. This involved assembling the data into a time sequence from early years to post-16 taking an intersectional approach as far as possible. A range of case studies were submitted to this inquiry demonstrating initiatives and activities that were helping to overcome inequity in STEM education. Six case studies have been selected to highlight some of the learnings that can be taken from existing projects, resources, ideas and best practice.

CASE STUDY 1

Longitudinal understanding of young people's science capital ASPIRES Research

ASPIRES 2 is a large, national mixed-methods project looking at young people's science and career aspirations from ages 14 to 19 based at the UCL Institute of Education (2020). The study extended previous research conducted with the same cohort of young people from ages 10 to 14 and looks at how and why young people come to see science as being 'for me', or not. The first ASPIRES project (King's College London, 2013) developed the concept of 'science capital', a method for encapsulating all the science-related knowledge, attitudes, experiences and social contacts that an individual may have. This term has since been influential in understanding the influences on young people.

ASPIRES 2 provides an authoritative and valuable source of evidence as to how young people view science (and STEM), how these views change over time, and the key factors that influence their views and aspirations. In particular, it provides fresh insights into factors shaping young people's STEM participation and why existing participation patterns are so resistant to change.

The study explored:

- What shapes young people's desire to continue with science qualifications and career ambitions after compulsory education (science aspirations)?
- What are the factors that influence how young people identify as being 'good at science' and/or being 'sciencey' (science identities)?

IMPACT

The ASPIRES research has achieved considerable impact on policy and practice across primary, secondary and informal science education sectors, both nationally and internationally. It has been awarded the British Educational Research Association 2018 prize for Impact and Public Engagement and won the 2019 ESRC Panel's Choice award for impact.

Key findings include:

- Inequalities in science identities and aspirations were evident in primary school and exacerbated through secondary school
- A multitude of inequalities and experiences interact to either support or constrain a young person's science identity and/or aspiration
- Young people's science choices, aspirations and progression were channelled and constrained most strongly by stratification of science routes at Key Stage 4 (into 'Double' and 'Triple' routes) and through stringent grade entry requirements for science A levels
- Issues of teacher specialism, supply and retention impacted most strongly on students from working-class and minority ethnic backgrounds
- Careers education provision was patterned by social inequalities, with working-class, minority ethnic students, girls and lower-attaining students being significantly less likely to receive and benefit from high quality careers support.

Early years and primary

Perceptions about STEM begin to form from an early age, with children as young as 3-4 years showing preferences for gendered work roles (Fawcett Society, 2019). Those from low socio-economic backgrounds are already behind their middleclass counterparts in key areas of cognitive development by up to five months when starting school (Washbrook and Wagdofel, 2011). There is also evidence that variation in the time at which places are taken up by children from different groups puts them at a disadvantage. This can be seen in maths where failing to be placed in the top set is often linked to whether the child was young for their year or to gender.

In primary education, many of the important influences on inequity in STEM learning are linked to teaching and the pressures teachers are under. Gender stereotyping from a young age leads to development of unhelpful perceptions of 'masculine' vs 'feminine' skills. However, many practising primary teachers do not currently undergo training on sexism and gender stereotypes. Practitioners themselves report unknowingly treating children differently, segregating both by task and through symbolic gestures such as different colours or groupings (National Education Union, 2013). The Government's Social Mobility Commission found that teachers' perceptions and expectations of different social and economic status, gender and ethnic groups impact negatively on attainment within some groups (Shaw et al, 2016).

Disadvantaged pupils start to fall behind in science at Key Stage 1 and evidence shows the gap gets wider at Key Stage 2 (Education Endowment Foundation, 2018). Unhelpful perceptions about STEM become more established, for example: STEM subjects are seen as for 'clever' pupils only and pupils as young as 10 self-identify as 'not STEM' with these misconceptions impacting more negatively on girls, other disadvantaged pupils and some from ethnic minority backgrounds (Teach First, 2019 / Macdonald, 2015). Over time those who are placed in lower sets for maths, where this occurs, take on board the message they are not good at it, leading to a reduction in performance. This is against a background of the quantity and quality of primary science education being reduced in favour of English and mathematics. In 2018, an estimated 9.4% of FSM pupils met the expected standard based on Key Stage 2 science sampling assessments compared to 23.3% of non-FSM, and there are important gender differences such as a consistent gender gap in above age mathematical performance favouring boys (MathsWorldUK, 2019 / Standards & Testing Agency, 2019). Despite these challenges, significant numbers of young people are interested in STEM and research suggests that girls' interest in STEM peaks at around the age of 11 (Microsoft Philanthropies, 2017).

CASE STUDY 2

STEM subjects for those with visual impairment

CodeJumper

Torino is a physical programming language for teaching computational learning to children ages 7-11. It was developed as part of a Microsoft Research project which aimed to address social inclusion in education and the reality of teaching STEM subjects for those with visual impairment. Children connect physical instruction pods and tune the parameter dials to create music, audio stories, or poetry, and generate code. Torino has been tested and evaluated in multiple stages, which have resulted in a full-featured, manufacturable version of Torino, complemented by a scheme of work that guides non-specialist teachers and children through the concepts of the computing curriculum.

IMPACT

A large-scale evaluation of the Torino Learning Environment was undertaken to capture children's engagement and learning, as well as considering the experiences of teachers from collecting survey and diary responses. The findings show that children were highly engaged and that teachers reported age and ability appropriate learning across the cohort. The research also:

- Demonstrated that children ages 7 – 11 with mixed visual abilities can successfully learn using a novel physical programming language at scale
- Provided insight into design features, persistent program overview and liveness, that support or hinder non-specialist teachers to co-produce learning using the Torino Learning Environment with children of different ages, visual, and cognitive abilities
- Offered reflective guidance for future research aiming to evaluate inclusive educational technologies at scale.

The resources are now being distributed under a new brand (CodeJumper) as an aid to teaching computer coding to students who are blind or visually impaired, encouraging them to think computationally, solving the same challenge in multiple ways.



Secondary

Group differences in engagement with STEM are evident from the start of secondary school (Archer, 2020). This takes many forms, for example children from lower socio-economic backgrounds are less likely to take part in enrichment activities during summer holidays (Falk et al, 2012) and Black Caribbean pupils are under-represented in entry to the higher tiers of science and mathematics at Key Stage 3 (Campaign for Science and Engineering, 2014). Disadvantaged students' enthusiasm for and engagement in science can be reduced due to fewer resources for tutoring, extra-curricular clubs, facilities and activities such as practicals, with these students being less frequently exposed to enrichment activities.

Unsurprisingly, as at primary level, teaching at secondary level continues to be a key factor as illustrated by a study of GCSE achievement in England which found that high quality teaching could make up a significant part of the gap in achievement between economically advantaged and disadvantaged students. Teacher shortages due to difficulties with recruitment and retention are common in secondary STEM education, particularly in physical sciences, computer sciences, design and technology, and maths (Teach First, 2019). This problem disproportionately affects students at schools in disadvantaged areas (Slater et al, 2009).

There are also concerns about how teachers are allocated to different courses and year groups in relation to their specialist subjects which can affect the aspirations of students as well as their learning. For example the uptake of GCSE Physics is linked to whether a student is taught by a physics teacher with a physics degree, a situation that is less likely in deprived areas (Teach First, 2019). Many schools do not have enough specialist physics teachers available to teach the subject at A level.

Research shows that male pupils more likely to be called upon by teachers to get actively involved in STEM (WISE Campaign, 2019) and that teachers often pay boys more attention than girls in class (Culhane and Bazeley, 2019). Evidence submitted to the inquiry suggests there are deficiencies in training to help teachers challenge stereotypes and avoid reinforcing inequity.

There is evidence that Black students are more likely to be misallocated to lower sets irrespective of their attainment (Archer et al 2018). The inquiry's attention was also drawn to the fact Black Caribbean students are expelled three times as often as white students and that missing even a single lesson can set students back significantly and can put them off further STEM study (HM Government, 2020). Other groups who are over-represented in exclusions include FSM pupils, SEN pupils, looked after pupils and those from a Gypsy/Roma or Traveller or Irish Heritage ethnic groups. While 27% of young carers (aged 11–15) also miss school or experience educational difficulties; a figure that rises to 40% where children care for a relative with drug or alcohol problems (Dearden & Becker 2004).

Research has identified the scale of inequity in some areas, for example: the difference in attainment between young people from disadvantaged backgrounds and those from non-disadvantaged backgrounds is 18.4 months across GCSE subjects (Education Policy Institute, 2018); some 36% of highly able FSM6 boys fail to achieve a good set of GCSEs (The Sutton Trust, 2016), and in GCSE maths there is a whole grade difference between those on free school meals and those not.

It should be noted that while there is good research and evidence concerning inequity around some aspects of KS4 education, only a subset of studies are concerned with STEM subjects or take an intersectional view. As with other levels of education, much of the research is also focussed primarily on either gender, disadvantage or ethnicity despite indications that there are substantial interactions such as between ethnicity and socio-economic status and between ethnicity and gender (Strand, 2014) and there is a relative lack of information about other minority groups such as those with SEND.

A contributor to the inquiry pointed out that disabled students often fall through the cracks with their deficits receiving more attention than their strengths, adding that bullying can push them out of the education system preventing them pursuing STEM further.

The uptake of GCSE courses shows large imbalances in some STEM subjects. Students from the most disadvantaged quintile are less than half as likely to take Triple Science at GCSE compared to those from the most advantaged quintile (Archer et al, 2017). In terms of gender, the proportion of females sitting JCQ exams in 2019 were: computing 21%, design and technology 30%, engineering 10% and ICT 35% (Joint Council for Qualifications, 2019). Certain ethnic minority groups are also less likely to sit computer science (University of Roehampton, 2019).

All students should have the opportunity to study the main GCSE science route most suitable for them. This is not the case at a significant number of schools which also contain some 20% of highly able FSM6 status (The Sutton Trust, 2015) and are more likely to be in disadvantaged areas (Aston University, 2019). More worrying, some 16% of all pupils who didn't study Triple Science said they would have done if it had been an option available to them (UCL, 2019).

Some 38% of schools do not offer GCSE computer science at all. The evidence shows these are more likely to be those with a less affluent intake (Kemp et al, 2019) and are more likely to be the smaller schools with shortages of computing teachers (Royal Society, 2017). Poorer students are also found to be less likely to take computer science GCSE where it is offered (University of Roehampton, 2019). The COVID-19 crisis has shown that many disadvantaged students lack access to a computer at home, which could inform why some of these students may not take up computer science.

The curriculum itself and associated teaching resources often focus too heavily on male role models and to perpetuate unhelpful stereotypes in relation to STEM. For example, in a sample analysis of three Double Award GCSE specifications from the major exam boards, a total of two female scientists were named compared to the mention of over 40 male scientists or concepts or materials named after them (Sundorph, 2020).

There is considerable concern that many of these factors affect students' attitudes and perceptions about STEM and shape their confidence and aspirations. The impact on attitudes is clear from recent research into gender inequity. Girls' enthusiasm for STEM was found to drop more steeply than for boys through secondary education, lagging behind their male peers by the time they reach the age of sixteen (WISE Campaign, 2019) and there is evidence that girls tend to lack confidence in their ability in science compared to boys (Wellcome Trust, 2020). Pupils from communities with low STEM capital can be less interested if STEM subjects contain less practical work or if there are fewer links to real applications, which can lead to them seeing studying the subject as a chore (GhScientific, 2019).

Qualifications: Dual route

In addition to the problem of some schools not providing both the Triple Science and Double Award routes to GCSE science, many contributors to the inquiry cited the dual Triple Science/Double Award system as a significant cause of inequity. The causes of inequity included how students are allocated to each route and differences in the quality of each route, suggesting that the Government's policy is not being achieved at a number of levels. There is a lack of consistency between schools with research showing a wide variety of approaches to how they manage the two routes, each with different implications for the quality of teaching, resources and student outcomes.

Overall, submissions to the inquiry pointed to students receiving poor advice (Geological Society of London, 2019 / University of Roehampton 2019) and not being properly involved in deciding which course was most suitable for them. Over half of both Double Award and Triple Science students have reported that they were not given a choice between the two routes (Teach First, 2019). There is also concern that decisions are not always being made in students best interests (Geological Society of London, 2019) with respondents citing 'tight gatekeeping' directing disadvantaged students away from Triple Science (Teach First, 2019) and selection based on unreliable internal school data or the behaviour of students (Ark, 2019).

Schools are less likely to enter disadvantaged pupils with high levels of prior attainment for Triple Science than others with similar levels of prior attainment (Aston University, 2019). Working-class students are found to be more likely to accept the school's choice if they are not put in for Triple Science ('I wouldn't have been able to cope') even if they are high attaining, and more likely to regret their 'choice' when considering aspirations and plans (UCL, 2019).

Triple Science and Double Award are often perceived to have different status (Geological Society of London, 2019) with Triple Science being seen as the 'academic route' with 'high status' (UCL, 2019). Some 68% of those who didn't study Triple Science cited personal barriers such as lack of confidence or interest, or concerns about coursework (Wellcome Trust, 2020) and pupils not selected for Triple Science by their school can perceive this as a failure (Archer et al, 2019).

Overall, there is a picture of serious inequity in the uptake of the two routes:

- Disadvantaged pupils are almost three times less likely to take Triple Science (Liverpool John Moores University, 2019 / Teach First, 2019)
- Highly able students on pupil premiums are less likely to take Triple Science (Burgess and Thompson, 2019) - 53% of the highly able FSM6 pupils take Triple Science compared to 69% of those not in the FSM6 category (Sutton Trust, 2015)
- There is stratification of those studying Triple Science/Double Award in terms of ethnicity (UCL, 2019).

There were also a number of concerns that those studying Double Award are more likely to receive lower quality teaching than Triple Science students (Lauchlan, 2018). Findings include Triple Science being prioritised in decisions over staffing with provision of more teachers, more discipline experts and more experienced teachers compared to Double Award (Ark, 2019). Double Award was commonly under-resourced in regard to staff and thought to be less in need of disciplinary experts due to lower levels of content (Lauchlan, 2018).

Looking forward, only 14.6% of those taking science at A level took Double Award GCSE (Teach First, 2019), reducing their options for further study of STEM and limiting their access to such as HE engineering (Royal Academy of Engineering, 2019) and ultimately to STEM careers (UCL, 2019).

Even for students who are in schools that provide both courses, the inequity of apportionment to Double Award and Triple Science combined with the differences in the two routes leads to inequity and lost talent.

England requires earlier educational choices than most EU countries and requires children to specialise at an earlier age (Biochemical Society, 2019 / Royal Academy of Engineering, 2019) and the inquiry found links between this early narrowing of the curriculum and inequity. For example, making decisions at 15-16 without sufficient knowledge of the impact of their decisions has been linked to disproportionately high number of girls dropping out of STEM subjects (UCL, 2019 / Royal Academy of Engineering, 2017).

In England since 2015 GCSEs have moved from a modular to a linear course structure where learners take all exams at the end of the course. This impacts the way knowledge development and assessment opportunities are structured which some learners find less motivating and may exacerbate some forms of inequity. Similarly, there are questions about the impact of accountability measures such as the EBacc and how these can affect subject choices. An investigation showed that more disadvantaged pupils achieved GCSEs at Grade C or above in maths and fewer dropped out of education in schools that quickly increased the numbers entering EBacc subjects, however there are also concerns that the number of academic subjects in EBacc may stretch some pupils' efforts too widely, and result in very low grades (Hutchinson and Francis, 2018). There are concerns over inequity due to the practice of streaming candidates into foundation or higher tiers of science GCSEs and there have been suggestions that decisions can be prejudicial (Teach First, 2019). There is also a view that the practical work now required disadvantages pupils with low science capital who are attracted to STEM because of its practical context. Recent figures show that 65% of students in years 7–9 and 57% in years 10–13 wanted to do more practical work than they currently do, and this attitude was most common among students traditionally less engaged in science (Wellcome Trust, 2020).

Teenagers show considerable lack of awareness about where STEM education can take them, and their aspirations do not relate to the labour market (Mann et al, 2013). There is evidence of basic misconceptions such as that science qualifications are only relevant to science careers (Archer et al, 2019) or that maths only leads to a narrow range of careers (MathsWorld, 2019). Research into the attitudes of young people to engineering reveal that girls are less likely than boys to know about engineering, to view it positively, to consider a career in the industry or to believe they could become an engineer if they wanted to. The same study found that those who knew more about what engineers did were far more likely to have positive perceptions of engineering (EngineeringUK, 2019).

Despite the introduction of a new careers' strategy, there are concerns about compliance. Many schools are still not providing pupils with access to careers advice on further technical education options (Royal Academy of Engineering, 2019) and the inquiry heard that STEM careers guidance can be patchy, inconsistent and of variable quality. Some 82% teachers said they lacked necessary knowledge to offer careers information to their students (STEM Learning, 2020). Girls receive less information than boys about their education choices or the support services they may need (Youth Employment UK, 2019) and indeed are found to be more likely than boys to go to their friends, relatives or other young people for careers advice (STEM Learning 2020). Some initiatives such as Tech She Can are trying to address this by creating a collection of lesson packs for 10-13 year olds to help teachers promote the opportunities of tech careers.

Young peoples' aspirations toward STEM jobs also appear to be limited by a lack of opportunities for work experience with only 8% of those in Year 10 having participated in a work experience in STEM at some stage, and young women experiencing fewer chances to explore the world of work (Youth Employment UK, 2019). STEM outreach interventions that fill this void can be effective, for example young people attending a STEM careers activity in the past 12 months were over three times as likely to consider a career in engineering than those who had not (EngineeringUK, 2019).

CASE STUDY 3

Triple Science for all Ferndown Upper School

Ferndown Upper School in Dorset, an active STEM school, competes with local grammars and has a mainly white working-class intake starting from year 9 and has been looking at long-term interventions to enhance science attainment and engagement.

The school decided to put all students through Triple Science, one of the first in the country to do so. The Science department ensured that foundation tier science courses were accessible and engaging as students of low ability could struggle with single sciences. Students also have access to a broad range of other Ebacc subjects. Key success factors have been the recruitment and the retention of the best science teachers who are attracted to concentrating on their speciality and a dedicated STEM support pathway to enhance parental engagement and develop practical and employment skills.

IMPACT

As the arrangements for science GCSE bedded-in, the school noticed a huge decline in negative views towards science within the school. The school reports that students and teachers are happier, and have seen significant improvements in maths attainment. Students who would previously have studied Double Award are making significantly improved progress and there has been a marked improvement in student engagement, behaviour, motivation and enthusiasm for STEM careers, particularly among girls.

The Progress 8 scores for the school at Key Stage 4 (KS4) in 2019 were among the highest in the county for 2019, with exceptional results for maths and science. Students consistently achieve higher than national average outcomes at KS4 and KS5, particularly the most disadvantaged pupils with special educational needs and/or disabilities who achieve exceptionally well. The school has also been the most successful school in Dorset across the three key government accountability measures of GCSE progress and outcomes at A Level and Vocational A Level and was the top performing Upper School in the country in 2019 on these measures.



CASE STUDY 4

Impact for students from disadvantaged backgrounds CREST Awards

The CREST Awards is a curriculum-enhancement scheme that recognises success, and enables students to build their skills and demonstrate personal achievement in project work. It acts as a framework for educators, accredits partner activities, and gives students the freedom to design their own projects and experiments. CREST is the British Science Association's flagship education scheme and has been running for over 30 years.

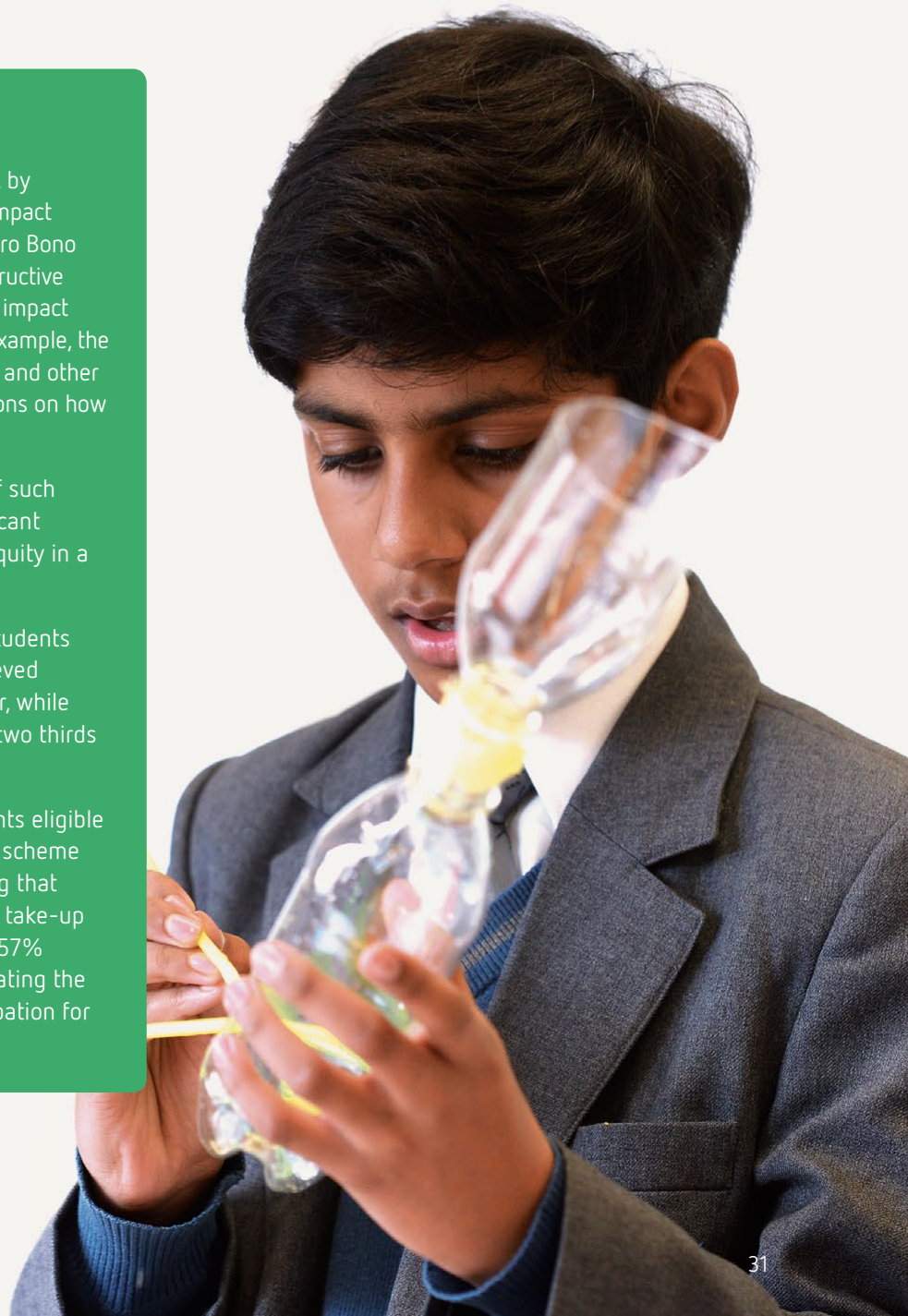
Previous research to evaluate the impact of the CREST Awards programme focused on the process of the scheme and the self-reported experience of participants. In 2016, it was decided to explore a quantitative outcomes-based approach, using attainment of students in GCSE science subjects and the probability of them taking a STEM subject at AS level.

IMPACT

The research conducted for the BSA by resulted in the Quantifying CREST impact report (Stock Jones et al, 2016) by Pro Bono Economics. This report is highly instructive in addressing the issues involved in impact studies of STEM interventions, for example, the need to control for prior attainment and other factors and includes recommendations on how this might be improved further.

Despite the technical challenges of such a study it found statistically significant evidence of positive impact on inequity in a number of areas:

- Non-Free School Meals (FSM) students taking Silver CREST Award achieved around half a GCSE grade higher, while FSM students achieved around two thirds of a grade higher
- The study also compared students eligible for FSM who were in the CREST scheme with those who were not, finding that those in the scheme had a 78% take-up of STEM AS levels compared to 57% who were not, clearly demonstrating the benefits associated with participation for those in this group.



Post-16

Women, working-class students and minority ethnic groups are all underrepresented in 16-19 (UCL, 2019) and post 19 education. Intersectionality also become more apparent at this level, with serious implications. For example, by age 19 a majority of students eligible for free school meals have not achieved a good standard in mathematics (Education Endowment Fund, 2018), limiting their opportunities. Despite being interested in and highly valuing science, Black students tend to express limited aspirations to careers in science and remain underrepresented in post-16 science courses and careers, a pattern which is not solely explained by attainment (Archer et al, 2015).

The problem is not always easy to quantify. One study that sought to take a broad view found that across all subjects the achievement gap associated with social class at age 16 was twice as large as the biggest ethnic gap and six times as large as the gender gap. The study concluded that ethnicity, gender and socio-economic status do not combine in a simple additive fashion, and each education pathway may differ widely (Strand, 2014).

At A level, patterns of inequity are of considerable concern. Overall, some 27.1% of girls' A level entries in 2017 were in STEM subjects, compared with 45.6% for boys (Joint Council for Qualifications, 2019), with physics, ICT, psychology, computing and design and technology all showing large gender imbalances. Only 2% of White British students take Biology, Chemistry and Mathematics A levels compared to Chinese 8%, Indian 13% and other Asian over 16 (Campaign for Science and Engineering, 2014).

There is evidence that access to science A level is disproportionately difficult for students from disadvantaged backgrounds (Royal Society of Chemistry, 2019) and that some schools are not entering any students who have taken Double Award science at GCSE (Lauchlan, 2018). Concerns have been raised for some time that more severe grading of A level science reduces the range of ability of entrants to these subjects and inequitably limits student choice, particularly in schools in more deprived areas of the country. The inquiry also heard suggestions that the decoupling of AS levels may be reducing opportunities for students to try out subjects in which they are less confident such as maths and go on to a full A level, and that the demise of A level Applied Science and the reduction in Level 3 post-16 Vocational qualifications offered in many sixth forms and colleges has led to fewer options for those who are not higher attaining and may be exacerbating perceptions that STEM is only for clever people.

Research by the Institute of Physics into gender balance interventions has led to calls for work across the whole school to challenge gender stereotypes, look at patterns in progression data, appoint a gender champion, and review the options processes through a gender lens (2017). The new 'Gender Balance in Computing' research project run by the National Centre for Computing Education aims to trial new initiatives to tackle the problem that girls make up only 15% of the cohort for computing A level.

There continues to be a lack of parity of esteem between academic and vocational pathways. The uptake of apprenticeships is a concern with declining numbers of level 2 and 3 apprenticeships (Royal Academy of Engineering, 2017) and there are a range of other problems with the ambition of the apprenticeship levy to improve social mobility.

Pathways to the construction industry are highly inequitable. Some 97% of enrolments on construction training courses are from white young people and 99% are male. Construction apprenticeships are similarly segregated with 96% of apprenticeships taken up by white young people and 98% taken up by boys. Engineering apprenticeships show considerable inequity with only 8% of engineering apprenticeship started by females and there is a lower uptake by those from Black, Asian and Minority Ethnic (BAME) communities (EngineeringUK, 2018).

Concerns about equity in vocational training identified by contributors to the inquiry included:

- Black Caribbean pupils are disproportionately encouraged into vocational training (Campaign for Science and Engineering, 2014)

- Overly high academic entry requirements and excessive academic content in vocational training (Allan, 2018)
- Lack of funding for travel expenses for those wishing to do an apprenticeship away from home, which can exacerbate geographic and financial inequity (Royal Academy of Engineering, 2019)
- ‘Cold spots’ in apprenticeship provision in areas of pre-existing socio-economic disadvantage (Royal Academy of Engineering, 2019).

The figures for those starting further education or training at all levels (intermediate, advanced and higher) in 2018/19 (HM Government, 2020) in comparison to all subjects are shown below.

Subject	BAME	Female
All subjects	23.5%	59%
Construction, Planning and the Built Environment	5%	6%
Engineering and Manufacturing Technologies	8%	8%
Science and Mathematics	4%	58%

Source: Department for Education (2020)

There are a range of concerns about inequity in STEM apprenticeships at level 4 and above. In work-based learning, higher level apprenticeships are taken up in large part by people from wealthier backgrounds and only a minority are taken up by those under 25 years. There is a need for more opportunities for SEND students to take part in STEM apprenticeships and work placements that are designed with their needs in mind. There are too few technical options post 18 for those in a technical pathway and issues with access to degrees, for example insufficient weighting may be given to BTECs in decisions concerning entry to science degrees or the level of maths skills needed for engineering degrees may be too high.

There are wide variations in uptake of higher education. In terms of gender, the large majority of students studying computer science (82.9%) are male, while female first degree students make up 79% in subjects in Psychology and Behaviour Sciences and Veterinary Science but just 9.6% in Mechanical, Aero and Production Engineering subjects (Equality Challenge Unit, 2015 / Royal Society, 2014). Students can lack support at university, for example mentoring schemes during the transition from school to university can reduce drop-out rates for those with autism. Young White British participate in HE at a lower rate than those from ethnic minority groups, a trend that is particularly marked when comparing young people from similar social and economic backgrounds (Shaw et al, 2016).

Initiatives to increase applications to university from disadvantaged communities have been helpful but considerable inequity remains. Furthermore, it is unclear what interventions are most effective for this group and others such as BAME, LGBT+ and others. During their time at university, the inquiry found that students from lower income backgrounds find it harder to gain work placements and internships that can help with entry to many careers in STEM and that young women are half as likely to ever have received any careers-based interactions than young men (Youth Employment UK, 2019).

In postgraduate education, there is considerable variation generally favouring white men, for example women are less likely than men to progress from a first degree to further research-based study (Royal Society, 2014) and there is a lower proportion of women in science at post-graduate level in physical sciences than at undergraduate level (UCL, 2019).

CASE STUDY 5

Addressing cold spots in outreach provision

Uni Connect

Uni Connect, formerly known as the National Collaborative Outreach Programme (NCOP), brings together 29 partnerships of universities, colleges and other local partners in England to offer activities, advice and information on the benefits and realities of going to university or college. During 2018-19 over 180,000 young people and 1,613 schools and colleges took part. The programme, now in its second phase, aims to support the government's social mobility goals by rapidly increasing the number of young people from underrepresented groups who go into higher education and in particular to add value to the work that higher education providers undertake through their access and participation plans.

Uni Connect aims to:

- Reduce the gap in higher education participation between the most and least represented groups
- Support young people to make well-informed decisions about their future education
- Support effective and impactful local collaboration by higher education providers working together with schools, colleges, employers and other partners
- Contribute to a stronger evidence base around 'what works' in higher education outreach and strengthen evaluation practice in the sector.

IMPACT

An independent impact assessment of phase one found (Office for Students, 2019):

- The collaborative approach is successfully addressing 'cold spots' in outreach provision. As a result of NCOP some schools and further education colleges (FECs) are engaging in outreach for the first time ever, or after a number of years
- The NCOP offer comprises well-established interventions as well as new and innovative approaches
- Partnerships are increasingly providing programmes that are tailored to the age and circumstances of learners, school/college type and the local context
- Notable progress has been made in addressing the challenge of engaging parents as key influencers on young people's aspirations and decision-making
- Locating NCOP staff within schools and FECs to coordinate and/or deliver outreach activities boosts the capacity of the schools/FECs to engage with the programme and supports the professional development of teaching staff.



Workplace

Existing evidence indicates that there is a STEM skills mismatch rather than a simple shortage (National Audit Office, 2018). STEM qualified individuals are in demand across the core STEM sectors and the wider economy and it is likely STEM skills gaps will continue to be a challenge (Campaign for Science and Engineering, 2018). Prior to the COVID-19 crisis, STEM skills shortages were most acutely affecting businesses in sectors such as, engineering, pharmaceuticals, healthcare, accountancy and fintech (STEM Learning, 2018). For example the annual shortfall in demand for Level 3+ engineering skills was estimated to be at least 83,000, and up to 110,000 (EngineeringUK, 2018).

There is very marked inequity in the workplace. This risks providing unhelpful role models to young people, perpetuating a negative cycle. ASPIRES research (Archer et al, 2013) found that one contributory factor to girls aspirations to science careers is the widely held view that science jobs are predominantly done by men. The study suggested that even parents who were supportive of their daughter's science aspirations recognised that girls will probably have to work 'twice as hard' to succeed in a male-dominated field such as science, especially in the physical sciences.

Across STEM-based careers, only 22% of roles are occupied by women (Teach First, 2019). Nearly all jobs (98%) in the skilled construction trades are held by men (Warwick Institute, 2016) where even basic facilities are often not suitable for women. Within the engineering workforce, 12% are women (UCL, 2019), 24% are from low socio-economic backgrounds and 8% are BAME compared to 13% of population (Warwick Institute, 2016). Less than 10% of life sciences professionals are from a working-class background, and just 0.4% researchers are Black compared to 3.3% for the general population (UCL, 2019). The pattern of ethnicity in the scientific workforce is extremely complex (Royal Society, 2014) with roots that can originate in early childhood.

At present, inequity worsens further as careers develop. By mid-career, science workers living in households in the highest income bracket are more than five times as likely to progress to a professional level occupation than those in the lowest household income bracket (Royal Society, 2014) and women make up just 13% of management level roles in STEM-based careers (Sundorph, 2020). At senior levels, women, disabled people, ethnic-minorities and those from socially disadvantaged groups are consistently underrepresented in STEM jobs (Campaign for Science and Engineering, 2014).

For graduates, the evidence shows that socio-economic background, gender and BAME status all have an effect on an individual's ability to enter the STEM workforce (Royal Society, 2014) with graduates 'leaking' from the pipeline at this stage (EngineeringUK, 2018). Black and minority ethnic students are less likely to progress to scientific jobs after graduating than white students (Royal Society, 2014), in engineering 71% of white engineering graduates enter full-time employment compared to 51% of their BAME counterparts after 6 months, and black engineering graduates had the lowest proportion in full-time work at 46% (Royal Academy of Engineering, 2019). Male graduates are more likely to be employed in mathematics, computer sciences, engineering and technology occupations than women, while in subjects allied to medicine the pattern is reversed (Royal Society, 2014). The data also shows that a larger proportion of women leave the engineering sector (35.7%) within six months of graduating than men (29.6%) compared to all those who graduate in STEM (EngineeringUK, 2018).

Government does not have a stable and consistent set of definitions for STEM making targeting and measuring more difficult.

CASE STUDY 6

Encouraging business Tech Talent Charter

The Tech Talent Charter (TTC) is a commitment by signatory organisations to work together to increase the inclusion and diversity of the tech workforce in the UK. The TTC's ultimate goal is that the UK tech sector becomes truly inclusive and a reflection of the society which it represents. The TTC works at scale, addressing the tech ecosystem to drive change and focuses on the how, not just the 'why' of inclusion and bring communities together.

Signatories of the Charter make a number of pledges in relation to their approach to recruitment and retention. The TTC is supported by the UK Government's Digital Strategy. Membership is free. The TTC has over 430 signatory organisations including government bodies, corporate and SME employers of tech, recruiters, diversity and inclusion consultants and other charters.

IMPACT

With funding from the Department of Digital, Culture, Media and Sport and strategic partners including HP, Cisco, Nationwide, TechUK, Lloyds Banking Group, and the Institute of Coding the TTC aims to grow to 600 signatories by the end of 2020.

The Charter:

- Provides cross sector opportunities for companies to publicise, learn and develop practical resources
- Collects and curates sector-leading insights
- Demonstrates the commitment of signatories to drive inclusion, enhancing their brand as an employer of choice
- Maps and facilitates collaboration across the ecosystem across the UK
- Measures inclusion and diversity in tech by collecting and producing annual benchmarking data.





Glossary

The following terms used in this report are defined as follows.

Applied General Qualifications	Level 3 academic qualifications for 16-19 year olds which aim to give students a strong but broad understanding of an occupational sector and to allow entry to higher education courses.
BAME	Black, Asian and Minority Ethnic
Double Award	Informal term used to denote 'combined science' or 'double science', equivalent to two GCSEs
EBacc	English Baccalaureate
eFSM/eFSM6	Eligible for FSM/FSM6
Equality	Treating everyone the same
Equity	Giving everyone what they need to be successful
EYFS	Early years foundation stage
FES	Further Education and Skills providers
FSM	Students who are eligible for free school meals
FSM6	Those who are eligible for the pupil premium because they have received free school meals in any of the previous six years, known as the 'ever 6' model
IB	International Baccalaureate
LGBT+	Lesbian, Gay, Bisexual, Transgender and other sexual identities
MAT	A group of schools forming a Multi-academy trust
PPG	Pupil Premium Grant (England)
Progress 8	This score shows how much progress pupils at this school made between the end of key stage 2 and the end of key stage 4, compared to pupils across England who got similar results at the end of key stage 2.
SATs	End of Key Stage Tests and Assessments
SEND	Special Educational Needs and Disability
SES	Socio-economic status
STEMM	Science, technology, engineering, maths and medicine
T levels	Due for introduction in September 2020, T levels are 2 year courses to provide young people aged 16-19 with a route to technical occupations, equivalent to three A levels. They will provide a common core followed by a specialisation year in a single occupational area including an extended industry placement.
Tech Levels	Level 3 qualifications for students aged 16 plus which develop specialist knowledge and skills to help get an apprenticeship or job.
Technical certificates	Level 2 technical qualifications recognised by employers for students aged 16 plus who wish to specialise in a specific industry or prepare for a job
Triple Science	Informal term used to denote separate GCSE's in biology, physics and chemistry

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Appendices

Appendix 1 – Methodology

Call for evidence

An open call for evidence was sent out by the APPG Secretariat, the British Science Association, inviting interested parties to answer the following questions:

- Where is there inequity across different protected characteristics within the STEM education system in England, at any age?
- What can we learn from approaches in other countries or across the devolved nations?
- What policy change could alleviate this inequity?
- What other implications could a change in policy have, and who would be affected?

Some 20 written responses were received, which were analysed to provide a foundation for questions for expert interviews and to direct the scope of the desk research.

SUBMISSION

Anonymous
Ark
Aston University
Biochemical Society
Bradfield school
Canterbury Christ Church University
Dyspraxia Lambeth
Fawcett Society
Geological Society of London
GhScientific
Liverpool John Moores University
MathsWorldUK
Royal Academy of Engineering (Education for Engineering)
Royal Society
Royal Society of Chemistry
Teach First
University College London
University of Cambridge
University of Roehampton
WISE Campaign

Parliamentary hearings

Two hearings were held at the Houses of Parliament to hear from a range of witnesses, including schools, national organisations, grassroots youth organisations, universities, businesses and government. The sessions were chaired by APPG Chair, Chi Onwurah MP (19 March 2019), and APPG Officer, Baroness Brown of Cambridge (20 May 2019).

WITNESSES

Lucy Rimmington, ARK
Shaun Reason, Association for Science Education
Kayisha Payne, BBSTEM
Kiera Newmark, Department for Education
Charlotte Pearson, Drax Group
Vicky Bullivant, Drax Group
Toby Osborne, Ferndown Upper School
Hannah Conway, Institute of Engineering and Technology
Ann Fomukong-Boden, Kakou CIC
Ilesha Small, LKM Co
Joysy John, Nesta
Kike Agunbiade, Researchers in Schools
Peter Kemp, Roehampton University
Hayaatun Sillem, Royal Academy of Engineering
Mathew Rogers, St Michael's Youth Project
Emily Dawson, University College London
Professor Louise Archer, University College London
Jane Clarke, University of Cambridge, Royal Society
Billy Wong, University of Reading
Anita Krishnamurthi, Wellcome Trust
Mark Ellis, Wellcome Trust

Desk research and expert interviews

The Secretariat undertook desk research of over 80 pieces literature, including academic reports, sector studies and government reports. These informed interviews with 20 experts from delivery organisations, representative organisations, government and academia.

Ameen Memom, Education and Skills Funding Agency, Department for Education.

Becky Parker, Institute for Research in Schools

Bill Conmar, Senitus, Northern Ireland

Bill Lucas, University of Winchester

Carol James, Welsh Government

Dom McDonald, Royal Institution

Dr Anjana Khatwa, Learning and Earth Science Specialist

Erik Stengler, Oneonta

Helen Wilson, Oxford Brookes University

Ian Menzies, Scottish Government

John Mason, The Education Directorate, Welsh Government

Professor Justin Dillon, University of Exeter

Karen Chouhan, National Education Union (NEU)

Mark Ellis, Wellcome Trust

Penny Fiddler, Association for Science and Discovery Centres

Peter Finegold, Royal Society

Professor Rachel Mills, University of Southampton

Ray Kirtley, GIGS

Simon Humphreys, ARM

Stephen Breslin, Glasgow Science Centre

Jan Peters, Katalytik

Critical review

A draft of the report was sent for critical review to a select group of reviewers. In addition, the draft was reviewed by our sponsors and Members of the APPG.

Amanda Dickins, STEM Learning

Beth Jones, Gatsby Charitable Foundation

Colin Wilkinson

Dawn Bonfield, Aston University

Hilary Leever, EngineeringUK

Professor Louise Archer, UCL Institute of Education

Mark Ellis, Wellcome Trust

Professor Michael Reiss, UCL Institute of Education

Dr Nicola Rollock, Goldsmiths, University of London

Sarah Chick, Challney Girls School, Luton

Sarah Main, Campaign for Science and Engineering

Appendix 2 – Policy review

England

Education policy in England is the responsibility of the Department for Education (DfE), UK Government.

SKILLS

The industrial strategy, published in November 2017, emphasised the important role of education in driving skills, economic growth and productivity and the need to identify and address sector-specific skills gaps to support this objective.

The Government's vision for a revised technical education and apprenticeships landscape, its Social Mobility Action Plan and its commitments to raising the take up and quality of STEM learning through the industrial strategy is intended to bring about the 'skills revolution' this country needs, and safeguard investment in education and skills from the uncertainty surrounding Brexit.

The UK Commission for Employment and Skills was closed in 2017.

SCHOOLS

State schools in England must adhere to the National Curriculum, which is designed to ensure that pupils in primary and secondary schools all follow the same programme. Academies must follow the National Curriculum in English, Maths and Science, but are otherwise free to create their own curriculums. There has been a move to a more academic curriculum.

Maths and science are statutory in the first two Key Stages, but science is not part of the key stage 2 universal testing programme or accountability measures.

Successive governments have promoted academy sponsorship as a way to improve the educational achievement of young people from disadvantaged backgrounds. As the academies programme has developed, academy chains and especially multi-academy trusts (MATs,) have come to be seen by Government as the best way of working to improve the performance of previously struggling schools and the educational outcomes of their often disadvantaged pupils. Forty per cent of schools are now academies and free schools, educating over half the children in state-funded schools. Eighty-two per cent of these schools are part of a MAT (Ofsted, 2020).

The DfE now reports annually on the performance of academies with respect to more able and talented students; there has been less attention to outcomes for disadvantaged pupils.

New accountability measures have moved from absolute attainment towards using relative pupil progress as the key measure of performance. Attainment 8 is based on pupils' average attainment (whether or not a grade 4 or 5 is achieved) across eight subjects including mathematics and the sciences and three further subjects.

The EBacc is a performance measure for schools, not a qualification for pupils. It is the most demanding of the accountability measures, requiring that a pupil gains standard or strong passes at GCSE in five core academic subject areas including mathematics and the sciences. The proportion of pupils entered for all EBacc subjects is regarded as a government accountability measure and can boost Attainment 8 scores. The Government's ambition is to see 75% of pupils studying the EBacc subject combination at GCSE by 2022, and 90% by 2025.

Progress 8 scores are based on prior attainment. Progress 8 is the most important measure in terms of accountability, since it is used for the floor standard. It is based on the same subjects as Attainment 8, but measures pupil progress between Key Stage 2 (KS2) and Key Stage 4 (KS4), using a pupil's KS2 results in English and mathematics as a baseline. It is calculated by comparing the Attainment 8 score of each pupil with the average score of all pupils nationally who had the same attainment level at KS2.

The Pupil Premium Grant (PPG) operates an 'Ever 6' model meaning that pupils attract the grant if they have been FSM at any point in the last six years. The main purpose of PPG is to raise the attainment of disadvantaged pupils of all abilities to reach their potential.

For those with SEND, the principle of setting high expectations for every pupil underpins policy. The National Curriculum Framework sets out the inclusion statement, with expectations that in many cases pupils with SEND will be able to study the full National Curriculum and the SEND Code of Practice sets out what should be done to meet their needs.

In 2017, the Department for Education published the Careers Strategy for England, which set out a plan to improve careers advice and guidance provision in England, supported by the Careers and Enterprise Company. Guidance includes appointing a Careers Leader in schools, using the Gatsby Benchmarks to improve careers provision, and providing encounters with employers for students between year 7 to year 13.

Students in England can take biology, chemistry and physics as separate subjects at GCSE (often referred to as Triple Science) or combined science (often referred to as Double Award science). The Double Award is counted as the equivalent of two GCSEs and is a combination of all three sciences. Most students take one of these two routes, although some other options are also available.

As part of major reforms in England, GCSEs in science subjects examined from 2018 have altered considerably, with: new content, more overall content, and a greater emphasis on problem solving. Coursework no longer counts towards a final grade and all exams are now taken at the end of the course (a 'linear' pattern) and changes to patterns of early entry and resits have been seen. Single GCSEs in Combined Science have also been withdrawn.

POST-16

Reviews of inequity in grading of science subjects at A level have concluded that while there are legitimate concerns about reduced entries, adjusting grade boundaries is not likely to be sufficient to address problems in take-up (Ofqual, 2016) and more recently concluded there is no compelling case to adjust grading standards (Ofqual, 2018).

There has been considerable change to the higher education landscape in recent years, with reductions in public funding across the UK and increasing undergraduate tuition fees in England in 2017, and saw the passage of the Higher Education and Research Act (HERA), deepening the market approach already in place. The Act aimed to create more competition and choice, boost productivity in the economy, ensure students receive value for money and strengthen the UK's research and innovation sector. The Athena SWAN Charter, introduced to promote gender equality in HE and research institutions, was expanded in 2015.

The Department for Education is currently reviewing post-16 qualifications at level 3 and below to create a simpler, high-quality system (2020) and is implementing the Post-16 Skills Plan and apprenticeship reforms which represent major changes in technical education and training (Department for Business, Innovation & Skills, 2016). The changes have largely been driven by recognition of skills shortages and perceived flaws within the current system, including the low qualifications value of many apprenticeships and complexity that learners find difficult to navigate.

The Government has proposed a common framework for 12 technical education routes for college-based and employment-based training with a clearer delineation between academic and technical education and learners working towards A levels or T levels, and apprentices able to transition between the two. In addition, there are three 'apprenticeship only' routes. The new T levels, alongside reformed apprenticeships, are intended to address skills gaps in technician level jobs in industries such as engineering and provide an alternative for young people who would prefer vocational programmes to academic courses.

The plan also seeks to build on existing apprenticeship reforms already underway in England in the form of new apprenticeship standards (replacing frameworks), degree apprenticeships, and an apprenticeship levy on employers. Qualifications will be removed from all apprenticeships, which will become subject to assessment on completion only.

Wales

Education policy in Wales is the responsibility of the Department for Education and Skills, Welsh Government.

In 2014, Wales introduced the Well-being of Future Generations Act. This places a legal requirement on public bodies, including the Government, to work towards “A society that enables people to fulfil their potential no matter what their background or circumstances (including their socio-economic circumstances)”. The Welsh Government’s current educational action plan: Education in Wales: Our national mission states: “We are committed to the success and well-being of every learner, regardless of background or personal circumstance” (Welsh Government, 2017).

SKILLS

Current reforms seek to make learning more relevant to young people, and places a greater emphasis on problem solving, creativity and skills to equip young people for a more unpredictable and rapidly changing workplace.

SCHOOLS

Wales remains committed to the community-based comprehensive school model. There are no academies or free schools in Wales, and only a few foundation schools that are exempt from local authority control. All schools are subject to the same standards and inspection regime.

In Wales, just 17% of top schools control their own admissions. Four out of five top schools are located in the 40% most affluent areas (according to the Welsh Index of Deprivation).

In 2011/12 Wales moved from a Key Stage 1 curriculum for 3–7 year olds to the present Foundation Phase with a focus on developing learning actively and using play-based approaches.

Students do not sit SATs tests but do sit annual National Reading and Numeracy Tests between Years 2 and 9.

The Welsh Government is currently reforming the education system up to age 16 with a new curriculum to be rolled out in schools from 2022. The reforms are based on a report by Professor Graham Donaldson: Successful Futures, a key principle of which is inclusivity (Donaldson, 2015). The aim is to help schools focus effectively on learner well-being, equity and excellence (Welsh Government, 2017). This will include taking an interdisciplinary approach and moving away from a focus on student performance in standard tests. Key stages are to be replaced with learning progression steps for each child. Examinations will be adapted to the new curriculum in due course.

GCSEs and A levels designed specifically for Wales are offered by a single awarding body: WJEC. Qualifications Wales is the independent regulator for Wales. At GCSE, grading is still by the A* to G system with a mix of linear and modular exams (although internationally, modular secondary school examinations are not commonplace). The regulator states that research in this area suggests that there is minimal difference in the effect of modular or linear exam structures across protected characteristics including gender, ethnicity and socio-economic background.

GCSEs in Wales are being reviewed to ensure they reflect the new curriculum, but the aim is that they remain equitable with other qualifications.

At GCSE, the current Welsh system has a similar approach to England with two main science routes at GCSE: Triple Science and Double Award, although the qualifications are different. Candidates can take either GCSE Mathematics or GCSE Mathematics Numeracy and the great majority take both.

In Wales the Welsh Baccalaureate is a qualification for pupils (unlike the English EBacc which is just a performance measure for schools). The Welsh Baccalaureate is mandatory at KS4, and in widespread use at KS5.

The Pupil Development Grant (PDG) aims to tackle the impact of deprivation and disadvantage on educational outcomes providing extra money to schools based on the number of pupils eligible for free school meals (eFSM). A new Additional Learning Needs and Education Tribunal (Wales) Bill creates a unified system for supporting learners from 0 to 25 with ALN.

The proportion of pupils who participate in work experience in Key Stage 4 or in the sixth form has declined substantially over the last five years. Welsh Government no longer requires Careers Wales to maintain a national work experience database on behalf of schools (2017).

POST-16

In Wales since 2010 the average proportion of A level physics entries by girls has been 20.4% compared to 21.1% in England and 27.1% in Northern Ireland (Institute for Physics, 2020).

At A level, individual units can be retaken (but only once) compared to England where students have to retake all units. AS levels contribute 40% to the final A level grade.

Wales is subject to the Apprenticeship Levy but takes different approach to England in the development of apprenticeship programmes. It seeks to meet the needs of both levy and non-levy paying employers, and ensure that apprenticeship places are readily available in priority areas through the apprenticeship provider network.

Wales is the only country in Europe to offer equivalent living costs support for undergraduate full-time, part-time and post-graduate students. The proportion of Welsh 18 year olds applying for university reached a record high, with almost a third applying to higher education. There has been a recent increase in the proportion of applicants from students in the most deprived areas in Wales, and there is a disabled student allowance available (UCAS, 2019).

An enhanced postgraduate package of support was made available in 19/20 with the introduction of a Postgraduate Master's Finance package, a Post-graduate Doctoral Loan, bursaries for Master's students studying STEM subjects or Medicine and for those aged 60+. Numbers of Welsh post-graduate students in Wales are increasing both for full-time and part-time courses. For part-time courses the pattern of one third male, two thirds women remains quite static as does the proportion of BAME females.

Scotland

Education policy in Scotland is the responsibility of Education Scotland, a Scottish Government executive agency.

The STEM Education and Training Strategy focuses on identifying groups such as gender, disadvantage, BAME or disability. It also includes groups such as care-experienced young people, and a new gender equity task force is being established by the Deputy First Minister. Key performance indicators are used to measure equity gaps in participation and achievement in STEM learning, engagement, study, courses and training across all sectors in relation to gender, deprivation, rurality, race, disability and for care leavers (Scottish Government, 2019).

A 2018 Learner Journey Review found a key area for improvement was in: "Making it easier for young people to understand their learning and career choices at the earliest stage and providing long-term person-centred support for the young people who need this most" (Ekosgen, 2017).

A college-led STEM Hub network has been created at a regional level to strengthen collaboration between partners including universities, Science Centres and employers, and to facilitate more joint professional learning between secondary schools and colleges, and primary and early learning settings (Scottish Government, 2019).

SKILLS

The forthcoming Future Skills Action Plan will set out how the wider skills system in Scotland should be orientated so that it has the agility and flexibility needed to meet the opportunities, challenges and disruption the future will present. Other strands include establishing a National Retraining Partnership, the Flexible Workforce Development Fund, the strategic plan of the Enterprise and Skills Board, investments in City Deals, the Fair Work Action Plan, and the Disability Employment Action Plan.

The Developing the Young Workforce Programme supports the STEM strategy by focusing on raising awareness about the world of work and building partnerships across the different sectors of education and with employers (Scottish Government, 2018).

Goal 15 of the Race Equality Framework includes BAME Pathways to Work supported by young workforce programmes.

The Developing a Scottish STEM Evidence Base: Final Report for Skills Development Scotland report states that: "There is overwhelming feedback that there is further work to be done in terms of repositioning and rebranding STEM and overcoming outdated and misplaced perceptions which still exist about STEM careers and skills" (Ekosgen, 2017).

SCHOOLS

The vast majority of pupils attend their local school in Scotland. As a consequence, the average proportion of disadvantaged pupils attending these 70 top performing schools is very similar to the average levels of disadvantage in their catchment areas.

Since 2015 Scotland has provided targeted funding to seek to reduce the attainment gap across all subjects. This mainly focused on schools in deprived areas and includes the Innovation Fund and Pupil Equity Funding.

All exams in Scotland are overseen by a single awarding body. The traditional STEM route in Scotland has been the National 4 and 5 qualifications, the Highers at age 17 and 18, and Advanced Highers. In the Senior Phase (4th, 5th and 6th years) there is more choice between various pathways. This system is seen as serving some learners well, but not all, and Scotland is trying to open up multiple pathways.

An Improving Gender Balance and Equalities (IGBE) team is working with school clusters to explore and assess interventions to address gender imbalances in participation, curricular preferences and learner pathways at every stage for 3 – 18 year olds (Scottish Government, 2020). A recent research project looked at issues around gender imbalance in subject and career choice as well causes of gender imbalance in the uptake of apprenticeships, finding that: “The main challenge is the scale of change required to shift entrenched culture and perceptions” (Skills Development Scotland, 2018).

Scottish schools have used the Curriculum for Excellence (CfE) since August 2010. Between ages 3-15, learners follow a common curriculum with three compulsory core subjects: Health and well-being, Literacy and Numeracy. There is flexibility for schools and teachers to decide what to study beyond this. The Developing a Scottish STEM Evidence Base: Final Report for Skills Development Scotland report (2017) states that: “Curriculum for Excellence (CfE) is intended to have a positive impact on STEM education and it is generally agreed that this is the case at primary schools. However, some stakeholders feel CfE has not yet reached its full potential at secondary level”.

Foundation Apprenticeships are a new, work-based learning qualification for pupils in S4 to S6 to complete elements of a MA while they are at school.

POST-16

There are concerns about perceptions of standards for science Highers and Advanced Highers in Scotland (Royal Society of Chemistry, 2019). Under the Developing the Young Workforce Agenda there are plans to introduce alternative STEM routes such as Higher National Certificates and new Foundation Apprenticeships, which will be equivalent to Highers.

Scottish Vocational Qualifications (SVQs) provide practical, vocational skills (Ekosgen, 2017). For STEM-related subjects, they are developed by the relevant Sector Skills Council, informed by industry and the awarding body. SVQs are available at SCQF levels 4 to 8 (SVQ 1-5).

National Qualification Groups Awards (NQGAs) are designed to prepare people for employment or progression to study at HNC/HND level. They are aimed at 16 to 18 year olds or adults in full or part-time education and are available at SCQF levels 2-6. HNQs provide practical skills and theoretical knowledge that meet the needs of a specific sector. They are available in a number of STEM-related subjects.

Expanding STEM apprenticeships is seen as a priority. Apprenticeships are available at a variety of SCQF levels including Modern Apprenticeships (MAs), Technical Apprenticeships and Graduate Apprenticeships. As part of its strategic approach to addressing gender imbalances in Modern Apprenticeships, Skills Development Scotland (SDS) provides funding for projects that aim to get more young people from under-represented groups onto Modern Apprenticeships.

Scotland’s policies seek to retain students and finances within Scottish Universities. Each college and university has a Gender Action Plan (GAP) outlining how they will advance equity and reduce gender disparities within STEM subject areas.

Northern Ireland

Education policy in Northern Ireland is the responsibility of the Department for Education (DE), Northern Ireland Executive.

SKILLS

Northern Ireland has higher economic inactivity and levels of people with no qualifications than the rest of the UK. It has productivity challenges, and its economy has a high proportion of SMEs. Recent changes in the skills system has included the mergers of colleges, the introduction of the apprenticeship levy, the introduction of programmes such as Higher Level Apprenticeships and the innovative Assured Skills scheme.

The Northern Skills Barometer is used to help track skills demand and shows that the greatest shortages of graduates are in engineering and technology, maths and computer sciences, physical and environmental sciences.

SCHOOLS

Similar to England, Northern Ireland's education system has six compulsory, cross-curricular "themes": English, mathematics, science and technology, the environment and society, creative and expressive studies, and language studies. Each of these themes has compulsory contributory subjects in each key stage. The Key Stage 4 Entitlement Framework ensures that schools provide pupils with access to a broad, balanced and relevant curriculum. It provides pupils with access to a range of courses and programmes which are linked to relevant learning and career pathways.

Northern Ireland has a well coordinated STEM enrichment service for schools operated by Senitus. Senitus provides a range of events and programmes to support schools and provide careers links.

As in other parts of the UK, inequity is widespread, for example children entitled to Free School Meals (FSM) achieve a significantly lower level of academic achievement relative to their peers who are not entitled to FSM.

POST-16

Northern Ireland has particularly good take up of science A levels and has consistently seen a higher proportion of girls entering A level physics than other UK nations - since 2010 this average proportion has been 27.1% compared to England at 21.1% and Wales at 20.4% (Institute of Physics, 2020).

Demand for higher level skills is increasing, however, less than half of school leavers (43%) pursue the university route and there are relatively high numbers enrolling in low-level courses.

Northern Ireland has clustered and reduced the number of its colleges and has an integrated careers service model. It has pursued a policy of 'quality' modern apprenticeships. These schemes typically last three years and are focussed on specific high-level growth occupations.

The Assured Skills programme has sought to link demand with skills provision. Companies have been closely involved in identifying need and co-designing courses.



**The British Science Association
provides the Secretariat for the
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