Factors in Successful STEM Learner Engagement

A case study approach

Final Report for Education Scotland

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ekosgen

Part of Insight

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Overview

ekosgen, working with Education Scotland, has undertaken in-depth research with schools across Scotland to identify key factors in successful STEM learner engagement. The research team undertook a series of "deep-dive" consultations with schools across Scotland, to explore the underlying reasons for successful STEM intervention.

The study has been conducted in the context of Scottish Government's STEM Education Training Strategy Refresh, increasing focus on boosting STEM education engagement and participation, and growing the pipeline of STEM education skills.

Key findings

There is a series of key findings arising from the work. These are critical factors that underpin improving and retaining the levels of STEM uptake, equality, equity and attainment in schools.

Support for STEM within schools

The **support of school Senior Leadership Teams** is critical to increasing STEM education engagement. Dependent on the school's circumstances, this may be actively supporting faculties and departments through particular interventions or dedicated space in leadership team meetings or school plans, or it may be more indirect in terms of the environment created for STEM staff to work. This support often enables the STEM-related faculty or department to deliver in-class STEM education and out-of-class activities in the way they see fit, to maximise learner engagement within the school.

Broadening the number of education and qualification pathways available to pupils, and increasing the scope for collaborative working and interdisciplinary learning helps to drive higher levels of STEM engagement. This is in line with evidence on increasing participation and engagement elsewhere with regard to STEM and also education more generally. Not only does this create opportunities for STEM teaching staff to make learning more innovative and appealing, it also creates different ways in which learners can participate and thus pursue STEM qualifications – increasing their appeal and (perceived or actual) achievability.

The potential to develop **peer influencing opportunities** within schools should be maximised by staff. Whether within cohorts, with adjacent year groups, or with cluster primary schools, peer influencers for learners such as Young STEM Leaders can play an important role in gaining traction with learners and providing an extra stimulus in inspiring or encouraging them to engage with STEM education.

Wherever possible, schools should seek to augment their STEM education activity through **relationships with external organisations**, to increase and enhance learning opportunities. Likewise, secondary schools should recognise the similar role that they can play with their associated cluster primary schools. Expanding the STEM capability of primary schools, for example through the loaning of equipment or joint teaching activities, as well as through increased CLPL, is an effective means of stimulating early STEM education engagement that can be continued through into the broad general education (BGE) phase and beyond in secondary school.

Internal structures and resourcing

A full **staffing resource complement** ensures a department has sufficient capacity to improve STEM learning. In addition, the profile of STEM department or faculty staffing and the stability of staffing are also key factors. Consideration should also be given to the way in which knowledge transfer between junior and more senior and experienced staff – both ways – can be facilitated to maximise the skills and knowledge of all staff for the benefit of STEM learning within the school.

Ensuring **equipment availability** for STEM learning delivery is a must. Practical, hands-on learning opportunities in dedicated spaces enhances learning opportunities and prevents STEM subjects from being too abstract. This is an important factor in their attractiveness, and thus learner interest.

Taking a highly **flexible approach to timetabling** and subject columns can broaden the scope for pupils to choose STEM subjects. Coupling this with an adaptable rather than fixed approach to scheduling and delivery, and providing an increased amount of guidance resources can help to increase the extent to which learners select STEM subjects as they progress from the BGE phase.

The importance of **project-based learning, inter-disciplinary learning and out-of-class activities** in supporting STEM engagement should not be underestimated. Challenge- or project-based activities (often utilising externally-provided resources) with demonstrable real-world application will help to bridge the gap between the classroom and real life. Activities that are led by pupils or newly-qualified teachers (NQTs) in particular can also help to stimulate greater enthusiasm, though there is also a role for activities delivered by parents and external partners in driving up participation.

The learner journey

The **transition from primary school to secondary BGE phase** is a critical period in terms of STEM engagement. Early engagement through practical modes of learning – particularly with primary school pupils before they commence their secondary school education – helps to cement interest in and enthusiasm for STEM learning and understanding.

Taking opportunities to **increase the practical and project-based learning content in senior phase** helps to consolidate understanding, and thus maintain learner engagement in STEM. Where possible, bespoke approaches to curriculum delivery, combined with more flexible qualification pathways, can also keep pupils engaged in STEM learning.

There is good evidence that pupil interest in STEM education and careers is increasing. **Showcasing a wide variety of current and emerging STEM career possibilities**, whether within lessons or more generally, will provide inspiration to learners.

External factors

Maximising the potential of the local economy and local employers to bolster schools' STEM learning delivery, enhance their curriculum, and demonstrate potential STEM career pathways will help to increase understanding and anchor pupil learning in a locally relevant context.

Better understanding of the parent cohort can inform the way in which schools need to engage with parents – either to overcome barriers or to maximise parent STEM capital. This can help to stimulate more positive influences in terms of STEM engagement.

The **local environment can be utilised to provide a better rounded STEM learning experience**. Despite urban areas having more challenges in terms of green and blue space, opportunities for outdoor learning can still be found in parks and nearby outdoor education centres. Where the local environment can act as a barrier, for example for travel considerations, alternative options such as online provision can effectively remove accessibility issues.

Larger schools can typically offer a wider range of STEM subjects, while schools with smaller class sizes can offer a more personalised learning experience to pupils. **Consideration should therefore be given to the best approach that can work for schools and classes of varying sizes.** Use of comparator school approaches, benchmarking performance against a fictitious but demographically similar school (a 'digital twin'), is useful for assessing performance in STEM and removes an element of competition with other schools.

Equity and equality

Work undertaken to dispel common gender stereotypes has a significant impact on the take-up of subjects that have been traditionally perceived as being gendered, such as technology subjects (particularly woodwork). This can range from simple conversations with pupils highlighting previous pupils' successes, to more equal representation in the makeup of a subject's staff, to actively promoting STEM careers for women at careers days and parents evenings. **Targeted interventions help to alleviate concerns and perceptions of gender in STEM learning**.

Evidence suggests that **pupils whose primary language is not English perform better in practical work**, as there is less of a focus on literacy outcomes and pupils can therefore be better supported. Encouraging this cohort to undertake STEM subjects across the learner's journey can therefore be framed in this regard.

Creative solutions and use of the Pupil Equity Fund can help to maximise engagement in pupils that are within the higher-scoring SIMD deciles, with uses cited including supporting travel costs for school trips, providing basic equipment that is free to access for all, and wider outreach programmes for those that are not engaging with the school. Each school faces different challenges in respect to deprivation, therefore budgets for interventions around equity should remain discretionary.

Recommendations

The evidence gathered from across the nine case study schools has generated a number of strategic and operational recommendations.

Strategic recommendations

Recommendation 1: STEM faculties or departments should have equal opportunity to feature on the agenda for School Leadership Team meetings, and should also receive broader support from School Leadership Teams for the development of learning content and out-of-class activities.

Recommendation 2: Undertake greater promotion of peer influencer roles to ensure greater take-up of STEM ambassador and similar positions by pupils, and in turn increase involvement in activities that increase STEM engagement.

Recommendation 3: Schools should augment their STEM education activity through relationships and partnerships with external organisations, to increase and enhance learning opportunities, as well as recognising the role that secondary schools can play with their cluster primary schools in this regard.

Recommendation 4: Schools should amplify the opportunities for practical work in STEM subjects from an early age, and continue to use primary school transition days as key opportunities to demonstrate the value of practical lessons.

Recommendation 5: Schools should take a tailored or bespoke approach to developing and delivering their STEM curriculum, to help retain pupil interest in and appetite for STEM, particularly through the use of practical and project-based learning.

Recommendation 6: Successful teaching and learning in STEM can be augmented by a well-considered careers strategy. Schools should showcase a wide variety of STEM career possibilities to inspire learners.

Recommendation 7: There is a continued need for STEM practitioner career-long professional learning (CLPL), to boost capability and confidence amongst practitioners in delivering both in-class teaching and out-of-class activities and interdisciplinary learning (IDL). The development of practitioners through CLPL and industry exposure should be supported and maximised.

Recommendation 8: Development and use of 'digital twin' comparator school profiles can be influential in helping schools to understand a baseline performance target to benchmark against, and to identify areas of focus for improving performance and stimulating increased STEM participation and engagement.

Recommendation 9: There should be proportionate interventions to tackle gender stereotypes, and drive uptake by all pupils in subjects that traditionally have been perceived as being particularly gendered.

Operational recommendations

Recommendation 10: Schools should consider opening as many opportunities for STEM learning as possible, to increase engagement amongst pupils that think STEM isn't "for them".

Recommendation 11: Consideration should be given to the staff profile of STEM departments and faculties, and how the benefits of knowledge transfer between junior teachers and more senior staff members can be maximised, to enable a better rounded and more consistent STEM learning offer.

Recommendation 12: Consideration should be given to opportunities to pool resources across faculties where this will maximise available resources and provide best possible learning environments to support the open and collaborative work that is essential for effective STEM learning.

Recommendation 13: An adaptable approach to timetabling should be taken by schools, focused on maximising viability of STEM subject delivery, and increasing engagement amongst pupils that would otherwise not consider STEM subjects.

Recommendation 14: Schools should encourage STEM clubs or activities that are designed and delivered with pupil input as these drive greater enthusiasm, especially where these relate to a specific challenge or project.

1 Introduction

Overview

1.1 ekosgen, working with Education Scotland, has undertaken in-depth research with schools across Scotland to identify key factors in successful STEM learner engagement. The research builds on the multi-year evaluation of the Enhancing Professional Learning in STEM Grants Programme (SGP)[1], and the aligned research examining structural barriers to STEM Engagement in Scotland.[2] This report sets out the findings of this latest round of research, identifying the key factors that drive increased engagement with STEM learning in schools in Scotland.

Background to the research

1.2 Since February 2020, ekosgen has been working closely with Education Scotland to evaluate the STEM Grants Programme (SGP). In the previous round of the evaluation, ekosgen assessed the effectiveness of the SGP over Years 1-3 of delivery, and also undertook research to assess the structural barriers to engagement in STEM learning.

1.3 The SGP was launched in October 2018 to increase access to STEM learning opportunities, to build the capacity and confidence of practitioners, and to support the implementation of the STEM Education and Training Strategy for Scotland. The Programme was designed to enhance professional learning support to the following education sectors: early learning and childcare (ELC); primary; additional support needs (ASN) and secondary schools; community learning and development (CLD); and school-based technical support staff. It aims to deepen and extend subject knowledge to improve STEM learning and teaching and ensure that professional learning reaches new audiences and geographies and builds on existing STEM professional learning provision.

1.4 ekosgen has previously undertaken three STEM evaluations and one structural barriers report on behalf of Education Scotland:

- Evaluating the Impact of Professional Learning in STEM: Building a STEM Nation;[3]
- Evaluation of the STEM Grants Programme Round Two and Wider Education Scotland STEM Support;[4]
- The Structural Barriers to STEM Engagement;[5] and
- Evaluation of the STEM Grants Programme Rounds One to Three.[6]

1.5 Following conclusion of Year Three of the evaluation in 2022, ekosgen and Education Scotland discussed and agreed a focus for Year Four of the study. The aim of this phase of the research was to provide evidence in support of the following broad lines of enquiry:

- To analyse available data on the uptake of STEM subject and course choices in schools, colleges and universities, and present a picture of the current STEM pipeline in Scotland;

[1] ekosgen, for Education Scotland (2022) Evaluation of the STEM Grants Programme Rounds One to Three (2018-2022), Final Report
[2] ekosgen, for Education Scotland (2022) The Structural Barriers to STEM Engagement, Final Report
[3] https://education.gov.scot/media/20zh0hmk/evaluation-of-stem-grants-programme-round-1-final-report.pdf
[4] https://education.gov.scot/media/2wddhwgy/ekosgen-stem-evaluation-year-2-report-2021.pdf
[5] https://education.gov.scot/media/0skjinph/ekosgen-structural-barriers-to-stem-engagement-year-3-report-nov-2022.pdf
[6] At the time of writing this report has not been published. Please contact Education Scotland for further information.

- To provide evidence of how stakeholders have successfully increased STEM learner engagement, and positively influenced choices regarding STEM pathways and careers; and
- To increase understanding of the factors that positively influence learners' decisions with regard to STEM.

1.6 The research findings for this report sets out evidence on what works in terms of STEM awareness raising and learner engagement. It also sets out a series of recommendations and future considerations for a good practice model of delivery for enhancing STEM learner engagement.

Report structure

1.7 The remainder of the report is structured as follows:

- **Chapter 2:** sets out the study approach and methodological challenges of this research;
- **Chapter 3** considers the strategic context underpinning STEM learning and engagement, and provides an overview of the STEM learners journey pipeline;
- **Chapter 4** provides the overarching analysis of the findings from the programme of consultation;
- **Chapter 5** presents nine case studies of schools that demonstrated good practice and were engaged in the full research programme; and
- **Chapter 6** provides a summary of the key factors in increasing engagement and attainment in STEM, as well as important considerations for replicability and future delivery of STEM learning.

2 Study approach and methodological challenges

Approach

2.1 This research study has been conducted with a series of “deep-dive” consultations with schools across Scotland that had been identified as having interesting practice or approaches to STEM learning. The purpose of selecting these schools was to explore what the underlying reasons for successful STEM intervention had been, with a view towards exploring how replicable this could be across other schools across Scotland.

2.2 The schools that were selected were based on statistical analysis provided by Education Scotland’s statisticians. This analysis related to performance and uptake across each STEM subject and STEM as a whole, school year, gender and SIMD deciles, as well as consideration of schools which performed well across Skills for Work qualifications in STEM subjects.

2.3 A central tenet to the approach taken by this research was to sample practice from schools that were representative of the majority of schools across Scotland e.g. urban and rural areas, size of school roll, SIMD profile, cluster size, etc.). The purpose of this was to ensure that findings were achievable and relatable and could be implemented effectively within the contexts that many schools operate.

2.4 The full programme of research with each school consisted of initial engagement with the school’s lead teacher or contact for STEM (STEM lead), followed by detailed consultation with the STEM lead and Senior Leadership Team (SLT) member with responsibility for STEM. Engagement then extended to focus groups with staff with responsibilities for STEM learning, and engagement pupils at both the BGE and senior phase. Some of this engagement was delivered online, while some were delivered in person within the schools. Surveys for both pupils and parents of pupils at the selected schools were created to supplement the findings from the focus groups.

2.5 This programme of engagement was also supplemented by a desk-based analysis of the STEM pipeline, analysing the numbers of enrolments, attainment, outcomes and destinations and subsequent employment of learners across school, college, apprenticeship and university level education. A “mapping” exercise was conducted to understand the destination of learners and to identify where the greatest “leakage” from the STEM pipeline occurs. The mapping exercise shows for how long and to what extent STEM learners remain engaged before there is slippage, as well as the various pathways that are taken prior to employment or “leaking” out of the STEM pipeline.

Methodological challenges

2.6 The outreach and engagement with schools provided considerable challenge, in particular in relation to the initial engagement with schools. Much of this was as a result of continuing pressures faced by schools in terms of workload, teaching commitments and capacity of teaching staff to commit to engaging with the research.

2.7 STEM leads in certain schools were unable to find time to engage with the programme, indicating the extent to which teachers are under pressure, as identified in previous ekosgen work surrounding the Structural Barriers to STEM learning.

2.8 Further, there were also difficulties in participating in the full programme of engagement for some schools following the initial conversations with STEM leads, again as a result of competing pressures. For these schools, surveys were created for pupils and parents so that they could still feed into the research programme. These surveys were issued by STEM leads to pupils. However, they received little traction across both pupils and parents.

2.9 In the absence of a full consultation programme with some schools, and in order to provide consistently-researched case studies, it was agreed with Education Scotland that ekosgen would approach a wider pool of schools which satisfied the original selection criteria.

2.10 This second wave of engagement proved more successful, and as a result it was agreed that the primary research programme be extended to enable the consultations and focus groups required from all schools to take place. Nine case studies were created from the range of schools engaged across the entire study, with findings from the early engagements with STEM leads in schools that could not fully engage being included in the overall thematic analysis.

3 Strategic context

Introduction

3.1 This chapter details the strategic context for the STEM pipeline in Scotland. The Scottish Government has a range of strategies to improve access and uptake in STEM learning.

Strategic landscape for STEM education

STEM Education Training Strategy Refresh

3.2 The Scottish Government's STEM Education Training Strategy Refresh[7] aims to establish STEM learning in Scotland within the education system, by ensuring all learners have easy access to high-quality STEM teaching. Excellence, equity, inspiration and connection are the four key themes of the strategy, which outlines a range of key implementations targeted at addressing some of the challenges present in each.

3.3 Improving excellence in Scottish STEM education aims to increase the flow of high-quality teachers into STEM subjects, and improve opportunities, such as STEM apprenticeships, and routes into university for students to study STEM. There are bursaries of up to £20,000 for people who reskill and become STEM teachers in key subjects which have an insufficient workforce. This measure alone has already brought over 100 new teachers into STEM over the four years between 2018 and 2022. From 2018/19 to 2022 there have been 505 bursaries awarded with 416 successfully completing.[8] In the 2022/23 academic session, 84 bursaries were approved with 62 successfully completing and eight recipients are yet to complete. In the 2023/24 academic session, 104 applications were received, of which, 70 were approved.

3.4 Increasing the geographical spread of events aimed at engaging and attracting students into STEM learning will aim to increase equity and the accessibility of STEM learning to a greater range of students. Aimed, in particular, at young people and young girls with protected characteristics, the strategy will hope to increase the diversity of STEM subjects by promoting them to students who are under-represented in STEM pathways.

3.5 Inspiration is developed by engaging parents and carers in their child's STEM learning through creation and support for STEM learning centres and science rooms. This can involve the inclusion of parents and carers in student's learning and introduce students to a diverse range of STEM professionals and stakeholders, all of whom can act as role models for young people engaging in STEM subjects.

3.6 Connection is the final theme outlined in the strategy and relates to measures such as improving support networks for STEM learners seeking help and helping higher educators to be more responsive to the needs of the industry. The strategy sets out a range of support for schemes which support STEM ambassadors in schools to give guidance to pupils, as well as support for partnerships which help to get more children involved in STEM learning.

[7] https://www.gov.scot/publications/stem-education-training-strategy-refresh/
[8] https://www.skillsdevelopmentscotland.co.uk/media/bp2dzi1e/teaching-bursary-in-scotland-evaluation-2023.pdf

Developing the Young Workforce

3.7 The Scottish Government's Developing the Young Workforce (DYW) Strategy[9] was introduced in 2014 to help young people develop their professional skills to prepare them for work. One of the key recommendations of the strategy was to improve the number of children and young people choosing STEM learning and careers. STEM subjects were prioritised in college curriculums a few years after the strategy's inception, and the government supported a range of new STEM-based apprenticeships to offer young people different routes into the industry.

3.8 Some specific objectives of the strategy include improving the links between educators and employers to ensure clearly defined routes from education into work, and ensuring close collaboration with parents and carers to ensure pupils have support, and role models in work and education. A key facet of this will be to increase the diversity in STEM work and learning, through increasing the number of girls and ethnic minorities in the sector, as these groups have historically been under-represented.

The Young Person's Guarantee

3.9 The Young Person's Guarantee,[10] published in 2021, is a Scottish Government strategy which offers a 'guarantee' to young people aged between 16 and 24 to have access to either: study; apprenticeships; work experience; or volunteering. A key component of this is that inequalities in access to work and education are addressed, for example based on the Scottish Index of Multiple Deprivation (SIMD) or gender imbalances. The most pertinent inequality for STEM is the significant under-representation of women and girls in STEM industries. The strategy recognises this and pledges to address these imbalances. For example, the strategy suggests further support for STEM bursaries and grants to support young people studying STEM subjects at school.[11]

3.10 In a further update, the strategy pledged a raft of new funding for increasing access to education and training for young people in Scotland. [12] For example, £175 million in funding was announced to increase the availability of opportunities and the update also pledged 300 new school-based DYW coordinators across the country to improve connections with young people. The update also acknowledges that the strategy has currently helped 8,900 young people into some kind of training or education.

Enhancing learning and teaching through the use of digital technology

3.11 Enhancing Learning and Teaching Through the use of Digital Technology[13], published in 2016, is the Scottish Government's Strategy to improve digital learning in education in Scotland and it aligns closely with the Scottish Government STEM strategy.[14] The four objectives of the strategy include:

- Improving the confidence of educators to deliver digital learning and to use digital technology to deliver learning;
- Improve access to digital learning;

[9] https://www.gov.scot/publications/developing-young-workforce-scotlands-youth-employment-strategy/documents/
[10] https://www.gov.scot/publications/young-persons-guarantee-update-report-march-2023/
[11] https://www.gov.scot/publications/young-persons-guarantee-activity-plan-phase-1-eqia-equality-action-plan/documents/
[12] https://www.gov.scot/publications/young-persons-guarantee-update-report-march-2023/documents/
[13] https://www.gov.scot/publications/enhancing-learning-teaching-through-use-digital-technology/
[14] https://www.gov.scot/publications/stem-strategy-education-training-scotland-third-annual-report/

- Ensuring that digital technology is a central consideration in all areas of curriculum and assessment delivery; and
- Empowering leaders of change to drive innovation and investment in digital technology for learning and teaching.

3.12 The strategy emphasises the importance of developing STEM capability for everyone in Scotland. It highlights leadership and leadership empowerment initiatives which reflects the importance of programmes like the Young STEM Leader Programme, which is expanding to involve more schools and community organisations, demonstrating a commitment to enhancing STEM education.

Curriculum for Excellence

3.13 Curriculum for Excellence (CfE) is Scotland's curriculum for children and young people aged between 3 and 18. CfE was originally designed in 2004 and provides a broad and balanced education for young learners, encompassing STEM-related curriculum areas of sciences, technologies, and numeracy and mathematics. Experiences and Outcomes (Es&Os) are a set of clear and concise statements about children's learning and progression in each curriculum area and these also contribute to ensuring a balanced and consistent approach to education.[15] Engineering is incorporated within the Experiences and Outcomes for Technologies.

Science and research: Women in STEM

3.14 Women in Research: Science in STEM is a Scottish Government's initiative to engage more women and girls in STEM learning and the STEM workforce. STEM has traditionally been a male-dominated field, so this initiative fits in with wider strategies to diversify the field and increase access to groups who have traditionally been somewhat excluded.

3.15 Key objectives of the initiative are to improve the gender balance in both STEM education, and the STEM workforce, and to increase the availability of STEM learning to girls in school. This also sits within other policies targeting gender equality and eradicating the gender pay gap such as the Gender Pay Gap Action Plan.[16]

Fit for the Future: developing a post-school learning system to fuel economic transformation

3.16 Fit for the Future: developing a post-school learning system to fuel economic transformation, published in 2023, is a review from the Scottish Government of the existing skills delivery landscape in the country, and a set of recommendations off the back of this, as well as the desired future skills landscape.[17] These recommendations set out what the Scottish Government needs to do within the skills landscape to achieve its workforce development ambitions as set out in the National Strategy for Economic Transformation (NSET).[18]

[15] https://education.gov.scot/curriculum-for-excellence/curriculum-for-excellence-documents/experiences-and-outcomes/
[16] https://www.gov.scot/publications/fairer-scotland-women-gender-pay-gap-action-plan/
[17] https://www.gov.scot/publications/fit-future-developing-post-school-learning-system-fuel-economic-transformation/
[18] https://www.gov.scot/publications/scotlands-national-strategy-economic-transformation/

STEM education pipeline

3.17 A key driver in STEM education policy is increasing the STEM education skills pipeline. However, understanding the full extent of the STEM education skills pipeline is complex, given the wide range of data that needs to be considered, and the differences in recording and reporting factors such as enrolment, attainment and outcomes or destinations of learners. The following section attempts to synthesise available evidence to present a picture of the theoretical STEM education skills pipeline. This pipeline analysis can be refined as and when additional data is made available from those organisations responsible for publishing such data – Scottish Qualifications Authority (SQA), Skills Funding Council (SFC), Skills Development Scotland (SDS), Higher Education Statistics Agency (HESA), and Scottish Government.

Pipeline analysis

3.18 A pipeline analysis of 2020/21 STEM enrolments, passes, attainments, achievements, outcomes and destinations, and employment has been undertaken. This aims to quantify the number of young people continuing their STEM education and transitioning into STEM careers – i.e., remaining in the STEM pipeline. 2020/21 data has been used as was the most complete dataset for a whole academic year at the time of analysis. Appendix 1 contains information on the various education levels in STEM and an overview of the subjects, frameworks, and courses within STEM.

3.19 Various sources of data were used to estimate the number of enrolments and passes, attainments and achievements including SQA data on secondary school pupils, SDS data on apprentices (Modern Apprenticeships, Foundation Apprenticeships, and Graduate Apprenticeships – MA, FA, and GA respectively), SFC data on college students, and HESA data on university students and graduates. STEM outcomes and destinations and STEM employment data is not readily available, therefore, the study team has made a number of assumptions to arrive at estimates for this part of the pipeline, drawing on analysis on leaver outcomes and summary statistics on attainment and leaver destinations.[19] These assumptions will be described, in turn, when data is set-out for each stage of the pipeline.

3.20 The total STEM skills pipeline in terms of entrants is 99,564, though it should be noted that this not unique entrants, but simply a sum of total entrants at each stage. Using available data for pass rates and attainment, positive destination outcomes and employment, we can estimate that around half (c.50,000, or 50%) of all entrants across the STEM skills pipeline were in positive outcomes and destinations. Within this, around 38,100 (38%) of all entrants entered employment. Given constraints on available data, we are unable to determine whether the positive outcome or employment destinations are STEM. Instead, we must consider each of these as a *maximum potential number* that continues within the STEM pipeline.

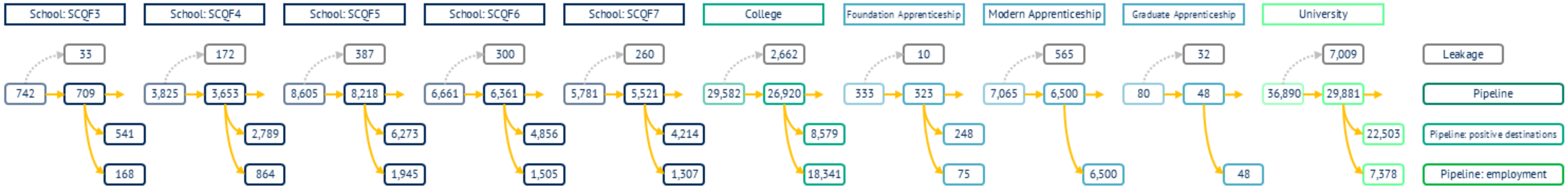
3.21 Conversely, total leakage – those leavers at each stage that do not go onto either a positive destination or employment outcomes – is around 11,400, or 11% of total entrants. This ranges from 3% at FA level, to around 19% at university level. Whilst the leakage rate for GAs is higher at c.40%, this proportion may be distorted by having to use historic achievement rates (2017/18 is the latest 'full' achievement rate available) for 2020/21 starts, though not all starts for this academic year have finished their studies yet.

[19] https://www.gov.scot/publications/summary-statistics-attainment-initial-leaver-destinations-no-4-2022-edition/

3.22 Nevertheless, in broad terms the leakage appears to increase at higher SCQF levels in the pipeline. Beyond understanding attainment rates at each stage of the pipeline, the reasons for this are unclear.

3.23 Figure 3.1 below sets out the STEM pipeline. Appendix 2 provides further detail on the analysis at each stage.

Figure 3.1 STEM pipeline



4 Key factors in successful STEM learner engagement

Introduction

4.1 The following chapter provides an overview of the key factors underpinning improving and retaining the levels of STEM uptake, equality, equity and attainment in schools. This is based on the consultations held with STEM leads across a wide range of schools, as well as with principal teachers and members of school Senior Leadership Teams. The research findings have also been augmented by findings and discussion points arising from an Education Scotland event centred around Raising Attainment in Sciences held in February 2024.

4.2 The findings have been arranged thematically, with various topics explored under the themes of:

- Support for STEM learning and engagement within schools;
- The internal structures underpinning effective STEM engagement and learning;
- The learner's journey from primary school, transitioning into Broad General Education (BGE), into senior phase, and also from senior phase into further/higher education or careers;
- External factors outwith a school's/pupil's control which influence STEM learning and engagement; and
- Any interventions or activities that have been implemented to address equity or equality considerations.

Support for STEM within schools

Highly supportive management teams

The support of school Senior Leadership Teams (SLTs) is critical to increasing STEM education engagement. Dependent on the school's circumstances, this may be actively supporting faculties and departments through particular interventions or dedicated space in leadership team meetings or school plans, or it may be more indirect in terms of the environment created for STEM staff to work. This support often enables the STEM-related faculty or department to deliver in-class STEM education and out-of-class activities in the way they see fit, to maximise learner engagement within the school.

4.3 One of the main factors contributing to STEM engagement is the presence of a highly supportive management and leadership teams within a school. In some schools, there can be a very proactive approach taken by SLTs to support STEM teaching, ranging from concerted attempts to ensure that equipment is well resourced, ensuring that staff have regular opportunities for career-long professional development (CLPL), to providing adequate representation opportunities to STEM-related faculties at Senior Leadership Team (SLT) meetings. It also includes providing opportunities to staff and pupils to attend various local STEM-related opportunities outside of the traditional curriculum. It is important to ensure that STEM education and STEM curriculums are linked to, and are rooted in, the real world of work so that STEM is promoted as relevant, engaging, and advantageous for pupils to study.[20] There can also be more hands-off approaches taken by SLTs that are equally supportive, including allowing STEM departments to implement their own approaches to stimulate increased engagement.

[20] https://education.gov.scot/media/0skjinph/ekosgen-structural-barriers-to-stem-engagement-year-3-report-nov-2022.pdf

4.4 Having a highly supportive leadership team within schools has previously been identified as a crucial factor in ekosgen's previous work relating to structural barriers in STEM engagement. That research previously identified that there were varying degrees of commitment to STEM promotion in schools across Scotland, often dictated by scale of resource or level of activity being delivered, but also by the levels of enthusiasm of individuals and their personal networks. A supportive leadership team will reassure staff that STEM is a key priority within a school's improvement plan.

4.5 Some examples of actively supportive management teams within schools can be seen in Case Study 1 and Case Study 6. In Case Study 1, the school ensures that there is a discussion point on the agenda for every meeting between the SLT, where they could talk about curriculum development, or wider out-of-class activities. Likewise, in Case Study 6, the school's STEM lead is a representative of all departments delivering STEM subjects and ensures that all voices are heard when needed.

4.6 Other schools (see Case Study 2 and Case Study 5) highlighted that their management team are supportive in that they "never say no" to any ideas that staff have. While funding can sometimes be an issue, if the staff provide potential avenues for funding that could be explored then there are support staff that can often explore these further to see how viable they would be. Typically, staff in these schools stated that the SLT work with them to fully articulate the opportunity and realise the benefits that can be achieved.

4.7 Equally, an SLT that demonstrates confidence in their teaching staff and gives STEM departments the latitude and freedom to implement teaching and engagement approaches that they consider most appropriate can equally stimulate confidence amongst teaching staff. It also allows scope for more innovative approaches to be taken. One such instance of this can be seen in Case Study 8.

Refreshing the curriculum and increasing STEM pathways

Broadening the number of education and qualification pathways available to pupils, and increasing the scope for collaborative working and interdisciplinary learning helps to drive higher levels of STEM engagement. This is in line with evidence on increasing participation and engagement elsewhere with regard to STEM and also education more generally. Not only does this create opportunities for STEM teaching staff to make learning more innovative and appealing, it also creates different ways in which learners can participate and thus pursue STEM qualifications – increasing their appeal and (perceived or actual) achievability.

4.8 Another key insight that has been gleaned from this research into successful STEM engagement in schools is that, schools that had previously not been achieving high STEM attainment had considered revising the BGE curriculum so that there is wider interest in STEM subjects. In some instances, this has been a specific targeted focus on vocational, work-based or project-based learning, while in others there has been wider collaboration with different subjects. Some schools also had specific themed weeks around certain STEM topics that were delivered across the school, like learning in different subjects focusing around various aspects of windfarms or sustainability challenges.

4.9 The previous ekosgen Structural Barriers report[21] identified that school curricula were often delivered in a siloed approach, meaning that often there was not a consistent approach being

[21] https://education.gov.scot/media/0skjinph/ekosgen-structural-barriers-to-stem-engagement-year-3-report-nov-2022.pdf

delivered across the schools and therefore fewer opportunities for collaboration, inter-disciplinary learning (IDL) or consolidating learning. By reconsidering the delivery of the curriculum and identifying crossovers and scope for consolidating learning – or indeed embedding STEM themes or principles in subject areas not often associated with STEM – there are greater opportunities for innovative content and delivery methods, which can often be much more engaging for pupils.

4.10 Case Study 6 highlights the impact that involving the arts and humanities under a "STEAM" collaborative can have. This collaboration involves faculties within STEM and arts and humanities subjects acting in a concerted effort to make learning across these subjects more seamless. Aside from providing a wider staff complement that enables staff to teach more than one subject (dual teaching) when necessary, it also means that a more extensive subject choice for pupils can be provided and pupils gain a more holistic view towards their learning, rather than perceiving subjects as being standalone areas of learning. STEAM as an example of an Interdisciplinary Learning (IDL) which is a planned experience that brings disciplines together in one coherent programme or project.[22]

4.11 This holistic view is further demonstrated in Case Study 3, where this school has integrated themed weeks into its curriculum, where pupils focus on a specific topic to learn about that would not necessarily be considered within a more conventional or traditional curriculum. One example they provided was for S2 pupils where they visited a nearby windfarm. Teachers developed course content relating to this (e.g. in mathematics, pupils considered the velocity of the turbine blades, in science the staff adapted physics lessons to explore renewable energy generation and in biology they considered the impacts on biodiversity of the windfarm). By providing this programme around a themed area, this again allows pupils to see how certain subjects interlink well and make connections across their learning.

4.12 Another way to reconsider the curriculum is to consider the school's subject offerings and STEM pathways. In Case Study 1, this school has worked well with the regional Developing the Young Workforce (DYW) Group to identify areas of demand for skills in the local area. Data from the local authority suggested that there was a desire for more vocational options, and as a result, there is a strong understanding within the school that future skills needed in the workplace can be delivered through STEM. They opened up wider subject choices to reflect this, including Barista, Bakery and Design, Engineer, Construct courses. These courses have been well-received in the school, and have led to a greater uptake in STEM-related subjects by those who had previously considered STEM to be too complex and "boffin-like."

4.13 In contrast, schools such as that in Case Study 7 are focusing on freeing up subject choices, within the constraints of school- or local authority-level timetabling, at key points in the learner journey. This helps to maximise the extent to which pupils are able to choose STEM subjects as they move from BGE into and then through senior phase. Others, such as the Case Study 8 school increase STEM contact time during BGE, and combine this with an increased number of STEM qualification pathways to meet different pupils' learning needs.

[22] https://education.gov.scot/media/bdahf0lv/idl-ambitious-learning-for-an-increasingly-complex-world-oct23.pdf

Peer influencer roles

The potential to develop peer influencing opportunities within schools should be maximised by staff. Whether within cohorts, with adjacent year groups, or with cluster primary schools, peer influencers for learners such as Young STEM Leaders can play an important role in gaining traction with learners and providing an extra stimulus in inspiring or encouraging them to engage with STEM education.

4.14 The efforts of ambassadorial programmes such as STEM Ambassadors[23] and Young STEM Leaders[24] were also noted as having a positive impact on pupils in the BGE phase as being particularly significant. These pupils are often those that are most enthused by STEM, and act as peer support and a potential source of inspiration for younger pupils. The Scottish Network for Able Pupils (SNAP)[25] programme also acts as a network of support to schools and teachers through sharing ideas and practise in education and learning.

4.15 Where there has been a minimised role for in-school influencers in schools, this was raised as a potential barrier to engagement in ekosgen's Structural Barriers research. It was stated then that influencers such as Young STEM Leaders need to strengthen their impact in order to increase positive influencers around learners. By having these influencers involved in the delivery of STEM activity, it can keep younger pupils more enthused and motivated in STEM learning.

4.16 In Case Study 8, the responsibilities of Young STEM Leaders in this school include the delivery of presentations and talks to pupils within the school's primary school cluster. This works well in that it provides inspiration to primary school pupils who may not have experienced the full complement of STEM subjects. The Young STEM Leaders are seen as a more "friendly face" and more approachable and easier to understand than teachers, recognising the importance of peer-to-peer learning and knowledge sharing. In the Case Study 7 school, the recently established Young STEM Leaders programme provides the opportunity to gain an SCQF Level 6 qualification, and Young STEM Leaders play an active role in delivering out-of-class activities within and outwith the school.

4.17 As shown in Case Study 5, the importance of these influencer roles for personal development has been recognised by pupils as it is often "their first recognition of achievement". Pupils in the senior phase stated that they would be putting their involvement in the school's STEM ambassadorial programme on their CV and personal statements when applying for jobs and university. In order for this to be effective, however, it is acknowledged that a significant amount of teacher resource is required to prepare pupils for the role.

Wider partnerships

Wherever possible, schools should seek to augment their STEM education activity through relationships with external organisations, to increase and enhance learning opportunities. Likewise, secondary schools should recognise the similar role that they can play with their associated cluster primary schools. Expanding the STEM capability of primary schools, for example through the loaning of equipment or joint teaching activities, as well as through increased CLPL, is an effective means of stimulating early STEM education engagement that can be continued through into the BGE phase and beyond in secondary school.

[23] https://www.youngstemleader.scot/stem-ambassadors
[24] https://www.youngstemleader.scot/
[25] https://www.gla.ac.uk/research/az/ablepupils/aboutsnap/

4.18 The schools engaged in this research also noted the importance of their wider existing relationships with other schools, colleges and universities as being significant in helping to increase STEM engagement. This provides opportunities for pupils which would otherwise not be available, mostly with respect to offering a wider complement of subject choices at various levels. It was also noted that having a strong relationship with primary school clusters also allows for more successful and engaging transition to take place. In addition, it would also complement CLPL for STEM practitioners in early learning and childcare (ELC), primary and Additional Support Needs (ASN) settings. Previous research by ekosgen and others has demonstrated the importance of increased CLPL to practitioner confidence and capability.

4.19 Greater collaboration between schools and colleges or universities was identified as a priority within ekosgen's Structural Barriers report. Aside from greater variety and opportunities for pupils, this would also lead to better alignment of learning to previous education, more consistent and equitable provision, and overall lead to better outcomes in STEM learning across Scotland.

4.20 This collaboration across schools can be seen in Case Study 2, where the school partners with other secondary schools in the local area to deliver subjects that other schools do not have the capacity to deliver, and vice versa. In the past, the school has delivered Advanced Higher Biology and Chemistry for pupils that are unable to take these subjects in their own schools. While they did not have the capacity to do that this year, it is something they are exploring in the future.

4.21 In Case Study 7, developing a stronger relationship with cluster primary schools is highlighted as an action area within the STEM Action Plan. As part of this, the school is currently considering what is most exciting to pupils and are focusing on "the next big thing" to stimulate a degree of excitement. There are plans underway for the transition period to include a requirement for pupils to develop a project in their transition that they can then showcase as soon as they start, highlighting the success of previously-delivered primary-secondary showcase initiatives.

4.22 An example of a strong college-school partnership can be found in Case Study 4, where the school has partnered with its local college to provide a number of new pathways for STEM subjects. Given this case study's rural location, attendance at their local college was often impractical. Instead of having to organise prohibitively expensive buses for pupils, they have explored provision of courses online (e.g. an Introduction to eSports National Progression Award). The school also takes part in a South West Education Improvement Collaborative digital offering, where schools within the region provide Advanced Higher courses online where they would struggle to otherwise run. This includes the STEM subjects of mathematics and graphic communication. This removes accessibility barriers and provides alternative methods of engagement in STEM learning. Anecdotally, the school's staff noted that there was greater uptake from the online provision.

Internal structures and resourcing

Staff resourcing

A full staff complement ensures a department has sufficient capacity to improve STEM learning. In addition, the profile of STEM department or faculty staffing and the stability of staffing are also key factors. Consideration should also be given to the way in which knowledge transfer between junior and more senior and experienced staff – both ways – can be facilitated to maximise the skills and knowledge of all staff for the benefit of STEM learning within the school.

4.23 Staff resourcing encompasses staff recruitment and recruitment planning, selection of the best staff candidates, and retaining staff. This also covers the levels of confidence and enthusiasm with which staff are able to deliver lessons and the relationships that staff build with their pupils, as well with colleagues within STEM departments and faculties. These are all key elements of garnering a knowledgeable and healthy workforce that is able to support pupils. Similarly, the availability of dedicated support staff, such as classroom assistants and school technicians, is an important aspect of the STEM learning environment.

4.24 Staff resourcing, is therefore, crucial to ensuring a healthy STEM education pipeline. The school environment and recruitment of STEM teachers was identified as a fundamental challenge in ekosgen's previous work relating to structural barriers in STEM engagement. It also highlighted the critical importance of upskilling and developing STEM practitioners through maximising CLPL and industry exposure wherever possible, including through protected time for CLPL, to build confidence and capability.

4.25 Ensuring high-quality staff resourcing can achieve a better STEM learning experience for pupils which can help to inspire pupils to pursue further STEM opportunities. Equity in STEM education can also be improved if there is sufficient staff resourcing across schools so that pupils don't miss out on opportunities within particular subjects if there is lack of staff resource in that area. These impacts can positively affect the STEM education pipeline.

4.26 Subject specialists were particularly noted as important in Case Study 9, and these specialists were identified through effective staff resourcing and recruitment processes. The school's STEM lead suggested that their staff complement is both extremely knowledgeable and highly enthusiastic in supporting STEM pupils, which can improve pupil's learning experience and potential longer-term STEM career development prospects.

4.27 As demonstrated in Case Study 4, hiring support staff that can set-up experiments and support pupils during experiments is an effective means to free up capacity for science teachers to plan and deliver lessons. This, therefore, enables the school's science faculty to function more successfully and efficiently in terms of teaching. Dedicated support staff enable lessons to run as smoothly as possible, only calling upon the teachers delivering the lessons when absolutely necessary, for example if the support staff are unable to answer a question a pupil may have.

4.28 Case Study 4 also highlights the importance of having a stable workforce. The low levels of staff turnover in this school make it possible for schools to provide continuity in subject availability for pupils, and therefore the offer available at this school is fairly consistent, with teachers being highly experienced in delivering the curriculum. As highlighted previously with regard to other schools, a relatively stable teaching staff complement can help with knowledge exchange or transfer to newly qualified teachers (NQTs), and in turn senior, experienced teachers can benefit from (and indeed make use of) the energy and enthusiasm that is typically reported in NQTs.

4.29 Crucially, several of the schools (Case Studies 1, 5, 7, and 8) engaged in the research have suggested that one of the most important considerations with regards to staff is the levels of enthusiasm and good relationships that the staff maintain with pupils. This helps to both motivate pupils and also develops a higher level of trust between pupils and teachers, which works both ways – pupils are often told that there are "no silly questions" and are able to freely contribute to lessons, and likewise, teachers receive a higher level of engagement as a result of this reciprocal trust.

Equipment resourcing

Ensuring equipment availability for STEM learning delivery is a must. Practical, hands-on learning opportunities in dedicated spaces enhances learning opportunities and prevents STEM subjects from being too abstract. This is an important factor in their attractiveness, and thus learner interest.

4.30 Equipment resourcing is an important aspect of delivering lessons in schools particularly in STEM subjects which often require specialised scientific and technological equipment. Properly resourcing schools with the necessary technicians, tools and equipment enhances students' learning experiences and prepares them for future careers in STEM fields. Consequently, a lack of technicians and/or equipment can be a significant barrier to pupils' access to STEM learning opportunities.

4.31 In ekosgen's previous Structural Barriers report, it was identified that limited equipment resourcing acts as a significant barrier to effective teaching and learning. Greater levels of co-ordination (both internally within the school and externally, working with partners across neighbouring local schools, DYW groups, colleges or local businesses) can help alleviate this barrier.

4.32 Case Study 3 shows that new schools that have classroom environments that lend themselves to collaboration help to improve accessibility to STEM equipment as larger numbers of pupils are able to work together and engage in STEM even if there are low levels of equipment resourcing. Typically, new school builds have open collaborative zones where both pupils and teachers are able to engage with each other and collaborate more effectively – in essence enabling more "water cooler" style discussions than what would be possible in a more siloed approach. In the absence of collaborative learning areas in older (or smaller) school buildings, schools have sought to transform communal areas such as assembly or sports halls or even corridors into collaborative or group learning areas. This is a reasonably common approach, and one that has also been employed to support the delivery of outreach activity in STEM programmes such as the Science Skills Academy.

4.33 Pooling of resources across STEM-related faculties (as seen in Case Study 4) can also help to mitigate the possible challenges of poor equipment resourcing. In addition, pooling of resources across the local authority (as suggested in Case Study 5) to achieve economies of scale when purchasing equipment can help reduce the cost of equipment resourcing for individual schools. Staff in other case study schools also note that they sometimes have to be creative in acquiring STEM kit to supplement what is provided by the local education authority. However, all stress the need to move away from a piecemeal approach to building a STEM resource bank.

4.34 It is typical for STEM equipment to be some of the most expensive apparatus for teaching in schools. A whole-school and leadership team understanding that the equipment needed for STEM is more expensive helps to target a higher weighting of school funding being allocated to STEM faculties (as shown in Case Study 8). In terms of reducing the costs of replacing equipment, both pupils and teachers in Case Study 6's school stated that providing pupils with clear instructions for using equipment improves the longevity of equipment and reduces unnecessary wastage.

Timetabling approach

Taking a highly flexible approach to timetabling and subject columns can broaden the scope for pupils to choose STEM subjects. Coupling this with an adaptable rather than fixed approach to scheduling and delivery, and providing an increased amount of guidance resources can help to increase the extent to which learners select STEM subjects as they progress from the BGE phase.

4.35 Schools' approaches to timetabling can also act as a way to enable higher engagement and attainment in STEM learning. This can range from using specialist timetabling software to enable the most viable subject choices to be delivered, to providing supplementary and informative resources to ensure both pupils and parents are well-informed around what each subject entails.

4.36 Timetabling is identified as a key issue in ekosgen's previous Structural Barriers report, in that where schools do not have an effective process in place (or are constrained by resources), there are much more limited options for pupils and therefore they would be less motivated – or less able – to engage in certain STEM subjects.

4.37 Using specialist software that enables pupils to make their initial choices entirely freely helps to remove these barriers, as shown in Case Studies 1 and 4. In these schools, pupils can pick whichever subjects the schools offer in the first instance, and then the software creates columns of best fit which ensure that as close to 100% satisfaction is guaranteed for pupils. While 100% viability is not entirely possible, it has been found in the school researched for Case Study 4 that at least 93% of pupils in S4 can pick all of their chosen subjects and 100% can pick all but one. In Case Study 8, viability in senior phase subjects is considered after subjects had been picked, and teachers are then flexible and discretionary about these subject choices to try and still field subjects that may be considered in other schools to be unviable – by still fielding these subjects, but with reduced contact hours. These timetabling approaches help to ensure that pupils have the closest possible outcome for their desired learning journey, helping them to keep engaged in subjects.

4.38 Other schools also provide detailed and informative resources that enable pupils to make informed decisions about their subject choices. In Case Studies 5 and 9, a wide range of support staff including pastoral, careers advisors, personal tutors and subject teachers are on hand to assist pupils in picking their subjects where needed. This has been found to be quite interconnected, where all support staff understand the balances between employability/further education options, the interests of pupils and also their strengths. A similar approach is also taken in Case Study 6, where information videos and PowerPoint slide decks are provided to pupils and parents about subject content, the progression implications as the pupil continues their learning journey, and the various career opportunities available.

Project-based learning, inter-disciplinary learning and out-of-class activities

The importance of project-based learning, inter-disciplinary learning and out-of-class activities in supporting STEM engagement should not be underestimated. Challenge- or project-based activities (often utilising externally-provided resources) with demonstrable real-world application will help to bridge the gap between the classroom and real life. Activities that are led by pupils or NQTs in particular can also help to stimulate greater enthusiasm, though there is also a role for activities delivered by parents and external partners in driving up participation.

4.39 A school's offering across project-based learning, inter-disciplinary learning and out-of-class activities can also help to retain interest in the school's wider STEM programme, by "bringing to life" the lessons that are learned in traditional subject delivery to make them more engaging for pupils. This can involve demonstration of real-world application, pupil-led activities that provide pupils with a sense of ownership, or utilising external partnerships to solidify learning and provide opportunity for recognition.

4.40 Out-of-class activities in particular have been identified as being key to removing structural barriers in ekosgen's previous work, where it was found that augmenting learning with highly engaging opportunities outside of formal classroom learning can be a very effective method in retaining interest in STEM learning.

4.41 Typically, project-based learning and out-of-class activities that are challenge-focused or have real-world applicability have been found to have the greatest uptake, particularly those where there are opportunities for certificates or demonstrable career development opportunities that can be provided on pupils' CVs or personal statements for university application. Examples of externally-provided resources for out-of-class activities include Keep Scotland Beautiful's "STEM the Flow Challenge" which is focused around hydrological and water considerations (see Case Study 2), ScotChem's "I'm a Scientist Get Me Out of Here" (see Case Study 5) where pupils could ask questions to scientists in live time, and the challenge-focused activities discussed in Case Study 9. This demonstrates the value of accessing high-quality resources that come at little to no cost to schools, but provide highly engaging learning content for pupils.

4.42 Case Study 2 also highlighted the importance of pupil-led initiatives in gathering interest, as the Young STEM Leaders in this school are involved in the design and delivery of clubs with a STEM lens. This approach can make it much more attractive to pupils as activities have been designed by their peers, and the leaders also learn valuable skills when they take ownership for activities. This school also has a section within the school newsletter dedicated to STEM, that enables both pupils and parents to learn more about the wider out-of-class activity on offer.

4.43 The degree of involvement of teachers in these clubs and activities also plays an important factor in some schools. In Case Study 7, it can be seen that the collective enthusiasm, knowledge and experience of NQTs and well-established staff means that pupils have both a mix of well-designed clubs, and also teachers that may have more time and resource to deliver them.

The learner journey

Primary to BGE

The transition from primary school to secondary BGE phase is a critical period in terms of STEM engagement. Early engagement through practical modes of learning – particularly with primary school pupils before they commence their secondary school education – helps to cement interest in and enthusiasm for STEM learning and understanding.

4.44 As learners make the transition from primary school to secondary school, stimulating early interest is key for ensuring ongoing interest and engagement. Nearly all schools engaged in this research reported that there was significant interest in STEM subjects (particularly science and technology subjects) for pupils entering S1 as these are entirely new areas of study and pupils are introduced to entirely new concepts through these subjects. The practical nature of the work involved in these subjects was what many pupils pointed to as being the key reason they enjoy learning in STEM, and this was expressed in various ways (including introduction to new concepts and ways of learning, peer-to-peer learning opportunities and real-world applicability) across different schools.

4.45 By introducing pupils to new concepts and new ways of learning, they become much more engaged in the curriculum. While it was noted in some instances (for example, by pupils from Case Study 4) that this can be a "big jump" in terms of coming to grips with these new concepts, every student that stated this said that it was a rewarding challenge to overcome once they had grasped it.

4.46 While most pupils in BGE phase stated that what they enjoyed most about practical work was being able to work with their hands rather than focusing on the reading and writing that would be associated with humanities subjects (see Case Studies 5 and 6), it was also found amongst some pupils (Case Study 1) that the practical work also allows for more social interaction between pupils and therefore there is a greater opportunity for communicating and making friends in class, particularly in the first year of secondary school. This enables a greater opportunity for peer-to-peer learning and reinforces a positive classroom environment, which can be beneficial to STEM engagement.

4.47 Other pupils stated that they could see how subjects could relate to the "real world" much better in STEM subjects (see Case Study 9), which helps them to solidify their learning better than conceptual knowledge. This school's approach to coursework is also quite distinct in the BGE phase, where the STEM lead suggested that assessments were more "gamified" to make them more engaging, for example providing assessments that take an escape room challenge style approach to make learning more engaging.

4.48 It is also worth noting that BGE pupils in some schools (e.g. Case Studies 1 and 8) also stated that they greatly appreciated the involvement of peer influencers (e.g. Young STEM Leaders) that attended their schools in primary school to tell them about the secondary school's offering and engage in pupil-led learning exercises, as it made learning about the schools' offerings more relatable than teachers could provide.

BGE to Senior Phase

Taking opportunities to increase the practical and project-based learning content in senior phase helps to consolidate understanding, and thus maintain learner engagement in STEM. Where possible, bespoke approaches to curriculum delivery, combined with more flexible qualification pathways, can also keep pupils engaged in STEM learning.

4.49 Pupils that had moved toward senior phase stated that they enjoyed both the practical element and opportunities for group work in STEM learning, but in some schools (Case Studies 1 and 5) they expanded further upon this. Pupils in these schools found that they were trusted to do even more experiments in senior phase, and that they also were provided with greater independence to problem-solve and "work things out" by themselves without assistance from the teachers. This bestowing of trust has been highly valued and as a result, the pupils stated they believed they learned much better by discovering things from themselves. This exercise also requires teachers to apply their judgement in assessing potential risk levels and consideration of the pupils' capabilities. However, staff noted that this was not a significant issue in Higher and Advanced Higher classes, emphasising that these pupils showed maturity and care with equipment.

4.50 In the Case Study 2 school, pupils and teachers both believed that the introduction of more project-based work in Highers and Advanced Highers classes meant that there could be a focused and concerted attempt at learning about specific content around STEM subjects, with pupils noting specific interlinkages between some subjects (like mechanics in mathematics, technology and physics). This project-based focus can help to consolidate learning effectively, solidifying conceptual learning across each subject by moving away from a purely abstract way of learning to a mode of study that is much more rooted in practical application of STEM.

4.51 In other schools (such as in Case Study 7), it was found that teachers have been able to flex the curriculum in classes that have a much smaller cohort in senior phase and therefore provide a more tailored approach based on both the capabilities and interests of pupils to offer a more personally enriching experience for individual pupils. Compared to more rigid and structured learning that has to be in place in larger classes, this provides greater opportunities for discovery and can help retain pupils on STEM pathways. Whilst tailoring and delivery of bespoke learning approaches may be easier with smaller cohorts, there is evidence from the case study schools to indicate that taking a more bespoke approach to lesson and curriculum planning and delivery can reap benefits in terms of pupil engagement.

4.52 Another crucial factor of STEM engagement in senior phase is the introduction of more flexible pathways being developed for pupils who may not necessarily have considered STEM to be "for them". This can involve providing more applied subjects and lessons (as seen in Case Study 5), to partnering with colleges to deliver subjects that otherwise could not be provided to these school pupils (see Case Study 6), to working with DYW to determine suitable offerings that have a more vocational focus (such as the Barista course offered at the school in Case Study 3, which includes mathematics skills as well as some food technology learning).

Plans for career/future study in STEM

There is good evidence that pupil interest in STEM education and careers is increasing. Showcasing a wide variety of current and emerging STEM career possibilities, whether within lessons or more generally, will provide inspiration to learners.

4.53 Encouragingly, the vast majority of pupils engaged across each school stated that they either had decided on a STEM career, or that they were at least considering it. This included many different examples from different fields such as architects, engineers, nurses, IT technicians and game design. This shows that there is a growing and genuine recognition of the importance and variation of opportunities in STEM, and that there is at least a general understanding of the pathways to gaining a career in these fields.

4.54 There have been focused attempts to encourage pupils to consider careers in STEM across some schools engaged in this research. For example, aside from traditional careers fairs and events, the STEM lead for Case Study 1 stated that the school organises an annual STEM-specific careers event, and particularly targeted both careers that are not traditionally considered to be the "boffin-like characters" such as chemists or physicists, and also made attempts to introduce exclusively female speakers to show that STEM can be for all. This has been well-received by both male and female pupils as it helps to dispel stereotypes and preconceptions about what a STEM career actually is, and who they are for.

4.55 Another example of work to inspire pupils to consider a career in STEM can be found in Case Study 8, where the school has established a STEM "Wall of Fame" of previous pupils that have went on to a career in STEM, showing their pathway once they had left school. This provides a source of inspiration for pupils who, again, may have thought that a STEM career is only for certain people when in reality, anyone could have a job in STEM. Additional encouragement is provided through STEM staff in the school making more explicit STEM career linkages in lessons.

External factors

Local economy

Maximising the potential of the local economy and local employers to bolster schools' STEM learning delivery, enhance their curriculum, and demonstrate potential STEM career pathways will help to increase understanding and anchor pupil learning in a locally relevant context.

4.56 Pupils and staff identified the local economy as being a key external factor influencing STEM engagement in the school. This includes the local business base, the reputation of the area and the links that schools may have with local colleges and education providers. Local business bases often lend themselves to more effective and engaging STEM learning (as seen clearly in Case Studies 2 and 7), most notably when they come to schools to give talks about the jobs available at the organisation, or in attending careers nights and events in schools. By involving local businesses, pupils are able to see the real-world application of their learning and can clearly point to specific career pathways to allow entry into these fields.

4.57 Close links with colleges and higher education providers are also seen as a positive force for STEM engagement (as shown in Case Studies 1 and 6). Such links can open up different pathways that would otherwise be unavailable to pupils, particularly in smaller schools that, due to staffing or resourcing issues, cannot run courses that pupils may wish to study.

4.58 Interestingly, the school in Case Study 6 stated that the reputation and makeup of the local economy had a significant impact on certain subject choices in this school. Given its location, the school's STEM lead was able to point to the influence that both the digital tech and offshore wind/renewables industries have had on uptake in certain subjects such as IT, Physics and

Technology. This suggests that pupils are perhaps more aware of local employment or career opportunities that STEM can deliver than is assumed or understood.

Parents

Better understanding of the parent cohort can inform the way in which schools need to engage with parents – either to overcome barriers or to maximise parent STEM capital. This can help to stimulate more positive influences in terms of STEM engagement.

4.59 Typically, it was noted that parents have not been overly involved in supporting the delivery of STEM outcomes beyond attendance at careers day, parents' evenings, and in some cases helping pupils pick their subjects. However, the STEM lead in Case Study 6 stated that these are ideal times to engage with parents and they try to take these opportunities to dispel any ideas that STEM subjects are necessarily harder than other subjects offered at the school.

4.60 It was noted in the majority of STEM staff in schools that there can sometimes be a degree of "parental push" either into or away from subjects. However, pupils at these schools that were engaged mostly did not consider this to be a factor when deciding subjects. Some STEM leads (those in Case Studies 7 and 9) stated that this can be a beneficial push when parents are employed in STEM industries, while in smaller schools (such as in Case Study 4) parental preconceptions of what STEM subjects actually entail arise from the parents' own experience of these subjects when they attended the same school as pupils in the past. It should be noted that in some schools (for example Case Study 8), there is currently work underway to remove these preconceptions. Proactive and positive engagement with parents is being undertaken, with the school seeking to stress the ways in which the learning experience is entirely different for their children than when they were at school.

Local environment/geography

The local environment can be utilised to provide a better rounded STEM learning experience. Despite urban areas having more challenges in terms of green and blue space, opportunities for outdoor learning can still be found in parks and nearby outdoor education centres. Where the local environment can act as a barrier, for example for travel considerations, alternative options such as online provision can effectively remove accessibility issues.

4.61 The local environment and geography also has an influence on STEM learning. A number of schools noted this: some stated this was a positive influence on STEM engagement, while others considered it as a potential barrier for pupil engagement.

4.62 Despite being located within urban areas, both the schools in Case Studies 2 and 5 utilise various green spaces around them for teaching, e.g. to inspire pupils to consider biodiversity in their area. For the Case Study 2 school, this includes a "study weekend" trip to a nearby outdoor education centre where they take part in recreational activity that is either skills-focused or subject-based. Pupils in biology classes in the Case Study 5 school are taken to local parks to complete sampling exercises. These examples show that outdoor learning is an opportunity that is available to all schools, even within urban areas.

4.63 In contrast, staff at the school in Case Study 4 stated that their rurality acts as a barrier to STEM engagement, as it is difficult to organise travel for pupils to more urban areas, or to specific STEM related attractions (e.g. Science Centres). This impacts the school in terms of being able to augment their teaching with off-site out-of-class activity – for example to take pupils on field trips – and also in terms of being able to provide pupils with options at local colleges. To remove the barrier to increased engagement and activity with the local college, the school has been exploring online provision with the college so that pupils can still access as many options as possible.

Other external factors

Larger schools can typically offer a wider range of STEM subjects, while schools with smaller class sizes can offer a more personalised learning experience to pupils. Consideration should therefore be given to the best approach that can work for schools and classes of varying sizes. Use of comparator school approaches, benchmarking performance against a fictitious but demographically similar school (a 'digital twin'), is useful for assessing performance in STEM and removes an element of competition with other schools.

4.64 The size of the school and class size can also have an impact on the way pupils engage with STEM. While larger schools such as those in Case Studies 1 can typically offer a wider range of subjects than smaller schools, schools with smaller pupil rolls or class sizes such as Case Study 7 have greater scope to flex their subject delivery around interest and capabilities of individual pupils. Both approaches have their advantages in maximising interest and engagement in STEM learning.

4.65 Other factors such as competition and the size of schools were explored with STEM leads, however, little was stated about these. The STEM lead in Case Study 2's school stated that rather than considering competition with other schools they are very co-operative (citing the example of letting pupils from other schools attend classes where their own schools can't provide the subjects), and that they use a "comparator" school approach that they benchmark their performance against a theoretical school based on SIMD and other demographic factors where expected results are produced.

Equity and equality

Gender

Work undertaken to dispel common gender stereotypes has a significant impact on the take-up of subjects that are often perceived as being gendered, such as technology subjects (particularly woodwork). This can range from simple conversations with pupils highlighting previous pupils' successes, to more equal representation in the makeup of a subject's staff, to actively promoting STEM careers for women at careers days and parents evenings. Targeted interventions help to alleviate concerns and perceptions of gender in STEM learning.

4.66 The majority of activity with regard to equality and equity considerations within the schools engaged in this research was focused on gender. Dispelling gender stereotypes was viewed both in terms of staffing, and also in terms of subject choices for pupils. Some schools also engaged heavily in university-provided events that attempt to get female pupils engaged in STEM, utilising partnerships and pre-existing relationships between these universities and schools.

4.67 The need to dispel gender stereotypes was a key finding within the ekosgen Structural Barriers report. Confidence in STEM learning varies by gender, and unconscious biases can often still play a role in discouraging young people to pick certain subjects. By demonstrating equality across all subjects, this can have a positive influence in removing the myth that any certain gender would perform better in certain subjects and subsequently in their careers.

4.68 Two schools engaged in this research pointed to the (potentially unconscious and unintentional) impact that recruiting teachers into certain subjects has had in driving higher uptake amongst girls. In Case Study 9, the school's STEM lead raised that they have seen a higher level of engagement amongst girls in Physics following their department hiring two new female teachers, and found that both male and female pupils found these teachers to be more relatable than previous staff. The staff in Case Study 2 also found that there has been a significant increase in female pupil uptake within woodwork and physics, traditionally male-dominated subjects, having recently appointed female teachers to these departments. In both instances, this demonstrates that a more representative staff body may inspire female pupils to consider subjects they may otherwise have considered to be "boy's subjects". However, it is important to consider research that suggests that the gender of the teacher is not the main factor but the strength of the rapport and relationships they have with pupils.[26]

4.69 There have also been attempts by schools to provide greater focus on the success of girls in traditionally male-led subjects so that these success stories can act as inspiration to other girls when they are considering subjects. In Case Study 3, it was revealed that technology staff in the school regularly point out that girls perform well, so it shouldn't be considered a "boy's subject," and that this often helps alleviate concerns. The school researched for Case Study 1 also ensured that all speakers at their STEM careers evening were female, and both male and female pupils that were involved in this research stated that this event was inspiring and helpful for them in learning how to find STEM careers.

4.70 More widely, schools have availed of their relationships with universities and have attended events that are ran by universities across Scotland. Both the schools presented in Case Study 6 and Case Study 9 attended the University of Glasgow's Girls into Physics events, which their respective staff cited as being a very attractive event for aspiring scientists that had previously seen the subject as being male-led. Another event that was mentioned was in Case Study 4, where they had attended the University of Strathclyde's Women and Girls into STEM event. Again, this event was seen as highly positive by staff and the extremely high female uptake in STEM at this school (95% at S4) suggests that this is a successful targeted intervention.

English as a secondary language

Evidence suggests that pupils whose primary language is not English perform better in practical work, as there is less of a focus on literacy outcomes and pupils can therefore be better supported. Encouraging this cohort to undertake STEM subjects across the learner's journey can therefore be framed in this regard.

4.71 When discussing equality concerns, some schools stated that they have programmes in place that help pupils that do not have English as their primary language. They believe that STEM is more accessible than many other subjects due to its practical nature, and there are resources that can help pupils to understand concepts more clearly.

4.72 Given that in some schools, particularly those in a larger urban area, there is a high proportion of pupils for whom English is not their primary language, finding ways to ensure that these pupils

[26] For example, favourable relationship between teachers and students can desirably influence students' academic engagement: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8525607/

can remain engaged in learning can be a significant consideration. By providing opportunities that enhance the learning journey for this cohort of pupils, it ensures that they have an equitable experience and are provided opportunities to develop at an equitable level to pupils whose primary language is English.

4.73 The school explored in Case Study 6 found that, due to certain subjects such as technology and woodwork being more practical and applied, pupils that do not have a complete grasp of English perform significantly better in their subjects than they do in subjects that have a greater focus on literacy outcomes. They felt that this is only possible because pupils are able to be better supported in these subjects, and because language is secondary to the application of knowledge to a practical element.

4.74 In the example of Case Study 5, all pupils at this school are provided access to a "learning station" that includes literacy materials that are related to the subject that can help consolidate learning. This material ranges from simplified versions of course content, to coloured overlays that help with dyslexia, to Simple English dictionaries for pupils unsure about certain complicated words, to basic materials such as pens, paper and calculators. While this has been designed to cater for a wide range of pupils, the school's STEM lead has found uptake of resources to be most apparent in pupils that have English as a secondary language, thereby providing them with resources that ensure they are on an equal footing to those whom English is their primary language.

Deprivation

Creative solutions and use of the Pupil Equity Fund can help to maximise engagement in pupils that are within the higher-scoring SIMD deciles, with uses cited including supporting travel costs for school trips, providing basic equipment that is free to access for all, and wider outreach programmes for those that are not engaging with the school. Each school faces different challenges in respect to deprivation, therefore budgets for interventions around equity should remain discretionary.

4.75 Different approaches have been taken by schools engaged in the research around how best to support pupils that are from areas of high deprivation, including creation of new pathways and finding optimal solutions for use of Pupil Equity Fund (PEF) and other resources.

4.76 The STEM lead at the school in Case Study 1 believes that the higher uptake in STEM subjects in pupils within the Scottish Index of Multiple Deprivation (SIMD) Deciles 1 and 2 can mostly be attributed to the school's recent development of new pathways, with practical and vocational courses (such as accounting, construction and design engineering) having increased engagement. These subjects have shown to these pupils that there are opportunities in STEM for all, and typically these courses are taken up by pupils in these deciles.

4.77 When asking schools how they have utilised PEF funding, STEM leads suggested different approaches to ensure that no child is "left behind." These ranged from ensuring that resources are free to access without having to ask as shown in Case Study 5 as described above, to supplementing the cost of travel for school trips (Case Study 4), to unique approaches to engagement with pupils that are not engaging with the school as much as expected (Case Study 2), including home visits to parents/carers and teachers staying late to provide after school support. All of these approaches are valid, and have anecdotally been successful in helping to retain interest in learning within the school for pupils that would be eligible for PEF.

4.78 The school in Case Study 3 has also been able to provide digital devices to some pupils free of charge, as a result of funding support provided by local businesses. This has helped alleviate the stigma and staff noted that it has helped to avoid "awkward conversations" both within class between pupils and at home, with pupils less likely to feel they have to ask their parents for something that would be unaffordable. Again, this approach has allowed for there to be equity within the classroom and therefore helps to avoid pupils being dissuaded from taking certain subjects and remain engaged in the STEM programme.

5 Case studies

Case Studies overview

Summary

Table 5.1: Case study overview

Case study	Region	Sector	School roll	Denominational / non-denominational	Deprivation (SIMD Quintile 1)
1	South East	Secondary	>1,200	Non-denominational	10-20% of pupils
2	West Partnership	Secondary	800-1,200	Denominational	50-60% of pupils
3	FVWL	Secondary	800-1,200	Non-denominational	0-10% of pupils
4	South West	Secondary	<500	Non-denominational	10-20% of pupils
5	West Partnership	Secondary	800-1,200	Denominational	80-90% of pupils
6	Tayside	Secondary	800-1,200	Non-denominational	40-50% of pupils
7	South West	2-18	800-1,200	Non-denominational	10-20% of pupils
8	Tayside	Secondary	800-1,200	Non-denominational	0-10% of pupils
9	South West	2-18	800-1,200	Non-denominational	40-50% of pupils

Case Study 1

Introduction

5.1 The school selected for this case study is a non-denominational comprehensive secondary school situated in an urban area in the South East Improvement Collaborative area. The school's pupil count is over 1,200 pupils.

5.2 Given its urban geography, there is a relatively balanced mix of urban pupils (over 60%), small town pupils (over 20%) and rural pupils (over 10%). There is also a reasonable spread of pupils across the Scottish Index for Multiple Deprivation, with just under 20% of pupils within both Quintiles 1 and 2, over 20% within Quintile 3, and over 30% within Quintiles 4 and 5, and between 10 and 20% of pupils are eligible for Free School Meals. There is also a significant amount (over 40%) of pupils that have Additional Support Needs.

5.3 In terms of STEM uptake across technology subjects, the school was performing very well at S6 level with an uptake percentage of over 10%. This included a very positive level of female uptake of technologies subjects at S6. Analysis shows that STEM uptake for pupils across Deciles 1 and 2 has nearly tripled from 2019 to 2022.

Support for STEM within school

5.4 The view of the STEM lead in the school is that the school's management team provides *"good"* support for STEM. At meetings with the Senior Leadership Team, the STEM lead noted that they always had a spot on the agenda where they could talk about various aspects relating to STEM, including curriculum development and out-of-class opportunities and activities. They noted that, since they have been working at the school, the curriculum has flexed so that there is more *STEM-related* content within lessons, recognising that:

"that's the way a lot of work is going, so we should also provide the learning to back up the skills needed in the future workplace".

5.5 The school's STEM lead also stated, similarly, the local authority is also aware that STEM presents a very positive destination once finished with school, and in particular cited the collaboration between the local authority, the school and the regional Developing the Young Workforce (DYW) Group. Whilst acknowledging, *"STEM isn't the be all and end all for learning, the local authority is clearly keen to see it promoted as a key priority in learning".*

Internal structures

5.6 In terms of resourcing, the STEM lead cited that it can be a struggle at times to get cover but *"on the whole, I think we're able to manage a full complement of lots of subjects that fall under the STEM banner".* While the school building itself is quite dated, it is the view of the STEM lead that it is the staff that *"make the subjects and their content much more vibrant with an ethos that encourages learners to pick their subjects".* It was raised by some pupils that the kit used in lessons was also quite dated and at times they have had to have larger groups when using it as often it does not work. The STEM lead stated that the Senior Leadership Team are *"constantly looking at the budget to see what and when we can upgrade,"* citing the recent purchase of a 3D printer for use in technology as one prime example of capital investment.

5.7 The school's STEM lead stated that they follow a timetabling approach that enables as many pupils to pick their desired subjects as possible. The school asks pupils to initially state which subjects they would like to do, and then use computer timetabling software that enables columns of best fit to be created. The pupils then select subjects in these columns, based on what the timetabling software determines are the most viable options for 100% satisfaction. However, it was noted that sometimes this does not always ensure students get to choose their entire desired portfolio, with one pupil stating that they *"had a choice between English and physics, and I had to go with physics because English seemed to be more limited for careers despite how much I love reading".* The school's STEM lead also stated that, as they were redeveloping the curriculum, they realised they could increase options relating to STEM *"to make things more accessible".* They cited their recent introduction of Design, Engineer, Construct courses following a review of DYW data and information from the local authority about the desire for more vocational courses.

The learner journey

5.8 In the BGE phase, STEM pupils stated that what they enjoyed most about STEM subjects is the *"hands-on approach"* that is required for subjects, and in particular that group work *is "quite nice because it's more social, so you can make friends that are interested in the same things".* They stated that as they transitioned into S1, they were well supported and found the subjects all highly engaging. The STEM lead explained that this transition period starts at primary school, with members of staff talking to each of the cluster schools and building resources to share. Sixth year pupils involved with the Young STEM Leaders programme also attend primary schools *"to let primary school pupils see what's in store, and also to talk to them on a peer basis"*. Additionally, primary pupils within the cluster visit the school for a two-day transition event, and the school's STEM lunch time club provide an activity which *"hooks them in before the summer"*. The school has also engaged with the Girls Get Set programme, offered as an out-of-class activity to S1 girls who will become STEM mentors as they move into S2. This scheme inspires the girls involved to engage with STEM, enjoy industry visits, gain insights into STEM careers and earn a GirlsGetSet Bronze Industrial Cadets Award.

5.9 Senior phase pupils agreed that the practical and group work elements of STEM subjects are what has retained their interest in these subjects, and in particular that they valued the *"freedom to do more experiments, as teachers trust us a lot more in senior school"*. One pupil also stated that as they pick their subjects moving from S4 to S5 that:

> *"teachers talk a lot more about the future as you move into S5, if you are taking STEM subjects then they will assume that you're at least thinking about a STEM career, which opens them up to talk about career ideas with you."*

5.10 The school has organised its teaching into a pathways programme that focuses on the career pathways that can arise from selecting certain subjects, and stating which subject choices are most appropriate for which careers. As part of this, there is frequently overlap between 'technologies' and 'expressive arts' areas such as in Design and Technology and Art and Design, or between 'technologies' and 'mathematics' pathways such as Accounting. As part of this, pupils could clearly identify areas of overlap and noted that quite often teachers would point this out:

> *"they'll say things like 'you probably have learned this in maths' and that helps solidify the learning a bit better."*

5.11 The pupils engaged in this research all stated that they had a rough idea of what they wanted to do for a career by the time subject choices in S4 came around, with pupils stating that careers work with DYW was a main focus of learning for the school over the Covid-19 lockdown. The school, through its work with Skills Development Scotland, also offers pupils drop in sessions with the school's two career advisors every lunchtime. Those that stated an interest in STEM career also stated they were very clear on the pathways they were going to take to achieve these careers. Several pupils stated that teachers were very helpful in providing advice "even when I didn't know for sure what I wanted to do, they presented the options very well," and one compared this level of support to that received by careers advisors within the school:

> *"I think because [teachers] see us every day they get to know us and know how to help. The careers advisors can only give us 'Google advice.' I want to be an architect so I was just told by them to do maths, whereas my teachers told me that it requires a certain amount of creativity too."*

External factors

5.12 It was raised by both the STEM lead and pupils that, aside from parents' evenings, typically parents are not overly involved in STEM activities delivered in the school. They are offered the opportunity to attend a STEM careers night with their children, which one pupil said *"was helpful in letting me speak to industries and so [their parents] could see why I'm doing the subjects that I'm doing"*.

5.13 The school's STEM lead believes that the local economy is supportive of STEM learning *"to some degree"*. It was noted that the local business base has a considerably strong profile with regards to Design and Technology, and Hospitality industries. In collaboration with DYW staff, school staff identified that *the "labour market profile for our local authority suggests we need more people in construction, healthcare and anything with an IT/computer science focus- so those are what we plan on training our pupils in"*.

5.14 The school's reasonably large size and catchment area also allow them to provide a *"much wider offering than other schools,"* with an assortment of new pathways beyond traditional academic courses. Where certain subjects are unavailable within the school as a result of low uptake or capacity issues, the school has partnered with the local college to provide even more options, such as Foundation Apprenticeships in Accounting, Engineering, Creative and Digital Media, Scientific Technologies and Social Services and Healthcare. The college also offer, in partnership with Shell, a 'Girls into (Renewable) Energy' course which enables pupils from the school to develop practical skills in building small scale wind turbines and hot water systems.

Equity/equality

5.15 As part of the school's redesign of the curriculum, the STEM lead noted that there is still a gender preconception that *"there's still the idea that a scientist is very much the Einstein-like male boffin figure,"* and the school has attempted to dispel this as much as possible. At the aforementioned STEM careers evening, the school ensured that all speakers were female and that, ultimately, new pathways were promoted to show that being a scientist *"doesn't just have to mean taking Advanced Higher physics or chemistry, or anything like that"*. Both male and female pupils cited the careers event as inspiring and helpful for them in learning about how to engage in STEM, suggesting anecdotally that this was a success.

5.16 The STEM lead explained that the recent considerably higher uptake in STEM subjects within the SIMD Deciles 1 and 2 can mostly be attributed to the development of new pathways as part of the school's wider exercise in refreshing the curriculum, allowing for more practical and work-based approaches to be taken. New Senior Phase options provided at this school include design engineering and construction courses, as well as Skills for Work Laboratory Science, National 5 and Higher Application of Mathematics, and National 5 and Higher Accounting courses.

Overall success factors

5.17 Given the significantly higher uptake of STEM subjects by pupils within SIMD Deciles 1 and 2, it appears that the biggest success factor within this school is the curriculum overhaul that took place, with a view to providing both new senior phase pathways and also supporting greater employability options for pupils based on local labour market insights and data gathered in partnership with the regional DYW group. The wider options provided has allowed what had previously been considered disadvantaged groups to find a *"good fit in the targeted approach we've taken, with many of the courses providing hands-on and practical workplace experience"*. The school has made significant efforts to dispel the preconception that STEM requires higher levels of intellect and that it is the realm of males only. As a result, the school has seen greater uptake of STEM subjects by those that previously struggled in a purely academic setting, and also there has been greater uptake of STEM subjects (particularly technology) in females.

Case Study 2

Introduction

5.18 The school selected for this case study is a co-educational, comprehensive, denominational secondary school in the West Partnership RIC area. Its current school roll is estimated at over 1,000 pupils.

5.19 Given its relatively populous catchment area, there is a high number of pupils that score highly on the Scottish Index of Multiple Deprivation, with over half of its pupils in Quintile 1 of the SIMD index. The school receives pupil equity funding (PEF) to support these young people. Given the large catchment area and urban geography, there is a high proportion (33% in 2022) of pupils in receipt of free school meals.

5.20 The pupils within Quintiles 1 of the SIMD index had a mean STEM tariff which had increased noticeably in the period from 2019 to 2022 and which compared very favourably with the national mean. This has coincided with a 188% increase in students within those deciles taking STEM subjects. The school is fairly unique in that pupils are able to pick specialised science subjects (i.e. physics, chemistry and biology) from S3 rather than from S4, which was a recent change implemented since the Covid-19 pandemic.

Support for STEM within school

5.21 It has been noted by STEM staff in the school that there is strong internal support for STEM within the school. The staff consider the Management Team to be highly supportive of STEM, and stated that they often go to Management Team with additional funding requests for additional materials or apparatus. This is often framed from the perspective of the curriculum overhaul, often needing extra resources to account for the restructuring of the science department to account for specialising in subjects from S3. Recent additional resources requested have included a ‘study weekend’ trip to a nearby outdoor education centre, where pupils were able to revise, while also taking part in recreational activity with a skills-based (e.g. problem-solving through escape rooms) or subject-based (e.g. learning about biodiversity while hill-walking) lens.

5.22 The school also has had strong partnerships with other local secondary schools in the past, having previously delivered Advanced Higher Biology and Chemistry for pupils that are unable to take these subjects in their own schools. This was not possible for this year, as the pupil counts for each of these subjects was already too high to accommodate other schools. It was noted by the STEM lead that:

“This is something that we would be more than happy to accommodate again in the future, but would require our own numbers in these subjects to fall before we could consider it.”

5.23 Within the school’s newsletter, there is an overview of “what’s happening” detailing the various learning activities taking place with regards to STEM. The school takes part in the Young STEM Leader programme, and often these ambassador pupils are encouraged to lead, design and deliver various school clubs with a STEM lens (with the support of teachers). Examples of these clubs include furniture upcycling (with a focus on woodwork and technologies), coding, chess and puzzles. The teacher responsible for the chess/puzzles club stated that:

"The older [pupils] come in and help, and the rapid problem-solving required in chess makes maths much more interesting in that sense."

5.24 The school has taken part in Keep Scotland Beautiful's 'STEM the Flow' engineering programme, a pupil-led marine litter challenge which encourages pupils to research issues with marine litter and plastic pollution and develop their own innovative project solutions for local water waterways.

Internal structures

5.25 When asked about the resourcing within the school, school staff noted that while they have all the equipment that is needed to deliver lessons, the sheer size of pupil numbers in each subject often means a larger amount of pupils have to share apparatus than would be optimal for quality learning. A staff member further elaborated that:

"This gets exacerbated by the fact that more pupils, unfortunately, means more accidents. Some of our microscopes have been damaged and therefore we have even less to share around in the next lessons."

5.26 It was discussed with technology staff that they would like the opportunity to deliver an Advanced High Engineering Science qualification to pupils, but unfortunately the equipment required for this was too expensive. Instead, senior pupils with an interest in engineering are encouraged to take graphic communication as a subject from National 4 to Advanced Higher Level, while practical craft skills and design and technology are available at National 3 level, and both practical woodworking and practical metalworking are available at National 4 and National 5 levels.

5.27 Staffing resources were noted by staff to be *"fit for purpose, but only just",* again eluding to the higher pupil count in sciences that means there is little room for flexibility. It was suggested that the staff are now managing a higher pupil count than before, and that there would sometimes be issues in finding cover in the event of staff absence, with STEM subjects often relying on whoever does not have contact hours, including non-STEM-related teachers.

5.28 Pupils are well supported in picking their subjects, and as noted above, science becomes specialised (i.e. into the individual subjects of chemistry, physics and biology) when pupils start in S3. No science subject is mandatory from S3 and pupils are relatively free to pick whichever subjects they like (aside from mathematics and English, which are mandatory). It was noted by the school's STEM lead that they have still seen sharp uptakes in all three sciences at this stage, with many students continuing their selected science subjects into S4.

The learner journey

5.29 Pupils at all stages of the learner's journey in this school noted that the practical elements of subjects is what has attracted them to these subjects. One BGE pupil stated that they *"like doing anything that shows me how things work"* while another stated gave an example:

"in woodwork we make models, I enjoy seeing how it all comes together and seeing the end product is very rewarding."

5.30 BGE pupils also suggested that teachers are always on hand to support them, but that they particularly enjoyed the independence and responsibility for learning being mostly on themselves:

"you need to think logically to not be trapped in a corner, but teachers are always there if it's too hard."

5.31 Similarly, senior phase pupils also enjoyed the fact that, at Higher and Advanced Higher stages, learning in science subjects is quite project-based which *"makes it more exciting and ties into the real world"* but did note that this can at times be *"more difficult because there's a lot more to fit in and remember"*. This real-world applicability does not appear to have been the focus of senior mathematics programmes which were found to be less interesting to senior pupils, with one stating that:

"I dropped [mathematics] as soon as I could. Some topics seemed more abstract and it was hard to understand the concepts behind them."

5.32 One senior pupil acknowledged that, during the years in which they were learning at home as a result of the COVID pandemic, they found the teaching in science subjects to be extremely limited as a result of being *"unable to do experiments, everything was all just on Teams instead and I didn't take it in"*.

5.33 Senior pupils also noted that they enjoyed participating in the Young STEM Leader programme, noting that they enjoyed *"looking back at our activity logs to see how far we'd come"* and acknowledged the value of this in their personal statements while applying to university.

5.34 It was noted by pupils that non-STEM subjects had recently been exploring topics that would traditionally be considered to be STEM topics. Examples of this include the emerging use of artificial intelligence and historical technology impacts of the industrial revolution in English (in particular how the printing press *"took over the world of writing"*), the more scientific topics of euthanasia and organ donation in Religious Education, and the prismatic spectrum of colours in art. Further, some senior pupils were able to recognise that there are connections between non-STEM subjects and what they'd learned in STEM subjects, in particular noting the *"underlying biology throughout Advanced Higher Geography"*. School staff also noted that there was currently a drive to bring science subjects more closely together with social subjects, and that the school has introduced a "sustainability group" for both pupils and teachers to discuss relevant issues in sustainability that are cross-cutting and could be applicable to lessons across overlapping subjects.

5.35 Encouragingly, none of the pupils engaged in this study's primary research were averse to the idea of a STEM career, with about half of the senior phase pupils stating specific roles (e.g. engineer, IT technicians and science teachers) and the remaining half suggesting that they were considering a STEM career at least.

5.36 Most of the pupils indicated that they had been considering a STEM-based career, and that they had been considering this since BGE phase. Some pupils were able to cite specific roles (e.g. electrician, plumber, chemical engineering, programme developer), while some were not sure what exactly they wanted to do *"but [I would like to do] something that involves experimenting and discovery"*. Pupils that stated they did not wish to embark on a STEM-based career were asked why not (and why they picked the subjects that they did), and one responded that:

"I just find [the subjects picked: chemistry and biology] to be quite fun, but what I really want to do [translation] doesn't really need STEM."

5.37 Senior pupils that were considering STEM-based careers were able to clearly articulate their career pathways and they had felt supported by the school to make the choices they have made in both subjects at school, and also in further/higher education when applying for courses. Prior to entering S4, pastoral care and careers advisors discuss career pathways with pupils. The process was explained by one senior pupil:

> *"They take us out individually and if you have an idea of what you want to do, they tell you how to get there. If you don't know, then they talk us through what they see our strengths as and then ask if we've thought about doing jobs that fit that, and then talk about how to get there."*

External factors

5.38 It was noted outside of typical parents' evenings and events, parents and carers are not really involved in the school's STEM programme, but that these events *"give a taster of what is being taught"*. Staff believed that there is some degree of *"parental push"* into mathematics and/or at least one science *"regardless of ability"*, which can sometimes be detrimental to attainment.

5.39 The school has good relationships with local STEM employers, having brought a local engineering company, construction company and an anaesthetist in at various points throughout the last school year to talk what to expect from a career in the relevant fields. The construction company had regular engagement with the school, as they were building a primary school nearby. The company, teachers and pupils thought it would be valuable experience for pupils of the secondary school to have regular visits to see the *"entire process from start to finish"*.

Equity/equality

5.40 While STEM staff could not point to specific programmes underway to address gender bias, typically uptake in STEM subjects as a percentage of the overall school cohort is higher for females than males (with the exception of technology at S4 and S6), relative to other schools' uptake. The positive uptake of girls into STEM subjects is particularly apparent within S6 mathematics and S6 science. Exploring this further with STEM staff, they stated that dispelling gender bias is important to them *"as there really shouldn't be any subjects that are seen as a 'boy subject' or a 'girl subject'"* and the staff believe the introduction of more female staff in traditionally male-dominated subjects has allowed for a more representative staff body, perhaps explaining particular increases in female uptake in woodwork and physics. Again, however, consideration should be given to the rapport that pupils have with teachers as gender is not the only impacting factor in pupils' decision making and engagement in subject choices.

5.41 Given that the majority of pupils within the school fall within Quintile 1 of the Scottish Index for Multiple Deprivation, the school is in receipt of Pupil Equity Fund (PEF) support. The school use this funding to support pupils who are not fully engaging. This involves visits to home, provision of after school support, accessible curriculum offers and more gradual re-engagement, depending on the degree to which the pupils weren't engaging. Anecdotally, STEM staff were able to point to specific examples of pupils that benefitted from this additional support and noted that some pupils who they had assumed would be moving on from the school returned in the following school year. This suggests that this has been a successful programme.

Overall success factors

5.42 From discussions with both teachers and pupils engaged in STEM, the overall contributors to an increase in both attainment and uptake in STEM seems to be mostly attributable to the fundamental overhaul of the curriculum, including introduction of subject specialisms in science from S3, the return to practical work across subjects following the pandemic, and also the reintroduction of senior phase assignments across STEM subject. These changes have been well-received, and school staff consider the increase in professional learning across departments has allowed for a more consistent approach to be applied across the whole school. While there is some evidence of interdisciplinary learning being taught to pupils, both pupils and STEM staff acknowledged that they would like to see more of this. At the same time, however, pupils could see the interlinkages of subjects independently demonstrating applicable knowledge. Pupils at the school indicated that they enjoy the practical nature of STEM subjects, and that they valued this and the problem-solving aspect of these subjects. Most pupils stated they were considering a career in a STEM, but crucially, even those that had decided that they did not want a career in STEM found the learning at this school to be highly engaging and enjoyable.

Case Study 3

Introduction

5.43 The school selected for this case study is a co-educational, non-denominational secondary school in an accessible rural area, serving a large geographical area within the Forth Valley and West Lothian Regional Improvement Collaborative area. Its current school roll is estimated at over 1,000 pupils.

5.44 Despite its rural setting, there is a lower than average amount of pupils within more deprived areas as ranked by the Scottish Index of Multiple Deprivation, with less than 10% of its pupils in Quintile 1 of the SIMD index (compared to a national average of 21.0%). Likewise, the proportion of pupils that are registered to receive free school meals is lower than the national average.

5.45 The pupils within SIMD Quintiles 1 had a mean STEM tariff which had increased by 50% in the period from 2019 to 2022, to slightly about the value for the national mean STEM tariff.

5.46 The school has open plan, multi-purpose and interconnected learning spaces with technology that lends itself to a more modern approach to learning.

Support for STEM within school

5.47 There is strong support for STEM learning within the school. The STEM lead noted that the Head Teacher and Senior Leadership Team are particularly interested in STEM teaching, and they have recently expanded this to include opportunities for “STEAM” (i.e. the consideration of Arts and Humanities within the overall STEM lens) collaboration. Each department/faculty have their own departmental meetings, but every term there is also a STEAM collaborative meeting to discuss interesting events, ways to integrate learning and teaching across respective subjects, and any barriers/opportunities for integration of topics. The staff pointed out that they run *“themed weeks where students learn about a topic outwith regular programming”* and cited a programme adopted for S2 pupils where they visited a nearby windfarm, and developed course content relating to this (e.g. in mathematics, pupils were challenged to work out the velocity of turbine blades, in science the staff adapted physics lessons to explore renewable energy generation and in biology they considered the impacts on biodiversity of the windfarm).

5.48 It was further noted by the school's STEM staff that the Management Team are always open to ideas around the STEAM collaborative within the school:

"As soon as I suggest an idea, [the Head Teacher] is all for it. The only issue we ever have is just about getting cover but we work well within the school to identify any times this would be needed or available and try to work events around this. It's very much our ethos that being taken out of the classroom means [pupils] get an enriched experience that a classroom setting wouldn't give"

Internal structures

5.49 School staff noted that the equipment and facilities that they have are paramount to successful delivery of STEM outcomes. They cited the amount of open space they have as being particularly inspiring as *"it allows for a lot of collaboration across subjects and departments"* and that this takes place quite often, whenever there is time for lessons outwith the curriculum. One staff member also stated that the equipment *"is much better than in my previous school,"* and they believe that the school build has allowed for a greater level of modernisation across all equipment they use. However, it was noted by a technology teacher that, as a result of the cost of living crisis and general inflationary pressures, they have had to "cut corners" in terms of quality of resources and equipment which then impacts on lessons.

"I've never been told no [for any requests made to SMT], but I am conscious of the budget constraints in my class. Take wood inventory for example, I've had to purchase the more cheaper materials which means that quality falls. Unfortunately cutting corners like this means our wood ends up splitting more often, which means that lessons are disrupted or pupils may have to share."

5.50 Staff were *"working well together"*, to provide an *"enriched learning environment"*. It was mentioned, however, that they would like to offer more additional courses (Skills for Work and National Progression Awards, as well as increasing capacity in those that are already delivered such as Lab Skills), but currently do not have the staffing capacity to deliver these. The STEM lead agreed, saying that there is plenty of ideas that they have but *"having to do the planning to provide an even bigger offer stretches us a bit too far right now, on top of the day-to-day"*.

5.51 Pupils begin to pick subjects in S2, and they have free choice (aside from the core subjects of maths, English and science) from then. When asked whether they could pick whatever they wanted to, pupils noted that *"I could pick whatever I wanted apart from core subjects. [There aren't any] columns, I guess the staff work around us to make sure we can do all the subjects we want"*. Staff stated this was only made possible due to a combination of offering split classes and with principal teachers resourcing going above and beyond in allocated contact hours:

"We're going for 100% efficiency, which means that if one member of staff is off sick, it affects everything. Our PTC is teaching a lot more than he should, but he's happy to do that if it keeps everything ticking over."

The learner journey

5.52 Pupils at all stages of the learner's journey in this school felt that STEM learning was the most interesting of all learning undertaken at the school. Through science lessons, both BGE and senior phase pupils made reference to being able to contextualise things through STEM, in particular enjoying that they could now:

"understand the world better, and appreciate the amount of science behind things like buildings, nature and technology."

5.53 BGE pupils acknowledged that there was a *"big jump"* in learning from primary to secondary school, but that they felt supported throughout. This was particularly true for science and technology, in that lessons included the use of *"equipment we hadn't seen before, but teachers could always tell us how to use it if we weren't sure"*. One pupil also stated that they felt like they were *"in the hands of experts"* as they didn't have teachers in primary school that were subject-specialists, and *"we only got [science lessons] every so often, which meant I'd forgotten everything the next time it came around,"* whereas they appreciated the more regular and structured approach taken in secondary school.

5.54 As pupils started to pick their subjects, they were also provided with introductory sessions towards the end of the year *"so that we got a taste of how it's taught"* before deciding to pick the subject. Some pupils stated that they hadn't fully decided their subjects for next year until those sessions, and all found it particularly helpful to *"even just have my decisions reinforced"*. Senior pupils also noted that they enjoyed the versatility of STEM subjects, in particular the blend between practical and theoretical lessons, and the wide range of topics explored within these subjects. One senior pupil stated that they picked STEM subjects as they believe these to be the most useful for pupils who hadn't decided on their career:

"If you haven't decided what job you want to do, STEM subjects keep these options open."

5.55 As has been stated above, there is a high level of collaboration between the humanities and STEM subjects, as the school has aimed to introduce a STEAM collaborative. One example of this STEAM identity in action, was a whole-school initiative which used Daydream Believers' "Solarpunk Island" resources.[27] This is project-based learning challenge in which pupils pretended they were stranded on an uninhabited island and had to develop their community following 15-minute neighbourhood concepts and principles. The pupils explored various different elements during relevant subject lessons, such as the concept of a 15-minute neighbourhood in modern studies and geography, electricity generation in physics, biodiversity in biology and building (habitat) design in technology and art. Staff pointed to this an exemplar collaborative themed event, stating that *"sustainability is a hot topic right now, and it's an ideal topic to bring the humanities into the work that we do in science"*.

5.56 Pupils at all stages of their learning journeys were able to say that they wanted a career through STEM pathways, in particular some named specific areas such as architecture and game design. Those that had a clear idea of what they wanted to do had rough ideas of the pathway into employment - those at BGE stage knew which subjects would aid for further study, and those at senior phases had already identified specific courses at university they were hoping to apply to. Encouragingly, BGE and S4 pupils who did not yet know what they wanted to do in their career

[27] https://daydreambelievers.co.uk/resources/solarpunk-island/

stated that they were planning on picking STEM subjects because they *"give a lot of opportunities"* and *"I picked my subjects because I like the experiments we do".*

5.57 The school is also particularly strong in its work-based learning approach, with a very high proportion of the cohort taking Skills for Work courses. The school offers plenty of vocational courses that pupils can engage with such as accountancy, graphic communication, design and manufacturing, and commerce. The school also partners with a local college to allow pupils in S4-S6 to access other vocational courses in afternoons, such as cyber security, engineering National Progression Awards and Foundational Apprenticeships in construction and childcare.

External factors

5.58 When pupils were asked whether their parents have any impact on STEM learning, some stated that their parents had a significant role in helping the pupils pick their subjects. Two stated that the parents chose their subjects for them, as they had careers in STEM and could help them identify specific subjects that would be *"useful for work".* One pupil noted that their parents didn't have a *"detailed understanding of what I could take"* so they were allowed to choose whatever they wanted. Interestingly, school staff seemed to suggest that a lack of knowledge of course content in parents has had a mostly negative impact on the delivery of STEM learning at the school, driven mostly by their own perceptions:

"You often hear things like 'my kid's too smart for admin' but that class teaches valuable life skills like database design and analysis, and how to write professional emails. I think we have a lot of work to do to dispel some of the stereotypes parents have in mind"

5.59 The school's STEM lead stated that they have good relationships with local STEM employers, and have been able to bring in a *"huge number of organisations"* to speak about career pathways and learning in STEM. This has included pharmaceutical companies with a local base, nearby finance and accountancy companies, and the NHS. Pupils found these talks to be inspiring *"especially when it's local people, I can relate to them"* and staff said it was only possible through establishing strong partnerships throughout the local economy, as well as one stating that the regional DYW Group *"helped us build these up".*

5.60 The school's size and openness to innovation and collaboration has led to positive outcomes in STEM. The school has been granted an extension to its existing build to support more pupils and also to develop more collaborative space. It is the view of the STEM lead that the larger the school becomes (and provided it adequately recruits teachers to fill the increases in pupils) , the more different opportunities that it would be able to offer:

"[The school size] is an opportunity to me, definitely not a barrier. Assuming there's the staff numbers and quality, the more pupils we get in, the more different [subjects, events, out-of-class activities] that we can offer them all."

Equity/equality

5.61 On a school-wide basis, there are programmes that help address equity and equality barriers to education. There is currently a push for girls to be involved in the design and technology classes, as the male to female ratio has consistently been disproportionate. The technology staff said that they *"regularly point out that the girls who do it get on really well in this class, so there's no reason for girls to think this is a 'boy subject'"* when it comes to making their choices. The school's partnerships also include some of the "Big Four" accountancy firms, who have focused attention on increasing women in investment banking and the school has sent girls on these work experience experiences which staff consider have inspired the pupils that have taken part in the following school years.

5.62 For pupils that cannot afford their own devices, the school provides these free of charge, which enables them to continue to work. Further, other locally-based companies have shown interest in reducing the deprivation gap by inviting pupils that are in receipt of Free School Meals to take part in work experience experiences. All of these efforts are seen to be a positive step in achieving equity by the STEM lead:

"We are always focused on closing those gaps within education. We can't shut them all completely, but we're definitely going in the right direction."

Overall success factors

5.63 Overall, based on discussions with pupils and teachers engaged in STEM, the school's successes in STEM outcomes appear to be derived from a combination of successful partnerships, both internally (from the perspective of the STEAM collaborative) and externally (in terms of their strong links with the local college, DYW Group and local actors in the economy). The school's modern physical facilities allow for greater collaboration and a relatively large offering of subjects including Skills for Work courses. Their push to introduce themed events where all classes (including those within the humanities) contribute to learning around a specific topic is also having a positive impact. The school's ethos and key working practices ensure that no pupil is left behind, and the school makes considerable efforts to ensure that *"there is always something that we can offer the pupils in STEM".*

Case Study 4

Introduction

5.64 The school selected for this case study is a co-educational, non-denominational secondary school in a remote and rural area in the South West Education Improvement Collaborative area. Its current school roll is less than 500 pupils.

5.65 Given its highly rural geography, over 90% of students are from a 'rural' classification. The Scottish Index for Multiple Deprivation places the vast majority of pupils (over 90%) within Quintiles 3 and 4, and less than 20% of the pupil roll are eligible for Free School Meals. While there is a low proportion of students that have English as an Additional Language (less than 10%), accessibility is still a relatively significant issue within the school, given that almost half (over 40%) of the school have Additional Support Needs.

5.66 The school has a considerably high uptake across STEM subjects at S4, with 97.8% pursuing STEM subjects within this cohort. The school has a particularly high uptake of technology subjects at S4 level (57.8% of the cohort).

Support for STEM within school

5.67 The school's support structures lend themselves quite well to STEM learning. In recent years, there has been a broader push on improving numeracy within the STEM faculty as part of the School's Improvement Plan. This has involved the development of resources from science and technology staff in tandem with the mathematics faculty, and benchmarking performance against pre-COVID numeracy levels to understand the baseline to be aiming for. Staff also highlighted how supportive the Management Team are any time they request anything (whether that's additional equipment, class trips or even CLPL). This is mostly funded through the school's PEF funding - while all curricular areas are eligible to bid, the Management Team acknowledge that typically STEM subjects require enhanced resourcing for equipment etc. The school also provides a dedicated technician for science and technology classes, who is:

"incredibly useful as they do all our prep work so that we don't have to leave class to do it ourselves, so we can carry on teaching."

5.68 The school also has strong partnerships across its local support system, including within its small cluster of primary schools, its alumni and its local area. The school hosts a *'school ambassador'* scheme within science, that features pupils focused on inspiring younger pupils to consider STEM subjects. This has involved a former pupil who is now studying biology at university providing an online chat with Advanced Higher Biology pupils and offering support in the form of tutoring to younger pupils. Science teachers, and other teachers delivering STEM subjects, have been involved in themed events, such as the 'Protect Our Planet Day' which focused on delivering lessons in sustainability across each subject. The school also took part in a 'Numeracy Town Trail' which involved pupils completing a scavenger hunt using mathematic formulae and puzzles to complete the trail.

Internal structures

5.69 School staff were quick to point out that, despite being a small school, they feel that STEM is particularly well-staffed and have described their situation as *'stable'* in terms of turnover. This stability means that the staff can offer each science as a discrete choice as early as S2 (from December), with chemistry being offered as its own subject, or alongside the John Muir Award if pupils wish to explore the natural environment.

5.70 When asked about equipment resourcing, staff found that the pooling of each subject's resources within the STEM faculty has been useful in helping to alleviate the greatest need. Examples within the last six months included 30 new scientific calculators (*'owned'* by physics), 3D printers for the school's graphics classes, and using digital literacy funding to provide mathematics with 96 iPads. While each subject retains responsibility for the equipment, they are shared across the STEM faculty whenever needed, and to date this has not caused any difficulties in terms of retention.

5.71 The school's STEM lead is the timetabler for the whole school, and is very keen to ensure that staff are supported to deliver the subjects and lessons they would like, on top of ensuring that all pupils can pick what they like. Pupils at S4, S5 and S6 are allowed to do a *"first trawl"* form of completely free options, and software is then used to categorise these subject choices into columns to get as close to 100% viability as possible. This means that the columns that are offered to pupils change every year, so as to ensure that as many pupils as possible can pick as many subjects as possible. In 2023/24, 93% of S4 pupils were able to pick all of their chosen subjects, and the remaining 7% could pick at least 90% of their chosen subjects. It was noted by some pupils, however, that they could only pick two of three discrete science options in S2 and as a result when picking this science to start their Nat 5s they found themselves *"on the back foot catching up"* in the subject they didn't pick in S2.

The learner journey

5.72 In the BGE phase, STEM pupils at this school noted that experiments were what drew them to consider continuing STEM subjects. They appreciated the practical elements most in lessons, and noted that it was completely different to what they had learned (and the ways they learned) in primary school. One pupil stated that they also attended a Women and Girls in STEM event at the University of Strathclyde - this was a two-day event in which the pupils got to experience the campus and learn more about science-related courses, as well as doing fun experiments to pique their interest. The pupil stated that "*this is when I realised I wanted to do something in chemistry as a job,"* suggesting that there is value to taking pupils out of traditional classroom teaching to learn about opportunities.

5.73 As stated previously, pupils begin to choose discrete sciences from as early as S2. Senior pupils, in hindsight, found the switch from general science to be *"challenging but rewarding – I'd rather learn about the things I'm only interested in but it was a big step up in content".* This was mirrored by STEM staff, who acknowledged that there is a *"huge jump in terms of STEM"* but that pupils seem to enjoy the trust and autonomy provided in working in groups for laboratory work and also within the technical department. Staff also stated that *"without overgeneralising, [senior phase] is the age when pupils are most on their phones, so incorporating any sort of digital aspect like our iPads or graphics drawing boards is always going to be more engaging than working from textbooks".*

5.74 Given the small size of the school, both staff and pupils believe there to be a significant amount of collaboration between STEM subjects. Pupils in the senior phase noted considerable linkages between maths and physics, including similar formulae in mechanics modules of maths, and also learning about vectors in both subjects. There has also been themed days in which all subjects within the school take part (e.g. Protect the Planet Day), and the STEM faculty have found the most engaged subjects *with "clear linkages"* to be within geography, physical education and computer technology.

5.75 The school is also highly engaged in delivering out-of-class activity that is supportive of STEM. There is a dedicated team of STEM prefects that organise and run a homework club, which provides support to peers and junior pupils when needed. The physics department has also ran a Lego Spike Robotics club. Aside from the trip to the University of Strathclyde and alternative chemistry pathway under the John Muir Award mentioned above, the school also provide other opportunities to *"get out of the classroom and learn"* including trips to Edinburgh Zoo, and opportunities to visit NHS hospitals during the themed NHS week. Local businesses and organisations regularly come to the school to give talks and inspire the pupils to consider STEM pathways.

5.76 The pupils that were engaged all stated that they were at least interested in a career in STEM. This has been spurred by the inspirational learning that has taken place, as well as the wider opportunities provided by the school. One pupil in S4 said that while they hadn't fully decided what they wanted as a career, the majority of the subjects they had picked and were interested in were almost entirely STEM orientated.

External factors

5.77 Given the small size of the school and its rural locality, it was noted by staff that *"parents have often been to the school themselves"* and therefore their influence tends to be based on their our own positive or negative perceptions (e.g. that *"three sciences are just for brainiacs"*) and this preconception is often a hindrance to pupils being able to make informed decisions.

5.78 The local economy is seen as a mostly positive influence for STEM, with both pupils and staff noting that local businesses and organisations (the NHS, the University of Strathclyde, the University of Glasgow, Edinburgh Zoo, a local museum curator, local care homes and digital land surveyors) have either visited the school to give talks, or allowed pupils to come and visit. The pupils recognised that these were *"really fun and interactive"* opportunities *"that showed us what happens in the real world with STEM".*

5.79 It was noted, however, that the local environment can also cause a hindrance to learning or engaging in activities. Given its rurality, the cost of organising buses has been noted as being expensive. Therefore, there are less opportunities to engage with local colleges and other schools to provide classes that are not provided within the school. To remove these accessibility barriers, the school has explored online provision of college courses and there has been reasonable uptake of subjects provided by the local college, such as the Introduction to eSports National Progression Award.

Equity/equality

5.80 When asked about equality and equity considerations, the school's STEM lead noted that there were considerable efforts to dispel gendered stereotypes within the STEM faculty. This includes participation in events such as the Women and Girls into STEM event that is hosted by the University of Strathclyde, and yearly Girls into Physics events for S2 pupils. Anecdotally, the school staff and pupils engaged all stated that they enjoyed these experiences, and the high proportion of female uptake across STEM in S4 (over 95%) suggest that targeted interventions have been successful.

5.81 While nothing specific has been undertaken by the STEM faculty in terms of deprivation, the school's STEM lead pointed to their use of PEF funding to ensure that *"those that are struggling aren't asked to provide more than they have to"*, including supporting bus fees for science centre trips and providing extra opportunities for *"catching up"* numeracy classes from lost learning during the COVID-19 pandemic.

Overall success factors

5.82 It seems that, despite the school's rural nature, the school has provided many opportunities for learning outwith the curriculum. This has been received very well by pupils. The school relies on its local economic ecosystem to provide support through talks to pupils or new qualification pathways in the local college. The school's choice to provide two discrete science subject choices for pupils in S2 also helps identify subject specialisms at an early age, but can also act as a barrier in terms of the 'catching up' required if pupils decide to do sciences later in their learning journey. The school's small size also appears to lend itself to STEM teaching, with the faculty able to work in collaboration with each other to ensure resources are appropriately allocated, and also allows for 'less formal style' relationships to be made between staff and pupils, which enables greater levels of trust between all parties.

Case Study 5

Introduction

5.83 The school selected for this case study is a co-educational, comprehensive, denominational secondary school in a large urban area within the West Partnership Regional Improvement Collaborative area. Its current school roll is estimated at over 1,000 pupils.

5.84 Given its relatively populous catchment area, there is a high amount of pupils that live in deprived areas as per the Scottish Index of Multiple Deprivation, with over 80% of its pupils in Quintile 1 of the SIMD index. Given the large catchment area and urban geography, over half of pupils within the school were reported to have additional support needs, and also a high proportion (over 40%) of pupils where English is an additional language.

5.85 The pupils within Quintile 1 of the SIMD index had a mean STEM tariff which had increased slightly over the period from 2019 to 2022 and which was significantly above the national mean. This has coincided with a 146% increase in students within SIMD Quintile 1 who are taking STEM subjects.

Support for STEM within school

5.86 Broadly speaking, there is strong support for STEM within the school. There has been a recent change of head teacher at the school, and it is the intentions of the school's STEM staff to ensure that the School Improvement Plan has a heavy focus on promoting and improving STEM outcomes. The staff are of the view that the Management Team are highly supportive of STEM, and noted that they are always willing to both provide funding for essential equipment, and also to allow pupils to participate in external visits and trips, as:

"[the Management Team] recognise the importance of getting out there and having experiences that we couldn't offer as teachers."

5.87 The school also has strong partnerships with its cluster of primary school partners, other secondary schools and also with local universities. The school's STEM staff regularly go to primary schools with pupils (often the Young STEM Leaders, but also other pupils enthused by STEM), as they found that primary school students often prefer when they are hearing directly about the pupil experience. When primary school pupils come to the school for transition days, they are shown 'taster sessions' demonstrating what will be learned in the BGE phase, and these have been well-received by the pupils. The school has taken part in ScotChem's 'I'm a Scientist, Get me out of here' STEM outreach programme, which allowed pupils to engage with university students and employees within industry to chat with students in text-only live chats where pupils can ask questions around any topic, which pupils have found to be quite inspirational and affirmed that STEM was *"for them"*.

Internal structures

5.88 When asked about the resourcing within the school, school staff have noted significant improvements (particularly in physics and technology) since 2020, and cited being able to achieve economies of scale through the local authority purchasing STEM kit and equipment for all schools in the area. Further, it was noted by technology staff that, given the high proportion of SIMD pupils within the school, they are often able to acquire resources that would often cost other schools more.

5.89 On staffing resources, it was noted that there has been less flexibility than in the past. At times, teachers have had to cover subjects which impacts on the time used to plan lessons and mark assignments.

5.90 Pupils are well supported in picking their subjects, with advice coming from a range of support staff. This is provided by form tutors in second year, pastoral care staff in fourth year, and by careers advisors supporting subject choices at each transition point. When asked whether they were able to pick all of the subjects they wanted, pupils stated they were able to choose whichever they felt they wanted to do. Staff explained that this was only possible through partnerships with other local schools, and that one of the columns for picking subjects included "travel" options.

5.91 It was noted by some pupils, however, that it would be helpful to have a *"taster session"* to help them pick their options. They also stated that it would be helpful to have a better overview of what is in the curriculum for later years, rather than assuming that performance and attitudes towards subjects previously would effectively underpin subject choices.

The learner journey

5.92 At all points of the learners' journeys, it was noted that the manner in which STEM subjects are taught is one of the most attractive aspects of learning in these subjects. BGE pupils stated that they enjoyed all of their subjects that had more of a practical element, such as sciences and technology as *"doing something hands-on is something completely different to what we did at primary"*. BGE pupils also welcomed the opportunity for *"supportive studies"* – where questions that pupils may have are put onto the whiteboard throughout the following week or two and then worked through as part of that lesson.

5.93 Similarly, senior phase pupils also enjoyed the practical side of sciences (particularly chemistry experiments), while physics pupils in particular enjoyed the problem-solving nature of their studies. One noted that it was challenging *"but in a good way"* as they valued how rewarding it was to have something they were unsure about, and arrive at a solution. Across all STEM subjects, pupils highly valued the collaborative group projects and were able to appreciate the value of peer-to-peer learning: *"it's much better not being spoon-fed and having to discover things with classmates for ourselves"*. This was supported by staff, who acknowledged the role of CREST awards in allowing pupils' achievements to be recognised early into their learning journey, allowing pupils to complete a project of their own creation, presenting it and planning it: *"[The CREST awards] goes miles for these young people as for some its their first recognition of achievement – being given that piece of paper can be quite impactful"*.

5.94 There have been purposeful attempts to encourage both joint learning across STEM subjects and STEM learning in subjects that are not traditionally considered as STEM subjects. For example, pupils have been taught to use consistent terminology in scientific notations and have learned mathematical equation techniques (e.g. the "triangle method") in physics. More widely, there has been collaboration with Physical Education (where pupils were working out speed, distance and time and linked that in with physics lessons). In Home Economics, links were made between microbiology and food safety, and in Design and Technology, pupils melted down plastic bottles and sculpted them into earrings. It was noted by staff that pupils have enjoyed this collaborative approach and that *"we can tell them how it relates, but they only truly understand how when they actually see it in practice"*.

5.95 Encouragingly, none of the pupils engaged in the primary research were averse to the idea of a STEM career, with about half of the senior phase pupils stating specific roles (e.g. engineer, IT technicians and science teachers) and the remaining half suggesting that they were considering a STEM career at least.

External factors

5.96 It was noted outside of the annual parents' evenings and assisting with homework, parents and carers are not overly involved in the school's STEM programme. There was a general feeling from both pupils and school staff that this would not necessarily be welcome, from pupils as they believed *"practically, they wouldn't be able to help much"* while staff noted that, *"while parental pressure can be positive as it pushes them into what they perceive as real careers, it can backfire if the kids choose subjects that aren't necessarily the best fit for them".*

5.97 The local economy is seen as a positive force for STEM, with pupils noting that local businesses (civil engineers, woodworkers in technology) have visited and given demonstrations *"which helped us see 'when will we use this' in action".* One of the pupils also said that this was *"inspiring when it happens, but I would like to see more of it".*

5.98 The local environment/area are also seen as positive influences that lend themselves to STEM learning. Pupils in biology are taken out to local parks to complete sampling exercises, and at BGE stage, science pupils are taken to a local science centre to learn about various different aspects of science, which they found to be *"really fun and hands-on".*

Equity/equality

5.99 As stated above, over 80% of the school's population are found within Quintile 1 in the Scottish Index for Multiple Deprivation. The school has also recognised that it has a high proportion of pupils that display dyslexic, autistic and ADHD characteristics. Likewise, there is a high proportion of pupils that are BME and have English as an additional language. As part of their assessment of quality indicators (3.1 is inclusion), they undertook to ensure no child is *"left behind"*. While working within the context of a constrained budget, staff in sciences have developed learning stations in each of their classrooms that assist in the delivery of lessons. Equipment found at these stations include coloured overlays, purported to aid pupils with dyslexia by minimising visual stress; dictionaries with Simple English definitions; and basic learning equipment necessary for certain lessons such as rulers and calculators. It was stressed by the STEM lead that these learning stations are designed so that pupils can take whatever equipment they need at the start of the lesson without needing to ask, so that *"they are not made to feel embarrassed about needing the equipment". T*here has been good uptake of these resources. Although this is the first year of this provision, staff have noticed marked improvements in their in-class assignments.

5.100 More widely (across the school), school staff support young people for whom English is an additional language. They ensure that these young people can access learning materials and are well supported with the literacy skills needed to succeed in specific subject areas. As a result, there is a high level of attainment in STEM across this cohort.

Overall success factors

5.101 Ultimately, it was apparent through the discussions with both teachers and pupils that the improvements and success of the school's STEM programme can largely be attributed to the relationships that STEM staff have developed with pupils. Pupils feel highly supported by their teachers and are encouraged to ask any questions, with one teacher stating that *"there are no stupid questions"* and pupils feel comfortable enough to ask them anything. While only roughly half of the pupils engaged in the primary research (through focus groups) knew that they wanted a career in STEM once they finished in education, almost all of them stated that they had a strong interest in STEM. They reported that they had been encouraged, inspired and maintained curiosity in STEM subjects as a result of the experiments and practical elements of their courses.

Case Study 6

Introduction

5.102 The school selected for this case study is a non-denominational and co-educational comprehensive state high school covering in an accessible small town in the Tayside Regional Improvement Collaborative area. The school has a pupil roll of over 1,000 pupils.

5.103 Given its surrounding geography, there is a mix of urban pupils (over 60%), rural pupils (over 30%) and some small town pupils (under 10%). The Scottish Index for Multiple Deprivation places the vast majority of pupils (over 80%) within Quintiles 4 and 5, and less than 10% of the pupil roll are eligible for Free School Meals. Despite having a low proportion of students that have English as an Additional Language (less than 10%), accessibility is still a relatively significant issue within the school, given that over 30% of pupils have Additional Support Needs.

5.104 The school performs very well in the uptake of STEM subjects at the S4 level, particularly in relation to mathematics and technology subjects. At S5 level, uptake of STEM subjects in general was also high, with S5 uptake of science subjects of particular note.

Support for STEM within school

5.105 The school has a broad range of support for STEM learning within the school. The school's improvement plan identified that numeracy was a key issue within the school. To address this, numeracy across learning has been developed across all subjects and a "star track" has been introduced, with a spreadsheet of numeracy-related questions being provided at the start of every lesson. The school's STEM lead stated that this has been successful, with an evaluation of numeracy skills showing significant improvement since implementation. Staff stated that they felt they could come to the STEM lead to represent them in Senior Leadership Team discussions, and that the lead *"ensured all of our voices are heard in those meetings".*

5.106 The school's STEM lead also stated that there was strong support for STEM within the local authority, citing the local authority STEM Co-ordinator as being *"really helpful – she has helped us with finding funding and opportunities that exist that I would not normally have heard about,"* . *They* cited the LAs support in being *"absolutely vital"* in enabling them to be one of the first school's to take part in Education Scotland's STEM Grants Programme, which allowed them to engage with local primaries and provide Young STEM Leader ambassador opportunities.

Internal structures

5.107 The school staff raised resourcing concerns, stating that often they find themselves *"stretched"* at times, particularly since the COVID-19 pandemic. *Staff stated, "that means we can't find time to develop lessons that go beyond the curriculum".* To resolve this, they have developed a STEAM collaborative (incorporating arts and humanities subjects into STEM). They found that this has allowed for more dual teaching and therefore the school can offer a more extensive subject choice for pupils.

5.108 Pupils were able to point to a wide variety of kit and equipment that is used within the school, including 3D modelling software, graphics software, and kit used in laboratory experiments. The school provide pupils with instructions on how to use these resources, and this is well received by pupils who find the equipment *"easy to use and explained well"*. Equipment resourcing requests are delivered through the STEM lead, which the staff seemed to believe was an adequate process. When asked how this works in practice, the STEM lead stated:

> *"simply put, teachers tell us what they want and we make it happen. We don't say no unless we have to – if someone sees something they want to do on social media they come to us, and we ask if other teachers want to get involved. The more backing a suggestion has, the more of a chance I'll get a yes from the Senior Leadership Team!"*

5.109 The school's STEM lead also has timetabling responsibilities, and have found this to be an opportunity to provide equal weighting to all subjects including STEM subjects. Since they have started in this role, the STEM lead has asked all teachers across the school to provide an informative video for each subject that they offer, where the teacher details the content of the course and speak about progression and career opportunities. This allows pupils (and their parents) to understand more about the course before deciding to take them on, and therefore pupils are empowered to make more informed choices.

The learner journey

5.110 In the BGE phase, STEM pupils stated that they were most fond of the practical element of STEM subjects. They stated that they enjoyed the experiments that they did in chemistry and that *"hands on subjects like in tech"* were the ones they enjoyed the most. These pupils also stated that they found mathematics to be a *"much harder than primary school but it's needed for other subjects too"*. They recognised the value of numeracy (as eluded to in the improvement plan) and how it links to other STEM subjects such as physics.

5.111 Senior phase pupils agreed that they really enjoyed the practical element of STEM subjects, and cited on several occasions that they were well supported in their learning. The STEM lead explained that their high uptake can probably be attributed to the development of a variety of pathways that allow for a more practical or applied science approach to be taken. There is a local college course offered to senior phase pupils, including National Progression Awards in agriculture, applied science, and rural skills (Animal Care and Horticulture). While none of the pupils engaged in the research had taken part in these wider course offerings, they stated that they both appreciated that another pathway option *"is there if we want it"*, and anecdotally that their peers found these subjects to be *"very interesting and job-focused"*.

5.112 As stated above, the school is organised in a manner that lends itself to a STEAM collaborative, factoring in the arts and humanities into the typical STEM fold. Aside from more collaboration, discussions and opportunities for dual teaching at a faculty level (e.g. geography teachers delivering environmental sciences classes), the collaborative also introduced a themed "STEAM" week in which guest organisations are invited to come in and give talks to pupils. As part of this they offered workshops to show what a typical working day at these organisations would look like, and explaining how they use STEAM in their every day life. According to pupils, this makes the experience more *"relatable and can clearly see what [they are] learning actually looks like in the world of work"*. Other themed events which take pupils out of their typical class time table interdisciplinary projects in architecture (incorporating physics, art and design, mechanics modules in mathematics and technology), animation (using drama, music, computing and art and design), and a Tour de France themed week where climate ideals were considered in the languages department.

5.113 Pupils highly valued the 'careers night' and 'meet the employer' events that take place annually in the school. Aside from the informative videos that provide detail about the potential courses they can select for learning in the following years, they see these as being the greatest influence on their choices. The school's STEM lead stated that their careers evenings are organised in the run up to subject choice, and have had over 100 different employers either come in or provide leaflets and information stands over the last three years. The pupils again highlighted the importance of these events in terms of understanding how to apply learning in STEM (or STEAM) and how these events help them find career pathways that they otherwise would probably not have considered.

External factors

5.114 The school's STEM lead stated that the school maintains very close relationships with its parents. The 'learning journey page' that provides the detail of pathways and videos on course content is available online for parents to also access, and both the parents evenings and careers nights are seen as ideal times to engage with parents. There is a *"cosy feel"* to both events, and they are seen as opportunities for employers and teachers to give presentations, to help parents understand the role that STEM can play in career pathways.

5.115 The school's close relationships with both the local college, and local employers, means that opportunities in STEAM are *"much more apparent and understood"* than before,. T he local college is able to provide courses that otherwise would not be delivered to pupils at this school, and both parents and pupils have a *"clearer understanding of what's out there"* in terms of potential jobs in STEM from the careers nights and parents evenings.

5.116 The local geography also lends itself to STEM learning quite well, with the reputation of its local specialist sectors, and the growing renewables and offshore wind sectors within close proximity acting as local drivers of interest in STEM subjects. The school is also located on the main bus route, making transport to the local college relatively easy.

Equity/equality

5.117 When asked about equality and equity, the school's STEM staff were able to point to specific examples of what they do to remove gender bias. This included participation in the Girls into Physics events and particular careers events were certain businesses stated a particular interest in *"having as many girls in the crowd"* as possible. It was also stated by one staff member that *"interestingly, it seems that girls are more likely to take risks on subjects that were normally considered to be a boy's domain"* than the other way round, indicating that gender bias is becoming less of an issue.

5.118 The school's STEM lead also eluded to work undertaken with pupils who have English as an additional language. These pupils initially do not take part in the traditional timetable but instead would *"pop down"* for some lessons so that they can experience this. Then, when their supporting teachers are confident enough in their capabilities, they enter into National 5 courses in mainstream education. Anecdotally, one of the school's technology teachers pointed out that the school's refugee intake from Ukraine *"were doing even better metal work than [the teachers]!"*, suggesting that certain STEM subjects can be seen as an opportunity for those that may not have a firm grasp of the English language to demonstrate more practical capabilities.

Overall success factors

5.119 Overall, it appears that the largest contributors to success in STE(A)M learning and identifying STE(A)M pathways comes from the school's very strong relationship-building activity. The school has good links with the local college, which offers a wider range of practically-oriented pathways. The school also has very strong links with local employers, and regularly invite them to provide talks, workshops and presentations about the work they do and how to get into the sector, as well as annual careers nights which parents, pupils and teachers all find to be extremely useful. Contrary to what has typically been found throughout the wider research, parental influence has typically been seen as a positive at this school and the school's STEAM collaborative take the opportunities provided by parents evening, their subject choice information videos and the careers nights to widen viewpoints about jobs and careers that are available and coming in the future.

Case Study 7

Introduction

5.120 The school is a non-denominational 2-18 comprehensive campus situated in an urban area, within the South West Educational Improvement Collaborative (SWEIC) area. It has over 1,200 pupils on the school roll. Overall STEM uptake in the school compares well with other schools in Scotland. It has a high STEM uptake at National 5 (over 80%) , Higher, (over 50%) and Advanced Higher levels (nearly 30%). Some 20% of the school roll is in the most deprived SIMD quintile. The mean STEM tariff for pupils in SIMD Deciles 1 and 2 increased significantly between 2019 and 2022, rising to well above the national mean. There was also a significant increase in SIMD Deciles 1 and 2 pupils taking STEM subjects and an increase in the proportion of pupils from SIMD Deciles 1 and 2 achieving a pass in a STEM subject at SCQF Level 6 or better between 2019-22. Whilst female uptake of STEM subjects is lower than for all pupils at National 5 level, it is comparable at Higher and Advanced Higher levels. Female uptake of science subjects is higher than for all pupils in the school, and is very high in comparison to other schools nationally.

Support for STEM within school

5.121 STEM learning has a considerable level of support within the school. There is a perception that, in line with many other schools in Scotland, there was a significant focus on literacy, numeracy and well-being in the aftermath of the COVID-19 pandemic, and so resourcing and support for STEM teaching and learning had been overlooked. This led to delivery of STEM teaching, clubs and activities being perceived as siloed and piecemeal.

5.122 The arrival of a new head teacher and depute head teacher provided a new impetus for STEM provision in the school. The school's Senior Leadership Team (SLT) appointed a new STEM lead, and tasked them with developing and implementing a new STEM strategy and action plan for the school.

5.123 The school's SLT is seen as being very supportive of the changes being implemented through the STEM strategy and action plan, affording the STEM lead and STEM subject staff the time and flexibility to implement plans.

5.124 Additional support for STEM comes from STEM leads from across the school cluster, with one STEM lead, based in one of the cluster's primary schools, being identified as particularly supportive. There is also wider support through the local authority, though a restructure within the local authority was highlighted as somewhat impacting on the level of support available. Further, there is a sense, both within the secondary school itself and in cluster primary schools, that the disruption caused by the COVID-19 pandemic has negatively impacted on primary-secondary engagement more than expected.

5.125 The school has also had a range of past and current engagement from universities (though some relationships were understandably interrupted by the COVID-19 pandemic). Overall, the school is happy with the traction they have had with universities though there is an acknowledgement that they do not know how the level of engagement compares with other schools:

"We have no idea what other STEM departments do in terms of wider college and university engagement for their teaching."

Internal structures

5.126 STEM subjects within the school are organised across four departments:

- Computing Science
- Design and Technology
- Mathematics
- Science

5.127 A range of STEM clubs are also provided for learners, focusing on subjects and topics including Coding, Space and Broad General Education (BGE) Science. These are typically led by newly qualified teachers (NQTs) both within the school and across the cluster, where these are delivered in primary schools. However, whilst there has been an ambition to engage cluster primary schools through secondary NQTs, this has not come to fruition.

5.128 Resourcing within the school is considered to be sufficient to support current teaching and learning needs, in contrast to challenges faced by comparable schools elsewhere in Scotland. The available teaching staff resource is considered to be good in terms of number and experience. However, access to necessary equipment is more challenging. The STEM Lead and their team have amassed what they consider sufficient kit, but there is a feeling that they have had to be creative in acquiring this, and building a bank of materials to use in lessons – including taking advantage of the opportunity to source free materials at STEM events and conferences, particularly those delivered by industry. There is agreement that the available ICT equipment in the school – and indeed the local authority – would benefit from further investment though budgetary constraints are acknowledged.

5.129 Part of the challenge is that a considerable proportion of STEM departmental budget is spent on paperwork and photocopying, because of a continued reliance on hard copies of learning material. Part of the Head of STEM's remit is fundraising, and the school is attempting to take more strategic approach to this with regard to teaching equipment and materials, recognising that past approaches have been more piecemeal (and thus have arguably perpetuated what could be perceived as dated modes of learning material provision).

5.130 Timetabling and subject choice for pupils within the school is a free choice model based on the core curriculum supplemented by subject choices from curricular areas rather than a column approach used schools elsewhere in Scotland. However, this is not seen as the most effective approach by STEM teachers. As pupils progress through transition points, they can select all science subjects if they want, but if the numbers are not sufficient for particular subjects, then the SLT take a view on whether to run a course or not. There is also a perception that this approach results in internal competition between STEM subjects to attract learners. Consequently, there is some appetite amongst teachers for a move to column-based choices for pupils.

5.131 There is a perception that the guidance service for pupils has a valuable role to play in advising on subject choices The STEM staff recognise they have a role to play in engaging and upskilling guidance staff within the school in relation to latest STEM-related opportunities and pathways to ensure pupils are well-advised in this regard.

The learner journey

5.132 Learners have a positive experience in the transition from primary into secondary. Aspects of the school's cluster are seen as particularly strong, driving engagement with STEM subjects at an early stage, and thus improving the attractiveness of STEM. From the school's point of view, engagement with its cluster primary schools is varied, and could be supported better e.g. through access to peripatetic STEM teachers that support STEM leads within the primary schools. From the cluster's perspective, engagement from the secondary school could be stronger and more co-ordinated (and this is being addressed through the STEM Action Plan). However, there are some strong success examples of innovative approaches to STEM teaching beginning to drive increased engagement in STEM. Part of this success is a focus on 'the next big thing', and stimulating a degree of excitement about STEM in primary pupils. Also, there is appetite amongst teachers to implement a requirement for pupils to develop a project as part of their transition, so that the new S1 cohort have an opportunity to present showcase their project when they start at secondary school. This may incorporate the re-introduction of a primary STEM showcase/competition that previously ran prior to the COVID-19 pandemic.

5.133 The school operates a 2+1+1 model between S1 and S4. As pupils progress through BGE to the senior phase, there is a degree of free choice enables that allows pupils to pursue all STEM subjects in the move from S2 to S3, and again from S3 to S4. There is effectively and open choice, with no STEM subjects ruled out as such, but the organisation of subject choices into curricular areas effectively prevents pupils from studying *every* STEM subject. The passion and enthusiasm of teachers is recognised as key – there is an acute awareness amongst teaching staff, and indeed the SLT, that a concerted collective and individual effort from the teachers to imbue positivity and enthusiasm throughout their teaching is important. The evidence suggests that this works, with pupils finding STEM lessons (and particularly those in science and technology) interesting and engaging.

5.134 Through the senior phase, subject choices are not limited. To support continued engagement and attainment at this key stage, the approach of teachers includes actively paying more attention to the capabilities and interests of pupils, to better tailor their teaching and support.

Despite the size of the school, this almost bespoke approach is seen as a positive aspect of STEM teaching within the school.

5.135 The recently developed STEM Action Plan for the school aims to improve the approach to learning and teaching and also the wrap-around support in terms of STEM clubs and activities. Initiatives such as Enhanced Curriculum days for S6 Young STEM Leaders, and supported subject study (in sciences) after school hours, help to provide additional opportunities for pupils to augment their learning. There is also a planned programme of activity to develop school-wide STEM capital. Pupils (and especially senior phase pupils and S6 Young STEM Leaders) will have an important role in this.

5.136 There are eight STEM clubs and activities already delivered in the school (with one delivered in conjunction with a neighbouring secondary school). The schools' ambition is to develop and deliver a further five clubs and out-of-class activities, to maximise the extent to which pupils can engage in learning outside their subject lessons and skills electives.

5.137 In addition, the school, led by the STEM Lead, is implementing a formal organisation of STEM activities under a STEM Base. This is a branding, single point of contact and a club in itself, designed to bring coherence to the school's approach to STEM learning, and break down silos between STEM subjects (and also with other non-STEM departments).

5.138 The school has also established a Young STEM Leaders Programme, initially for S6 pupils and with the opportunity to gain an SCQF Level 6 qualification. Young STEM Leaders are actively encouraged and supported to establish their own clubs, organise STEM events, engage with groups such as Scouts outwith the school, and also lead activities in the wider community. There are plans to introduce an S3 Young STEM Leader elective course to allow pupils to gain the Young STEM Leader Level 4 Award.

External factors

5.139 A number of external factors are identified as being particularly influential for STEM learning and the engagement of pupils in the school. Parental STEM capital is recognised as a significant external influencing factor. Many pupils' parents work in STEM or STEM-adjacent industries, and typically have a high degree of education and professional qualification. As such, parents are considered a positive influencing factor – though some parents do not have substantial STEM capital, and are also difficult to engage.

5.140 Local geographies and social structures are also an important factor. The school is situated between a relatively affluent area and a more deprived part of the catchment. This significantly influences peer groups.

5.141 Recognising the importance of external influencers, the school has ambition to re-build local connections with industry. There is a significant presence of STEM sector businesses in the local area, including a specialised cluster within 10 miles of the school. The STEM Lead is also developing a STEM Careers Fair, with the intention of securing input from local companies and parents working in STEM industries. The STEM Lead is keen to ensure a good cross-section of parents attend.

5.142 There are also ambitions to implement a *Café Scientifique*-style series of events. Café Scientifique[28] is a programme of events where ideas and issues in Science and Technology are discussed in a social setting (e.g. over coffee), inspired by the Café Philosophique in France, a grassroots forum for philosophical discussion.

Equity/equality

5.143 As noted above, around 20% of the school roll is in the most deprived SIMD quintile (1), though the school's catchment area covers some of the more affluent parts of the area that it serves.

5.144 Improvements have been made in engagement and attainment amongst pupils from the most deprived SIMD deciles, but further work to close the equity gap is a focus of the STEM Action Plan. Equity is built into future plans for STEM learning, focusing on the geographical and deprivation aspects of equity (over and above the school-wide commitment to equity and equality in teaching). This is particularly the case where opportunities to develop STEM capital and broaden STEM understanding of influencer groups exist (e.g. through the development of STEM careers fairs or the Café Scientifique concept, as discussed above).

Overall success factors

5.145 A number of key factors are identified as being important to the success of the school's approach to STEM learning to date, and achievement of future ambitions regarding STEM learning.

5.146 SLT support and the position of STEM within the School Improvement Plan is considered critical. The STEM Lead and STEM staff consider that without this, there would not be the scope to overhaul the school's STEM teaching, and consequently the siloed approach would continue, negatively impacting on engagement and teaching effectiveness.

5.147 Implementing an overarching structure for STEM within school, thereby avoiding a piecemeal approach, is also cited as a success factor in raising STEM engagement and attainment in the school. Seeing STEM as a critical and coherent whole within the school curriculum is deemed vital. Awareness, branding and the profile of STEM within the school is part and parcel of this.

5.148 Overcoming the silo nature of STEM teaching, something that has become more entrenched since the COVID-19 pandemic, and working to develop cross-over linkages and inter-disciplinary learning (IDL) is a key feature of this more joined up approach. The school is exploring an idea for a three-way approach to teaching engineering in science, taught jointly between Physics, Technology and Computer Science staff.

5.149 Enthusiasm of staff is another vital success factor. In particular, the importance of integrating the enthusiasm of NQTs with the knowledge and experience of well-established staff was highlighted, along with ensuring the involvement of all teachers in clubs and activities, not just NQTs (which typically tends to be the case). This provides an excellent opportunity to stimulate knowledge exchange between staff members – NQTs are thus able to benefit from the experience of more established senior teachers, who return can learn new ideas and approaches from the NQTs.

5.150 Equally important to success of the school is the strength of the cluster, and work delivered to engage primary pupils in STEM. One Lead Science Teacher within a cluster primary school has

[28] http://cafescientifique.org/

also acted as a local authority STEM lead, and previously a Primary Science Development Officer (PSDO) as part of the RAiSE Programme. They have been recognised for their STEM teaching within primary school settings through UK-wide industry awards.

Case Study 8

Introduction

5.151 The school is a non-denominational secondary school in an accessible small town in Central Scotland within the Tayside Regional Improvement Collaborative (TRIC) area, with a pupil roll of over 900 pupils. The school has high uptake across all STEM subjects for their S5 and S6 cohorts with an uptake percentage of over 60% and over 35% respectively. The uptake of female pupils in S5 was also particularly high within sciences, with an uptake percentage of over 70%. The school also has also had significant uptake across STEM-related Skills for Work subjects with an uptake percentage of over 10%.

Support for STEM within school

5.152 STEM teaching is delivered in line with the school-wide priority for active learning. All faculties stress the importance of this mode of delivery in capturing pupil engagement and enhancing the learning experience. STEM has a high profile within the school, and this is supported by an active social media presence for outside visibility of the school's STEM activities. However, the view from SLT is that no one subject or curriculum area is more important than others.

5.153 A whole-school approach for science is being taken, and also for technology. There has been a deliberate move away from what is perceived as a more traditional 'three science subjects' approach, to one that is more integrated and inter-disciplinary. The school has also broadened out pathways for learners beyond traditional academic routes and subjects. This is augmented by more out-of-class activities, trips, etc. and making more explicit career linkages with local industry.

5.154 There is support from the Senior Leadership Team (SLT) for STEM that gives each of the STEM faculties a good degree of freedom in what they do. The SLT support is enabling, but it is very much a hands-off approach. However, this kind of approach is valued by the faculty heads and the cohort of STEM staff – they feel valued, and trusted to get on with delivering STEM education in the school as they see fit. This allows staff to try out new things, test, modify, etc. – and facilitates a culture of continuous improvement.

"We are not told 'don't do that'. SLT is generally supportive in a hands-off way. If it wasn't working, they would step in!"

5.155 Teachers are also given the flexibility to teach their own way, rather than from a prescribed curriculum or lesson plan structure, and with a high level of support to apply new innovations in their teaching. NQTs are actively encouraged to do this – but also to test new or innovative practical tasks first, with other faculty staff.

"Teachers are told: 'teach what is in front of you, not what is in the book'. It is about teaching pupils for success."

"One of our biology teachers found an exciting way to make a bacteria Christmas tree in a petri dish. We actively encourage this sort of stuff."

5.156 In terms of teacher development, any and all opportunities are taken for delivery of career-long professional learning (CLPL), and the school applies for grants wherever possible. The Science and Technology faculties also maximise the opportunity for knowledge transfer and exchange both ways between senior staff and more junior faculty members, and not just in terms of imparting knowledge to NQTs. The view amongst senior staff is that the combined experience in the faculty allows them to better unleash their collective imagination to inform their teaching. Also, there is a perspective amongst teachers that current teacher training does not provide a particularly good background for STEM – and specifically there is too much emphasis on the abstract. Thus the school supports a lot of NQTs to develop through internal forms of training.

5.157 There is also a range of activity and support in making cross-subject connections and delivering inter-disciplinary learning (IDL) wherever possible. One example provided was in linking STEM to other subjects like arts and crafts, to model an exoplanetary solar system – research to find out information, using arts and crafts props and materials to develop individual models, and then technology approaches to produce an orrery. Since the project drew on IT skills, numeracy, art and craft skills, engineering and so on, it helped train pupils in using all relevant skills as would typically be the case in a scientific discipline. The result was a project that pupils highly enjoyed and were incredibly enthusiastic about.

5.158 All of this underpins the school's efforts to make real-world links in STEM learning, and demonstrating why STEM is relevant to everyday life, and why it matters to pupils. This is especially the case at Broad General Education (BGE) level.

Internal structures

5.159 The school's STEM subjects are organised across three faculties:

- Maths and Numeracy
- Science
- Technologies

5.160 A range of STEM clubs are also delivered, for Biology, Chemistry, Physics, and Mathematics. Other clubs and activities also delivered include: Science Club; Application of Maths Club; and a Craft, Design and Technology (CDT) Club.

5.161 The perspective from the Heads of Science and Technology is that they are very lucky with their staff complement. Staff – both NQTs and experienced – are enthusiastic, willing and have an appetite to try and teach differently. The school's guidance staff has some STEM capital in the team, and improvements have been made recently in developing the current STEM understanding amongst guidance staff.

5.162 In terms of equipment, faculty heads and staff recognise that they are in a relatively fortunate position. The school receives a higher weighting of funding to support teaching, yet budgetary constraints can still impact negatively on supplies of equipment for lessons and practical activities.

"[Purchasing is] not around specialist equipment, but using our imagination. If I don't have specialist kit, I need to think about what I do have, and what I could get that enables me to do experiments or practical sessions. It's finding different ways to engage on specific ideas."

5.163 Timetabling of subjects is according to core subjects of Maths, English and a Modern Foreign Language, plus one subject from each of four curricular areas: Expressive Arts, Science, Social Subjects and Technology in S2/3; Maths and English plus five free choices in S4; and then pupil choices in S5/6. The perspective from staff is that timetabling in the school could be more effective, but staff are aware of constraints. They are creative in working within the timetable constraints to support pupil choice.

5.164 It is perhaps also worth noting that the school does provide more contact time for STEM in general, which affords more learning opportunities. It is understood that pupils get at least one hour more per pupil per week for science than other schools at the BGE phase.

5.165 Classes of less than 10 are considered in terms of their viability and available resourcing. This means that they may not run (though there is more scope for smaller classes to be delivered in S5/6, but possibly with reduced teacher contact). However, pupils are helped to make that choice themselves in the first instance – with a focus on helping them to determine their future education and career pathway. SLT only take the choice to remove subjects if there is timetable congestion or where delivery of lessons is not viable.

The learner journey

5.166 The school has a comparatively high degree of active cluster engagement. A lot of outreach is undertaken with the school's cluster primary schools (e.g. equipment loaning, Young STEM Leaders leading primary sessions, P7 pupils visiting the secondary for STEM lessons), as well as with early years settings, community groups, etc. Importantly, staff deliver a substantial proportion of this outreach activity. The faculties recognise the need to maximise this interaction – to actively inspire and engage pupils at a younger age and build an image of STEM at secondary school as exciting, and to better influence the influencer groups – and to ensure that this engagement is as frequent as possible.

5.167 An important element of this is staff commitment. Teaching staff are persuaded to fully commit to this approach, and lead on the school's STEM outreach and out-of-class activity. Part of this approach is delivering training to primary school teachers, led by the secondary school's STEM teachers, through sessions using specific equipment tailored to the primary curriculum, e.g. using microscopes or focusing on the human body. This is done as part of the teachers' own non-class contact time (NCCT) as part of their development. Though this is done on an ad-hoc basis, there are currently ambitions to do more in response to demand from the cluster primary schools, and potentially 'loan' teachers to each primary school to teach P5-7 classes, and transfer expertise and knowledge to primary school teachers.

5.168 During BGE and in the shift from S2 into S3, there is an emphasis in the school on pupils taking science and technology subjects. There is a requirement for pupils to take at least one science, with many technologies subjects offered (and taken up) as electives in S2 and S3. However, in practice, many pupils take three science subjects in S3, and many continue at least one in S4.

5.169 The faculties have created a wide variety of pathways through to SCQF Level 7 qualifications. The SLT view is that whilst the number of qualifications may be comparatively large versus those on offer in other schools, it is the right thing to do – it helps to remove barriers for those pupils not 'conventionally academic', and sets a clear idea of where STEM can take pupils.

5.170 There is considerable proactivity to make sure that opportunities for STEM learning are open, accessible and visible to all pupils, so that there is:

"Something for everyone to access."

5.171 These pathways and opportunities are supported by a series of clubs (as discussed above), as well as regular science and technology competitions. The school also seeks to maximise opportunities for trips – to industry, science centres, etc. to supplement what is delivered in the classroom. There is a concerted effort by teaching staff to "make sure all things run." Staff within STEM faculties appreciate that some things they deliver is "messy and time consuming", but is worthwhile in terms of enhancing the learning experience and pupil engagement. Staff are therefore more than willing to take risks and put effort into developing effective lesson plans, and the consequence is that pupils more readily buy into this and engage more.

5.172 Also, in teaching there is a focus on practical work as much as possible (as discussed above with regard to the active learning priority for the school), but purpose-driven rather than using practical activity for its own sake. The intention is to make sure that the learning experience for pupils is as enjoyable and engaging as possible. This approach is taken across all year groups, but with a particular emphasis in BGE to 'hook' pupils – with staff employing a high degree of creative thinking to achieve this. For example:

- Using fizzed-up lemonade to deliver an experimental demonstration of half-life in physics.
- Use of playdoh in biology to understand enzyme action, immune system functions – combined with stop motion animation done by pupils.
- Taking practical demonstrations out of the classroom and into open/shared spaces, e.g. to demonstrate the scale of the solar system.

5.173 This allows lessons and activities to become more hands-on and physical in an otherwise dry and abstract topic. Across STEM faculties, staff are encouraged and supported to us practical activities at every opportunity. Staff also feel that this is done more since the COVID-19 pandemic – the forced innovation and the experience of the pandemic prompted teachers (and faculties) to redesign how lessons are taught, and this opportunity has been taken.

"It is all really about trying to build the enthusiasm [of pupils] through practical activities, building an ethos of 'science is exciting, science is relevant' across the school."

"A lot of what you can do with science is quite hidden, so we are making it as visible as possible."

5.174 The school, through faculty staff across all STEM disciplines, is building an ethos where pupils want to be involved, because learning in each school day is *'being made different'*.

5.175 Additionally, there is an explicit attempt by teachers to influence pupil perception. This is not confined to promoting STEM learning or its importance, but also extends to actively demonstrating its applicability to all subjects, and all aspects of life.

"We are really starting to work on [pupil perception] properly – making linkages at a higher level between subjects, not just doing inter-disciplinary learning but doing the conceptual heavy lifting too."

5.176 Further to this, the school has started developing a STEM 'wall of fame' for leavers – an in-school showcase of former pupils learning and working in STEM, so that current pupils can see what they can achieve as well. Personal relationships can help to bring career and education choices alive. Staff reflect that where pupils know past achievers, this makes it more meaningful, and contributes to driving the anticipation for their future STEM activity.

5.177 Evidence within the school is that this approach is working. Pupils are embracing active learning, and the school's approach to STEM learning more generally. Greater levels of engagement are evident, and there is increased appetite for learning too. One example of this is that in one lesson, S4 pupils were left with a practical Chemistry experiment to complete without direct supervision. Whereas previously this may have resulted in a situation where at least some pupils may have indulged in some time wasting and distraction, they had instead diligently undertaken their work, and progressed the experiment as instructed.

External factors

5.178 Parental influence is identified as a significant influencing factor, and teachers point to a dichotomy of experiences in this regard. The school gets strong support from parents who see STEM as worthwhile, with many parents working in professional occupations, such as in engineering or healthcare, with a number working outside of the local area in professional roles. However, from other parents there is a negative impact arising from their own views of STEM and whether they found STEM subjects difficult. The school is combatting this through positive engagement with parents and carers, stressing the differences in the learning experience of their children, and advocating the value of STEM choices.

5.179 The school is also actively trying to involve parents and carers to a greater degree beyond the typical input on homework, in line with the School Improvement Plan target to ensure parents experience greater opportunities to participate in their children's learning and in school activities.

5.180 The school recognises the importance of links with industry, and maintains active links with industry bodies and local employers, government agencies, learned societies and national education membership bodies. This is done for the way in which such connections can help build STEM capital, but also for the way in which they can open up opportunities for out-of-class activities, learning experiences in and outside of the classroom, and in the longer-term, career pathways for pupils. Such links also help to demonstrate the real-world application of pupils' own STEM learning.

Equity/equality

5.181 Work on equity and equality in the school focuses on gender disparity and geographical disadvantage. The STEM staff complement is broadly evenly split between males and females. It was also noted that the pupil cohort moving into the senior phase is relatively equally balanced. This even split amongst the staff and the S3 cohort is perceived to be helping the school to challenge conventions around who STEM is for, and thus breaking down any gender norms that persist. The school actively identifies positive role models too, to support equalities work.

5.182 There is a recognition that a substantial proportion of the pupil cohort is from areas of the school's catchment from less deprived SIMD deciles, but that there is challenge in engaging pupils from more deprived SIMD deciles. At the moment, it is considered that a critical mass of pupils with STEM capital in their family is effectively helping to 'pull' pupil numbers through STEM qualifications. However, there is a strong consensus amongst staff that their showcasing, awareness-raising work, and approach to practical, engaging teaching is helping to raise pupil ambitions regarding STEM across the school.

Overall success factors

5.183 The staff approach of openness, continuous innovation and focus on active learning is a strong positive influencing factor. The is an evident culture of holding each other to account, cross-checking work and undertaking 'critical friend' assessment of colleagues' learning and teaching. Identifying, sharing and discussing best practices in teaching is a rolling item on faculty meetings. Faculties also help more junior members of staff build up a strong core of subject, technical and pedagogical knowledge to drive confidence.

5.184 The enthusiasm of staff is also a critical factor. The view from the school is that everything starts from here – enthusiasm is infectious, and it helps to build engagement, interest, knowledge, etc. amongst pupils.

5.185 Also, the willingness of staff to use their STEM expertise and capital, and contribute to STEM life outside of the school is another factor in the success of STEM learning at the school. The readiness with which staff see their job as extending beyond the classroom underpins the school's holistic STEM-wide approach for pupils, parents, the community, etc. The perspective from staff in the school is that a fuller engagement (that is, beyond the basic confines of the classroom) makes it more interesting and rewarding for staff; it also helps to 'keep them fresh' in terms of subject matter knowledge and their style of approach.

5.186 The approach to teaching and maximising the scope for practical activity and contemporary content means that the 'everyday experience' in class is enhanced to provide maximum possible real-world experience. This is in important factor in driving and retaining engagement.

5.187 Another success factor for the school is the absolute focus on engagement of pupils throughout the learner journey, and the positive relationship that staff have with pupils in the school.

Case Study 9

Introduction

5.188 The school is a non-denominational secondary school that is part of a 2-18 comprehensive campus situated on the outskirts of an accessible small town in the South West Educational Improvement Collaborative (SWEIC) area. The current school roll at the secondary level stands at over 1,000 pupils The school has a high uptake of female pupils within Mathematics and Technology with uptake in Maths at the S5 level (over 40%) and Technology at the S4 level (over 35%). A significant number of pupils (over 40%) within the school roll were in SIMD Quintile 1 in 2022. Additionally the school had a Mean STEM Tariff well above the national average.

Support for STEM within school

5.189 STEM occupies a reasonably prominent position in the school, and is increasing in importance in terms of the school's curriculum and overall approach to learning. There is significant Senior Leadership Team (SLT) support for STEM. A number of changes have been implemented with regard to class structure, pathways, etc. (as described below). Though these changes were initially pushed by faculty heads, challenges around timetabling, and staff resourcing to support changes have meant that the changes have been championed by SLT. The positive impact of the changes means more senior staff have been championing a new approach to STEM.

5.190 The school improvement plan has driven a recent adoption of more creative approaches to planning of lessons and learning, and a practitioner enquiry to changing department- and faculty-wide teaching strategies. Staff report that this has seen a move away from more rigid, conventional approaches to curriculum delivery, to a more flexible way of teaching and learning where the school is more open to new initiatives, and more supportive of diverse teaching styles.

"The school is quite open to new initiatives – new approaches, new clubs; they are on board with quite a lot of new things."

5.191 The school has a good relationship with all primary schools in its cluster, and not just the primary school that is co-located on the same campus. It also has a strong relationship with the nearby further education college, and regional DYW team. These relationships have helped the school to diversify pathways for STEM subjects within the school, and a number of the school's pupils take courses delivered by the college. The school is also beginning to develop relationships with other outside education institutions including universities.

5.192 STEM Ambassadors are also used by the school wherever possible. The importance of these is recognised by SLT and teachers, especially for helping to inspire BGE pupils. Whilst the use of STEM Ambassadors generally works well within the school, some teachers have highlighted the challenge of giving up teaching time to allow for this.

Internal structures

5.193 STEM related subjects are organised according to:

- Mathematics department;
- Art, Design and Technology Faculty; and
- Science Faculty.

5.194 School lessons are scheduled according to 50-minute time periods. This timetabling is seen as rigid, which presents some challenges (though in part this may be as a result of the new learning pathways introduced, discussed below). For some teachers, the 50-minute time period can present challenges to effective teaching of some STEM topics and concepts. Further, there is a perception that it prevents effective delivery of inter-disciplinary learning (IDL) – though one perspective offered indicated that within STEM subjects (e.g. IDL between mathematics and science) this was not so much of a problem; rather, collaboration with non-STEM departments was more problematic. It was suggested that double periods might solve this – but only in the senior phase, since there are currently no double period lessons for BGE pupils.

5.195 NQTs feel that timetabling is an issue that needs to be discussed at the local authority level, particularly around grouping of subjects. This would allow a case to be made to allow school- or cluster-level timetabling decisions around STEM learning, and to effectively consider whether 50-minute periods is long enough to teach STEM topics or concepts, or if more flexibility is required around the use of double periods.

5.196 There are a number of learning and qualification pathways and disaggregation of classes through Broad General Education (BGE) and the school's Senior Phase. The school offer National 3 qualifications to create a possible career pathway for pupils not yet achieving Curriculum for Excellence (CfE) level 2. In addition, National 4 qualifications have been introduced as a stepping stone to National 5 qualifications, with the intention to capture those pupils that are struggling (or potentially could struggle) with National 5 level learning and coursework initially. This is helping to overcome disengagement from and accessibility of STEM learning.

5.197 A number of STEM clubs and activities are delivered (e.g. STEM Club, Skills Surge, Chess Club, Industrial Cadet Award), with the school making extensive use of GLOW and Google Classrooms to signpost STEM activities and clubs effectively. Many challenge-focused STEM clubs/activities are also run by NQTs. The school also runs a Young STEM Leaders programme. However, there is an appetite for more STEM activities to support the senior phase. Teaching is more constrained because of exam requirements, so the school would like to wrap around lessons with out-of-class activities to maximise the learning opportunities and potential. However, it was noted that there are some constraints due to the number of different learning pathways introduced, and the available space in the school timetable.

"When you are teaching to pupils in the senior phase, you're not always getting to teach what you want to – you're usually focused on exams, there is limited flexibility in the classroom, so we would like to deliver more extra-curricular activity."

5.198 The staff resourcing at the school includes subject specialists across the sciences. Departments also have access to teaching assistant support, particularly where pupils need additional support to progress through CfE Level 2 and into Level 3 during the BGE Phase.

5.199 The school has seen an increase in staffing recently. The intake of teachers has changed the age dynamic of teaching staff, especially in Physics. It is now a comparatively young department, which also has two female Physics teachers, considered unusual given the typical gender split of teaching staff for Physics in schools across Scotland.

The learner journey

5.200 Through its co-located primary school and other cluster primary schools, the secondary school delivers a range of activities aimed at encouraging STEM engagement amongst primary school pupils leading up to them starting in S1. There are a number of dual qualified teachers in cluster primary schools – i.e. teachers able to teach specific STEM subjects at secondary level. Through these teachers, and secondary teachers that regularly visit primary schools, the school is working with cluster primaries to build investigative skills, increase appetite for STEM amongst new intakes of S1 pupils, and tackle negative STEM stereotypes amongst primary school pupils early on in their learning journey. The school also conducts dual delivery with primary school teachers for P7 classes on transition days. There is appetite to do more for P5 and P6 so that pupils can be engaged with secondary STEM curriculum topics earlier – and thus get earlier interest. The school has already created booklets targeting first and second CfE level to help engage primary school pupils, and provide guidance on experiments that can be done with minimum equipment for primary teachers. It also regularly loans equipment to its cluster primary schools.

5.201 Throughout the school's STEM learning, and with a degree of emphasis placed on the BGE phase in particular, there has been a revamp of the teaching approach in S1 and S2 in recent years. The purpose is creating an environment that encourages pupils to be creative and curious, and aims to stimulate excitement in STEM learning. There has been a big push on contextualising learning more through provision of more real-world experiences, to help with understanding and comprehension. One challenge is to ensure that where successful and engaging lessons and approaches are used in senior phase, this effectively cascades down to BGE classes.

5.202 The addition of a separate National 4 stream alongside National 5 STEM delivery has resulted in greater pupil engagement and the school reports seeing regularly full classes. Further, the pupils are making the transition from National 4 to National 5 more confident, so they are being retained – whereas previously, pupils were effectively being lost. This is cited as a very positive impact of the new pathway.

5.203 Part of the change to STEM learning in the school has involved the adoption of the practitioner enquiry methodology, to help implement a greater amount of pupil-based or pupil-led learning. This is used as a form of informal assessment in the first instance, e.g. at the end of a week, term or block of lessons. However, as the school is still in the process of understanding the application of pupil-led learning, the use of this approach is not always as effective as intended:

We are trying to promote pupil-based learning, and have been investigating ways to facilitate that – we present, take a step back and then let the pupils teach themselves. It is really interesting and successful when it works, and chaotic when it doesn't. It is more a form of assessment…[just to] see if they can prove that they have learned."

5.204 In addition, there is appetite amongst teaching staff to tailor lessons more to the local area and economy. There is a challenge in doing this in line with curriculum on top of changes already made, and the time resource available to do so. Teachers recognise the risk of doing this and then underpreparing BGE pupils for senior phase.

5.205 There is a significant focus on practical activities, using conventional equipment (Bunsen burners, circuits, etc.) as well as other more novel or innovative equipment. Teachers see that the increased practical work content in the curriculum has led to improved behaviour – lessons are more engaging for pupils, and teachers are able to be more encouraging and even nurturing in their teaching. This aspect of the school's approach to STEM learning is supported by an active social media presence for separate faculties (e.g. science, technology), which extensively promotes practical activities, projects and out-of-class events – as well celebrating individual pupils to showcase their achievements and skills in STEM.

5.206 One aspect of this change has been the gamification of coursework in S1 and S2. Use of methods such as an escape room' style challenge has helped to make STEM principles more understandable and relatable for pupils. It has also seen success in engaging non-typical STEM learners.

"[The gamification of coursework] is doing well…it has been quite successful this year. The effects have been quite immediate – there's been immediate reward, the pupils are seeing the benefits of it straight away, and it keeps them engaged."

5.207 There is also appetite to include more outdoor learning, especially for technology lessons. This would help to cement theoretical knowledge acquired by pupils through practical experience. However, time is seen as a constraint to achieving this.

5.208 The school is currently working on transition points in the learner journey, and the transition from BGE to senior phase in particular. Part of the driver is to maintain engagement, but there is also recognition that there is not as much opportunity for out-of-class activity for pupils. As a result, STEM faculties and departments are working to smooth that transition, and build more tangible, interesting, engaging connections with real-world STEM issues. Prior to the COVID-19 pandemic, the school made good use of STEM Ambassadors from local businesses and industry, and it is exploring ways to scale this back up.

5.209 The STEM-focused clubs and activities that the school delivers sometimes struggle to secure take-up. Teachers highlighted the degree of competition from non-STEM subjects, with out-of-class offers from PE, music, drama, etc. However, it was noted that there was good traction with pupils on challenge-focused STEM activities– especially where certificates or demonstrable career development is offered.

5.210 STEM teachers highlighted some evidence that the changes implemented to enhance the learner experience, as discussed above, are helping to tackle pupil preconceptions around STEM subjects. There is also a suggestion from staff that peer influencing is also being addressed through a teaching approach that involves a greater proportion of practical activity, and enhanced lesson and curriculum content:

"Peer influences are still a factor, but there are more and more pupils that are breaking the norm [in terms of their learning] now."

5.211 One reason provided for this is the degree to which teachers plan, and are able to plan, lessons and blocks of lessons.

"We spend a lot more time building lessons and lesson plans to demonstrate [to the pupils] what is involved, and to overcome any barriers such as preconceptions."

5.212 The school sees that positive pupil relationships with teachers is important to pupil engagement. It was noted that all staff are able to deliver BGE and Senior Phase teaching – so staff are potentially able to maintain positive relationships through the entirety a pupil's learner journey in the school.

External factors

5.213 The local economy for the school is a major influencing factor for the school's STEM learning. STEM teaching staff highlight a considerable proportion of STEM jobs and careers in the local economy – including in engineering, advanced manufacturing and life science industries, as well as defence. Consequently, there is considerable activity through DYW and My World of Work (MWOW) to embed careers-related material into lessons. SLT are also actively engaged with DYW to identify recruitment opportunities with local businesses. Consequently, there is a relatively high proportion of pupils actively considering career pathways in engineering, advanced manufacturing and life sciences because of the make-up and profile local industry has within school.

5.214 In addition, since there is a relatively rural catchment for the school outside of the small town, there is a proportion of the pupil cohort interested in agricultural jobs or in veterinary roles. As STEM is very applicable in these sectors, teachers are able to make a variety of STEM links here.

5.215 Parents often have jobs locally in STEM industries, so they can be big influencing factor in terms of career choice, and thus subject choice in school for pupils. To try and get joint engagement with both pupils and parents, the school has delivered a number of public lectures on STEM to parents and pupils together.

5.216 However, teachers note that there is still a lack of awareness in terms of career options amongst pupils, and also STEM requirements in particular career choices. Also, there is some anecdotal evidence of pupils not understanding the full extent of their potential with regard to STEM careers, and what their education could provide them:

"There is still a trend of pupils selling themselves short in terms of their ambitions. It is hard to get some kids to give things a go, especially if they can't see where they can go with STEM."

5.217 The school is using its relationships with higher education institutions to deliver field trips and project or coursework components, and broaden their exposure to STEM. This includes for novel fields such as quantum technology, where pupils are not likely to have any knowledge or understanding – effectively using the 'shock of the new' to drive excitement, and raise awareness of different career pathway possibilities.

Equity/equality

5.218 STEM-related equality and equity actions within the school have a focus on gender issues, and raising the profile of females in STEM. Whilst gender issues were not specifically raised as a challenge within the school, there is nevertheless a range of activities delivered to promote women in STEM, and also to expose female pupils within the school to a wider variety of STEM education and career opportunities than they otherwise may be aware of. An example of this is the school's S3 participation in a Girls into Physics event delivered by the University of Glasgow.

Overall success factors

5.219 One of the main success factors in the school's STEM learning delivery and increased engagement of pupils is the greater focus on practical, hands-on activity, and particularly so in the BGE phase. This has demonstrably increased pupil engagement. This has been augmented by the school's promotion of activities and achievement through its social media accounts.

5.220 The use of NQTs to develop and deliver out-of-class activities is also identified by the school as a factor in raising STEM engagement. As there are limits on the number of classes NQTs can take, NQTs often help to develop class material, and run a number of STEM clubs and activities. The school's future ambition is to have one or two NQTs to dedicate time to developing range of (innovative) STEM materials for STEM faculties and departments.

5.221 Additional engagement success has been driven by the disaggregation of abilities and introduction of new pathways. By recognising the different needs (and indeed differing rates of learning development) of pupils, this has driven uptake of STEM subjects, increased engagement and thus raised confidence in the school's pupils.

5.222 Finally, the school's links with local industry, and the proactive engagement of business through DYW – and at a senior level within the school (i.e. SLT and heads of faculties/departments) is serving to bring STEM industries into the classroom, and raising the profile of STEM career pathways for pupils.

6 Factors in successful STEM learner engagement

Introduction

6.1 This chapter summarises the key factors in enhancing the learners' engagement in STEM subjects, and provides suggestions, actionable recommendations and potential considerations around maximising engagement.

6.2 These success factors have been derived from the analysis found in Chapter 4, on key factors in successful STEM learner engagement, and Chapter 5, on the case studies, supplemented by the desk-based review and findings from consultations with other schools' STEM leads, and engagement in Education Scotland's Raising Attainment in Sciences event in February 2024.

Overall success factors

6.3 Across each of the themes that were explored with schools, it appears that there are several significant factors that lend themselves to an effective STEM learning journey, and that are common across schools in Scotland. A short synopsis of these common factors, as explored in greater detail in the preceding chapters, can be found in Table 6.1. While other topics have been included in the overview found in Chapter 4, these twelve topics represent the greatest degree of commonality across schools engaged in the research.

Table 6.1: Common Success Factors

Theme	Topic	Overview
Support for STEM	Highly supportive management teams	Where there is a broad level of support for STEM learning within a school's Senior Leadership Team, generally attainment and performance is better in these subjects. This support can range from approving class visits, to ensuring staff have regular opportunities for training, to being open to any opportunities pupils and teachers put forward.
	Refreshing the Curriculum	Where reconsideration of the subjects and topics on offer within a school has taken place, there have been notable improvements to engagement and attainment in STEM. These "refreshes" have included consolidation of the Arts and Humanities under a "STEAM" collaborative, offering more practical and vocational subject choices, and the introduction of themed days and weeks where as many subjects as possible focus on one core topic.
	Wider partnerships	Existing relationships have been utilised well across schools and college partners to maximise opportunities available to pupils. These partnerships have resulted in courses being provided to pupils that are unable to take them in their own school, greater focus on the primary-secondary transition period, and new pathways being provided by colleges to secondary school partners.
Internal structures	Staff resourcing	Ensuring that there is sufficient staff resourcing from the perspective of staffing numbers and capacity/capability of teaching staff is critical for enabling effective lesson planning and continuity in the delivery of lessons. It was also found that having dedicated resource (in the form of classroom assistants and technicians) can also alleviate pressures around setting up and delivering experiments,

		thereby allowing time for teachers to plan lessons, grade work, or offer specialist one-to-one support during the experiments.
	Timetabling	Generally, by ensuring that the amount of STEM subjects choices offered to pupils is widened as much as possible (while still considering viability), and when additional information is provided to parents, pupils and careers advice services about subject content prior to choices being made, the timetabling approach for schools lends itself well to STEM engagement.
	Out-of-class activities	Out of class offerings that have a real-world application of learning (or externally recognised certification) can help influence STEM engagement. It has been found across the study that both challenge-focused activities and pupil-led initiatives (where pupils are at least partially responsible for the club) are the most well-received activities and lead to the highest levels of engagement.
The learner journey	Primary to BGE	Almost all BGE pupils engaged in the research stated that they enjoyed the practical elements of STEM subjects the most, and that it represented something entirely different from what they had learned in primary school, in particular the more hands-on practical aspects of certain subjects.
	BGE to Senior Phase	Pupils continued to enjoy the practical elements of certain STEM subjects, but also noted that teachers placed a greater degree of trust with apparatus and therefore there were greater opportunities for experiments. Retention of learners within the STEM pipeline at this stage can also be attributed to the introduction of more flexible pathways, particularly those with a vocational or applied focus.
	Views on further study and careers	The vast majority of pupils engaged in the research signalled that they were at least considering a career in STEM, indicating that their respective schools have fostered a positive outlook on STEM jobs. This is further amplified where there are inspirational events that highlight that STEM roles are available to all, dispelling preconceptions and stereotypes about careers in STEM.
External Factors	Local economy	Local business bases (including those of national significance) and representatives of the local economy are often supportive of STEM learning, in that both pupils and teachers are able to relate STEM learning to real-world roles and activities, with region-specific reputations in certain industries acting as a particular push on uptake.
Equity/Equality	Gender	Efforts to dispel gender stereotypes were viewed both in terms of ensuring there is a fairly balanced gender makeup of the teaching workforce in each subject, and also ensuring that subjects (and subsequently, potential career choices) were not engendered. This can be done through conversations highlighting the successes of girls in previously-considered "boys subjects," careers evenings with specific focuses on female success stories in STEM, and utilising external partnerships (such as university-sponsored programmes like Girls Into Physics) to alleviate gender bias.
	Deprivation	Creative use of Pupil Equity Fund (PEF) resourcing and creation of new pathways were the most common methods of retaining learners on the STEM journey, where

		the pupils came from deprived areas. PEF had been applied in many different ways, ranging from provision of resources and reducing the cost of travel for school trips, to outreach programmes for those that had not engaged with learning as effectively as expected. New pathways (with greater focuses on practical learning) had also been developed in some schools, which had resulted in greater uptake in STEM subjects in cohorts from more deprived areas.

Implementation

6.4 Based on the findings of this research, we have identified a number of recommendations and considerations for schools and Education Scotland, to inform any future action and intervention designed to maximise engagement in STEM throughout the pupil's learning journey.

6.5 These have been informed by the good practice adopted by the schools engaged in this research, reflecting the diversity of approaches taken by Scottish schools in response to the particular characteristics and circumstances of each school. Whilst every school is faced with its own unique challenges and has different opportunities available to them, the research has uncovered key insights that can be considered separately from one another or alongside other recommendations, wherever appropriate.

Strategic recommendations

Recommendation 1: The support of Senior Leadership Teams is critical to increasing STEM engagement. Where possible, STEM faculties or departments should have equal opportunity to feature on the agenda for Senior Leadership Team meetings, and broader support for the development of learning content and out-of-class activities should be considered by Senior Leadership Teams where possible.

Recommendation 2: The development of STEM ambassadorial roles in school has allowed for pupils in more senior phases to impart knowledge, enthusiasm and support to pupils that are in BGE phase, often acting as a source of inspiration and providing a greater degree of peer-to-peer support. This has been recognised by pupils in BGE phase as being particularly effective. Greater promotion of peer influencer roles, particularly framed from the perspective of personal development, would ensure greater take-up of these roles. These ambassadors would then be involved in activities that increase STEM engagement with younger pupils in transition from primary school, and also those in the BGE phase.

Recommendation 3: Wherever possible, schools should augment their STEM education activity through relationships with external organisations, to increase and enhance learning opportunities. Likewise, secondary schools should recognise the similar role that they can play with their cluster primary schools. By utilising effective partnerships in both primary and post-secondary education providers, expanding the STEM capability of primary schools, for example through the loaning of equipment or joint teaching activities, is an effective means of stimulating early STEM education engagement that can be continued through into the BGE phase and beyond in secondary school.

Recommendation 4: As pupils transition from primary school to secondary school, the practical elements, and being introduced to new concepts and ways of learning, appear to be the most appealing aspects of STEM learning. Schools should amplify the opportunities for practical work in STEM subjects from an early age, and continue to use primary school transition days as key opportunities to demonstrate the value of practical lessons.

Recommendation 5: Wherever possible, schools should take a tailored or bespoke approach to developing and delivering their STEM curriculum. As pupils progress from BGE to senior phase, interest in, and their appetite for practical and project-based learning can be retained. Bespoke approaches to curriculum delivery, combined with more flexible qualification pathways with a particular focus on practical and vocational subjects (often made possible through partnership models with colleges or other schools), can also keep pupils engaged in STEM learning. A review of options being offered at BGE level to Senior phase, S4 to S5 and S5 to S6, to maximise the potential for STEM subject choice, would support the delivery of a more tailored approach by schools.

Recommendation 6: Successful teaching and learning in STEM can be augmented by a well-considered careers strategy. Schools should take opportunities to showcase a wide variety of STEM career possibilities, whether within lessons, in careers-related events or more generally, to provide inspiration to learners.

Recommendation 7: There is a continued need for STEM practitioner CLPL, to boost capability and confidence amongst practitioners in delivering both in-class teaching and out-of-class activities and IDL. This should include protected time for CLPL, and incorporate both formal and informal CLPL – recognising the value of both knowledge exchange amongst faculty/department staff within schools and practitioners from other schools, as well as industry exposure to augment understanding of current trends in STEM applications, and possible career pathways for learners.

The development of practitioners through CLPL and industry exposure should be supported and maximised, to build confidence and capability within the STEM teaching cohort. Partners should capitalise on the need for protected time for STEM CLPL for staff, and pursue opportunities to build greater staff development time into timetabling.

Recommendation 8: Development and use of 'digital twin' comparator school profiles can be influential in helping schools to understand a baseline performance target to benchmark against, and also in helping schools identify which subjects to focus their efforts on in improving performance, enabling better targeted interventions for stimulating increased STEM participation and engagement.

Recommendation 9: Interventions that help to remove gender stereotypes have typically seen uptake in subjects that would traditionally have been perceived as being particularly gendered. These interventions can be proportionate to resources, but any activity to remove pupils' perceptions of a subject as a "girl" or "boy" subject is welcome and should be considered.

Operational recommendations

Recommendation 10: By broadening the number of education and qualification pathways that are available to pupils, there is a high chance of increasing engagement in those that think STEM isn't "for them". Schools should consider opening as many opportunities for STEM learning as possible, opening up opportunities both for teaching staff to be more innovative in their teaching, and also for pupils by providing qualifications and education pathways that otherwise would not have been in reach.

Recommendation 11: The profile of STEM departments and faculties can influence the degree of engagement, and consideration should be given to the benefits of knowledge transfer between junior teachers and more senior teachers to ensure a two-way flow of innovation, experience and enthusiasm. This will maximise the knowledge and skillsets of all staff, contributing to a better rounded and more consistent offer in STEM.

Recommendation 12: Understanding how to provide the best possible learning environments with adequate resourcing and spaces for open and collaborative work is essential for effective STEM learning. Consideration should be given to opportunities to pool resources across faculties if resources across each subject in STEM are particularly limited, and to provide shared space for collaboration where possible.

Recommendation 13: Having an adaptable approach to timetabling, focused on maximising viability, scheduling and delivering lessons, broadens the opportunities available to pupils. Coupled with provision of detailed and relevant guidance for pupils and parents at subject choice stage, engagement in STEM can be increased in cohorts that would otherwise not consider these subjects.

Recommendation 14: Schools should encourage as many pupil-led out-of-class initiatives as possible. The research has shown that where clubs or activities are designed and delivered with pupil input, there is greater enthusiasm for these activities, particularly if they relate to a specific challenge or project as these provide opportunities for real-world application of classroom learning.

Wider considerations

6.6 Alongside the recommendations set out above, a number of wider considerations are also provided.

I) Pupils whose primary language is not English often enjoy the practical elements of STEM learning as there is a smaller focus on literacy outcomes. By providing resources that make the theoretical aspects of STEM subjects more accessible, such as simple English dictionaries or experiment instruction books with informative diagrams, this can make STEM learning for pupils where English is a secondary language more engaging.

II) Wherever possible, schools should utilise and maximise the potential of the local economy and local employers to bolster their STEM learning delivery, enhance their curriculum, and demonstrate potential STEM career pathways. By involving local, inspiring and significant STEM employers in the learner experience, they can more clearly identify and relate classroom learning to the real world and thus can recognise pathways.

III) Proactive and positive engagement with parents and carers can help encourage STEM pathways by helping to alleviate preconceptions about subject choices. Better understanding of the parent cohort can inform the way in which schools need to engage with parents – either to overcome barriers or to maximise parent STEM capital – can help to stimulate more positive influences in terms of STEM engagement.

IV) STEM learning in both urban and rural schools can be impacted by the local environment both positively and negatively. Opportunities for outdoor learning should continue to be explored by schools, while, in locations where physical connectivity acts as a barrier, options such as online provision should also be explored.

V) Reflecting the particular circumstances that schools are in, the use of bespoke and creative interventions through the Pupil Equity Fund can maximise engagement for pupils in more deprived SIMD deciles. Schools should be encouraged to use this budget in ways that work best for their learners, reflecting the school's individual circumstances.

Appendix 1: Education in STEM

Education overview

There are a range of qualifications and awards which can be undertaken by individuals to support the development of the STEM skills required specifically in STEM sectors and for application across the economy. Due to the wide range of STEM-related roles available and the specialised skills required for many of these, many qualifications are tailored to specific skills or job roles. There is however an increasing focus on transferable numeracy, analytical and problem-solving skills within STEM-related subjects and qualifications. The core qualifications offer is summarised below.

National, Higher, and Advanced Higher-level qualifications

National, Higher and Advanced Higher qualifications are secondary level education qualifications. For STEM-related subjects, these are offered within the broad fields of Mathematics, Sciences, and Technology. National level qualifications are offered at Scottish Credit and Qualifications Framework (SCQF) Levels 1 to 5, Higher level subjects are offered at SCQF Level 6, and Advanced Highers are offered at SCQF Level 7.

Scottish Vocational Qualifications (SVQs)

Scottish Vocational Qualifications (SVQs) are accredited qualifications based on National Occupational Standards (NOS) and result in a certificate of vocational education. They provide practical, vocational skills for both people already working in the sector and those looking to move into it. For STEM-related subjects, they are developed by the relevant Sector Skills Council, informed by industry and the awarding body. SVQs are provided by colleges and training providers and assess workplace competencies in relation to a specific job role.

SVQs are available at SCQF levels 4 to 11 (SVQ 1-5), meaning they are suitable for learners in a variety of job roles within STEM industries. The qualifications and their content are split by the purpose of the qualification and the needs of the learners, ranging from 'users' to 'professionals'. SVQs are designed to be undertaken by people working or seeking to work in STEM occupations.

National Qualification Group Awards (NQGAs)

National Qualification Groups Awards (NQGA) encompass both National Certificates (NC) and National Progression Awards (NPA). They are designed to prepare people for employment or progression to study at HNC/HND level and aim to develop transferable knowledge, including core skills. 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. Because of the limited availability of detailed data on subject specific NQGAs, these have been excluded from the definition.

Higher National Qualifications (HNQs)

HNQs provide practical skills and theoretical knowledge that meet the needs of a specific sector. They are awarded by the Scottish Qualification Authority (SQA). Higher National Certificates are at SCQF level 7, and Higher National Diplomas at SCQF level 8. They are available in several STEM-related subjects.

HNCs and HNDs are suitable for those in technical-level and first-line management roles, and some HNDs enable learners to progress into the second or third year of university degrees. They are delivered by colleges, some universities, and many independent training providers, and many enable learners to progress from HNC or HND provision onto a degree course, either at college or at university, to further their studies.

Apprenticeships

Apprenticeships are a key part of the Scottish Government's strategy to tackle the skills gap in Scotland. They enable employers to develop their workforce and allow individuals to gain qualifications whilst in paid employment. The training provided prepares learners for a role in the sector and equips them with the skills required by employers to work in a range of roles. Individuals learn on-the-job and undertake off-the-job learning, usually through colleges or training providers.

Apprenticeships are available at a variety of SCQF levels. Modern Apprenticeships (MAs) are typically available at SCQF levels 5-7, with some elements ranging from SCQF levels 5 to 12. Technical Apprenticeships are available at SCQF level 8-9 and Professional Apprenticeships at SCQF level 10 and above. Graduate Apprenticeships have also been launched, providing learning up to SCQF level 11. In addition, Foundation Apprenticeships are a work-based learning qualification for pupils in S4 to S6 to complete elements of a MA while they are at school.

Apprenticeship frameworks are developed for STEM sectors by Sector Skills Councils in partnership with employers and awarding bodies. Modern Apprenticeship frameworks include Engineering, Construction, IT and Telecommunications, Life Sciences and Related Science Industries, and Rail Engineering. Foundation Apprenticeship frameworks include Civil Engineering, Hardware and System Support, Scientific Technologies, and Software Development. Graduate Level Apprenticeship frameworks include IT Software Development and Civil Engineering.

Diplomas are developed in line with apprenticeship frameworks to provide competence-based qualifications in line with apprenticeship learning in the workplace.

Professional Development Awards (PDAs)

PDAs provide qualifications for individuals already working within the sector to enhance their skills. The qualifications are delivered by colleges, training providers and some employers. They include Higher National units and are delivered through a variety of learning mechanisms which can include taught learning, self-directed study, research, and practice-based learning. The inclusion of HN units means that candidates can progress from PDAs to complete full HN or SVQ qualifications.

Reflecting the wide range of STEM occupations, many PDAs are available, providing specialist skills in a number of areas and supporting continuous professional development and improved professional practice. PDAs are available at SQCF levels 6-12, with credit values ranging from 16-64 credits, reflecting the level of content in each PDA and the number of learning hours required to complete them.

Degrees

There is a vast array of degree subjects which can lead into a career in STEM roles and industries, with most of these courses available at both undergraduate and (taught) postgraduate level. These include degrees in Medicine and Allied Subjects, Biological, Physical and Chemical Sciences, Mathematics and Computer Sciences, Engineering, and Architecture and Planning.

Higher level qualifications enable individuals within STEM sectors or seeking employment in a STEM sector to significantly enhance their knowledge and specialist skills and Higher Education Institutes (HEIs) provide valuable skilled workers required by the sector.

Appendix 2: Detailed pipeline analysis

A pipeline analysis of 2020/21 STEM enrolments, passes, attainments, achievements, outcomes and destinations, and employment has been undertaken. This aims to quantify the number of young people continuing their STEM education and transitioning into STEM careers – i.e., remaining in the STEM pipeline. 2020/21 data has been used as was the most complete dataset for a whole academic year at the time of analysis.

Various sources of data were used to estimate the number of enrolments and passes, attainments and achievements including SQA data on secondary school pupils, SDS data on apprentices (Modern Apprenticeships, Foundation Apprenticeships, and Graduate Apprenticeships – MA, FA, and GA respectively), SFC data on college students, and HESA data on university students and graduates. STEM outcomes and destinations and STEM employment data is not readily available, therefore, the study team has made a number of assumptions to arrive at estimates for this part of the pipeline, drawing on analysis on leaver outcomes and summary statistics on attainment and leaver destinations.[29] These assumptions will be described, in turn, when data is set-out for each stage of the pipeline.

The total STEM skills pipeline in terms of entrants is 99,564, though it should be noted that this not unique entrants, but simply a sum of total entrants at each stage. Using available data for pass rates and attainment, positive destination outcomes and employment, we can estimate that around half (c.50,000, or 50%) of all entrants across the STEM sills pipeline were in positive outcomes and destinations. Within this, around 38,100 (38%) of all entrants entered employment. Given constraints on available data, we are unable to determine whether the positive outcome or employment destinations are STEM. Instead, we must consider each of these as a *maximum potential number* that continues within the STEM pipeline.

Conversely, total leakage – those leavers at each stage that do not go onto either a positive destination or employment outcomes – is around 11,400, or 11% of total entrants. This ranges from 3% at FA level, to around 19% at university level. Whilst the leakage rate for GAs is higher at c.40%, this proportion may be distorted by having to use historic achievement rates (2017/18 is the latest 'full' achievement rate available) for 2020/21 starts, though not all starts for this academic year have finished their studies yet.

Nevertheless, in broad terms the leakage appears to increase at higher SCQF levels in the pipeline. Beyond understanding attainment rates at each stage of the pipeline, the reasons for this are unclear.

At secondary school level, the pipeline has been split by SCQF or qualification level including: SCQF3; SCQF4; SCQF5/National 5; Higher; and Advanced Higher. At SCQF3 there were 889 leavers in 2020/21. The STEM pass rate in 2021 for this level was 83.5%[30] and assuming that all school leavers from this year have had to study at least one STEM subject at SCQF3 then this indicates that there were 742 school leavers with a STEM SCQF3 qualification out of 889 total leavers with an SCQF3 qualification. Based on the fact that 95.5% of school leavers in 2020/21 went onto positive destinations, approximately 709 of those STEM leavers (school leavers with at least one STEM qualification) were in positive outcomes and destinations. Within this, around 22.6% of school leavers in 2020/21 went in employment. Assuming the same proportion can be applied to leavers with STEM qualifications, around 168 were in employment.[31]

[29] https://www.gov.scot/publications/summary-statistics-attainment-initial-leaver-destinations-no-4-2022-edition/
[30] https://www.sqa.org.uk/sqa/98566.html
[31] From the supplementary tables that accompany Summary Statistics for Attainment and Initial Leaver Destinations, No. 4: 2022 Edition. At: https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2022/02/summary-statistics-attainment-initial-leaver-destinations-no-4-2022-edition2/documents/supplementary-tables/supplementary-tables/govscot%3Adocument/supplementary-tables.xlsx

We are unable to determine whether the positive outcome or employment destinations are STEM. Instead, we must consider each of these as a *maximum potential number* that continues within the STEM pipeline.

There were 4,322 school leavers in 2021 that studied at SCQF4 level. The STEM pass rate in 2021 for this level was 88.5%[32] and assuming that all leavers at this level had had to study at least one STEM subject at SCQF4 then this indicates that there were 3,825 school leavers with a STEM SCQF4 qualification in 2021. Based on the same set of assumptions as for SCQF3 leavers, approximately 3,653 of those STEM leavers were in positive outcomes and destinations and, of these, around 864 were in employment.[33] Again, we can consider these the *maximum potential number* that continues within the STEM pipeline.

At SCQF5/National 5 level there were 186,390 enrolments on individual STEM subjects.[34] STEM passes equalled 151,383. There were 11,004 school leavers with a STEM-related SCQF5 qualification in 2021 and the STEM pass rate was 78.2%.[35] Assuming that all leavers at this level have had to study at least one STEM subject then this indicates that there were 8,605 school leavers with a STEM qualification at SCQF5. Based on the same set of assumptions as above, then this indicates that 8,218 of those STEM leavers went on to positive outcomes and destinations, and, of these, approximately 1,945 entered employment.

At Higher level in 2021 there were 66,055 enrolments on individual STEM subjects. STEM passes equalled 53,642 in the same year. Since schools often give pupils a free choice of subjects at Higher and Advanced Higher levels, it cannot be assumed that all leavers at SCQF6 have at least one STEM pass. Instead, we have instead estimated the number of leavers with STEM passes based on the ratio of STEM to all subject passes (grades A-C), which in 2020/21 was 31.4%.[36] If we apply this rate to the number of leavers with SCQF6/Higher in 2020/21[37], then it is estimated that there were 6,661 school leavers with a STEM-related SCQF6 qualification. Applying the same assumptions regarding positive destinations and employment as above, then this indicates that of those leavers with a STEM qualification at SCQF6, 6,361 went onto a positive destination. Of these, approximately 1,505 STEM school leavers with a STEM qualification at SCQF6 went into employment.

At Advanced Higher level in 2021 there were 13,212 enrolments on individual STEM subjects. STEM passes equalled 11,370 in the same year. As above, it cannot be assumed that all leavers at SCQF7 have at least one STEM pass. Instead, we have instead estimated the number of leavers with STEM passes based on the ratio of STEM to all subject passes (grades A-C), which in 2020/21 was 47%.[38] If we apply this rate to the number of leavers with SCQF7/Advanced Higher in 2020/21[39], then it is estimated that there were 5,781 school leavers with a STEM SCQF7. Applying the same assumptions regarding positive destinations and employment as above, then this indicates that of those leavers with a STEM-related qualification at SCQF7, 5,521 went onto a positive destination. Of these, approximately 1,307 STEM school leavers with a STEM qualification at SCQF6 went into employment.

[32] https://www.sqa.org.uk/sqa/98566.html
[33] Ibid.
[34] Note that this is number of enrolments on STEM subjects and not number of students. One student could enrol on multiple STEM subjects.
[35] https://www.sqa.org.uk/sqa/98566.html
[36] Based on SQA attainment data for 2021, at: https://www.sqa.org.uk/sqa/98566.html
[37] https://www.gov.scot/publications/summary-statistics-attainment-initial-leaver-destinations-no-4-2022-edition/
[38] Based on SQA attainment data for 2021, at: https://www.sqa.org.uk/sqa/98566.html
[39] https://www.gov.scot/publications/summary-statistics-attainment-initial-leaver-destinations-no-4-2022-edition/

At College level there were 71,616 enrolments in the 2020/21 academic year. STEM passes were 29,582 in the same year.[40] In the same year, 91% of college leavers went on to positive destinations. Assuming that those studying STEM courses continued on a STEM trajectory and by applying the 91% rate to the number of STEM passes then it is estimated that 26,920 STEM college students went on to STEM outcomes and destinations. Within this, around 62% of college leavers in the 2020/21 academic year went on to employment.[41] Consequently, if we apply this rate to the number of STEM passes in the same year, and assume that those with a STEM college qualifications are going into STEM employment, then this indicates that 18,341 college students go on to STEM employment in 2021.

There were 1,173 starts on STEM FAs (Foundation Apprenticeships) in the 2020/21 academic year out of 2,975 starts on all FAs so STEM starts represented 39% of this cohort.[42] There were 333 STEM achievements (an apprentice's achievement of a STEM FA) in the same year. Around 97.1% of SCQF Level 6 FA completers from Cohort 4 (2019) are in education, training, or employment which indicates that 323 STEM FAs from Cohort 4 may be in some form of STEM education, training, or employment if they continue with their STEM trajectory. Around 6.4% of FA leavers went on to employment or a Modern Apprenticeship (MA) and if we assume that STEM FAs went on to STEM employment or a STEM MA then this would be 75 people that moved from a STEM FA into STEM employment from Cohort 4.

There were 8,467 starts on STEM MAs in the 2020/21 academic year out of 18,655 starts on all MAs so STEM starts represented 45% of this cohort.[43] There were 7,065 achievements in the same year. Around 92% of MAs stay in work once they've qualified (six months after completing their MA).[44] Consequently, it is estimated that around 6,500 people transitioned from a STEM MA into full STEM employment (assuming that those that achieve their MAs remain in the field that they completed their apprenticeship in).

There were 692 starts on STEM GAs (Graduate Apprenticeships) in the 2020/21 academic year out of 1,169 starts on all GAs so STEM starts represented 59% of this cohort.[45] However, only c.11.5% of GAs were new employees: the rest were already with their employer, so these must be discounted. Therefore, discounted enrolment is 80 GAs. Given that GAs can be anything from 2-5 years, the most recent 'full' achievement rate for GAs is 60.6% for 2017/18 enrolments. Applying this achievement rate to 2020/21 enrolments, then it is estimated that there are 48 achievements from the discounted enrolment figure. In the absence of other data, we have to assume that all these remain in employment (in contrast to MAs).

There were 138,960 enrolments on STEM university courses at undergraduate or postgraduate level in the 2020/21 academic year. Approximately 36% of these enrolments were postgraduate and 64% were undergraduate. There were 36,890 passes in the same year. Approximately 81% of Scottish STEM graduates in 2020/21 were in high-skilled employment which indicates that around 29,881 STEM graduates could be in STEM outcomes or destinations or high-skilled employment.[46] Around 20% of

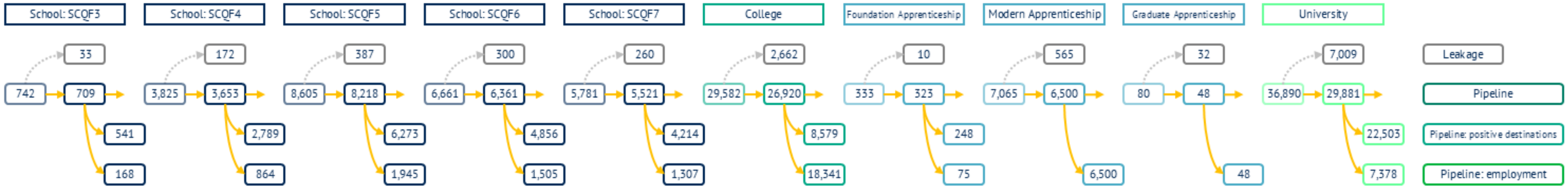
[40] https://www.sfc.ac.uk/wp-content/uploads/2024/07/College-Region-National-Tool-2020-21.xlsx
[41] https://www.sfc.ac.uk/publications-statistics/statistical-publications/2022/SFCST082022.aspx
[42] https://www.skillsdevelopmentscotland.co.uk/media/dh1hzikp/foundation-apprenticeships-progress-report-june-2021.pdf
[43] https://www.skillsdevelopmentscotland.co.uk/media/qqmdxu3b/modern-apprenticeship-statistics-quarter-4-2020-21.pdf
[44] https://www.skillsdevelopmentscotland.co.uk/what-we-do/apprenticeships/modern-apprenticeships
[45] 1,169 less non-STEM frameworks taken from: https://www.skillsdevelopmentscotland.co.uk/media/xe2nuwx5/graduate-apprenticeship-annual-report-2022.pdf
[46] https://www.hesa.ac.uk/news/31-05-2023/sb266-higher-education-graduate-outcomes-statistics/study

Scottish STEM graduates in 2020/21 entered work in a STEM SIC sector.[47] This indicates that 7,378 STEM graduates from the academic year 2020/21 went on to STEM employment.

Figure A2.1 below sets out the STEM pipeline.

[47] The UK Standard Industrial Classification of Economic Activities (SIC) is used to classify industries by the type of activity they do. Graduates are asked what their employer makes or does. This information is coded using the SIC2007 coding frame. The codes are grouped together for publication. See Standard Industrial Classification: SIC2007 (https://www.hesa.ac.uk/collection/coding-manual-tools/sicsocdata/sic-2007) for the full list of codes and how they are grouped together.

Figure A2.1 STEM pipeline



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