

Learned Societies' Group on Scottish STEM Education

Advice paper

March 2023

Response to the national discussion on education



Summary

- The future learning system will need to fulfil a number of objectives: providing all learners with opportunities for growth, success, and personal fulfilment; producing school leavers able to become citizens and apprentices whose skills align with the needs of the economy and our society; and teaching young people how to think critically about the world around them and devise creative solutions to our most enduring societal challenges.
- There are numerous education reform initiatives and review exercises that are currently underway. The Learned Societies' Group on Scottish STEM Education (LSG) would strongly argue that these multiple strands of inquiry be appropriately aligned and cross-referenced to arrive at a clear and unified set of recommendations on the way forward.
- A learner's command of reading and writing has significant implications for how well they are able to understand - and therefore access - STEM learning. It may be appropriate to re-evaluate how literacy is taught in schools to ensure it reflects current best practice.
- Meaningful baseline data across a range of metrics is scarce. Before Scotland can look to devise and enact the changes necessary to transform the education system, it needs to understand what is currently working well and what is not. This can only be achieved through a commitment to well-informed, extensive, and integrated data-gathering.
- Another area of growing interest to the LSG is the teaching of the ethics of knowledge, both within the STEM subjects but also more broadly. Rather than merely absorbing knowledge, learners should be able to think critically about its origins, strengths, weaknesses, and eventual applications. Questions such as 'who is benefiting from this knowledge?' and 'does it have the potential to be harmful?' become particularly resonant in a time of manipulated narratives and 'fake news' which make it increasingly difficult to separate fact from fiction.
- Practical laboratory work is an important component of a high-quality STEM education. The LSG would like to see an enduring commitment to the principle of laboratory work with the scope to make changes where current approaches are found to be inadequate.
- There are several strengths within the Scottish education system. It is important that these are maintained and built upon further. For example, Curriculum for Excellence's (CfE) ethos of breadth remains one of its defining characteristics and a rightful point of pride. We would like to see this subject breadth retained in any future system. However, as was described in our response to the Organisation for Economic Co-operation and Development (OECD) review of CfE, this theoretical breadth is often constrained in its delivery due to factors such as timetabling restrictions and teacher shortages.
- The LSG remains concerned about the relatively low level of entrance qualifications in the STEM subjects for those entering primary teacher ITE and variability in the quantity of STEM subject provision within primary ITE. In addition, recruitment of secondary teachers in most of the STEM subjects has consistently fallen below Scottish Funding Council targets for many years.
- The LSG welcomes the explicit commitment to scientific literacy for all as exemplified in policies such as the STEM Education and Training Strategy.
- Related to ensuring Scotland maintains a high-quality teaching workforce committed to the professional values of social justice, trust, respect, and integrity, it is important that equity, diversity, and inclusion issues are addressed by practitioners throughout the education system.
- It is important that Scottish education benefits from a much clearer curriculum framework, especially for ages 3-15 before young people begin to specialise in their studies. One added element should be a curriculum (and the pedagogy used in its fulfilment) that is not adversely impacted by the corresponding system of qualifications and assessment for certification.

Summary (continued)

- We strongly endorse the need for sustained widespread engagement and are able to offer multiple routes to reaching many of these stakeholder groups through our individual societies' networks.
- In addition to facilitating access to STEM opportunities, young people should be provided with comprehensive and accurate careers advice to illustrate the wide array of STEM pathways and destinations available to them and to raise their aspirations as to what may be possible.
- Climate change and sustainability matters should be given more deliberate and consistent focus within the curriculum in order to satisfy the concerns of learners and prepare them to design and implement the solutions required to continue mitigating the climate emergency.
- From the LSG's perspective, knowledge must continue to hold a prominent - if not principal - place in the curriculum as cumulative knowledge gain is the mainstay of STEM learning and attainment.
- Scotland should continue to uphold the value of disciplinary knowledge whilst making space for interdisciplinarity in order to keep pace with the changing nature of the labour market and indeed the 21st century.
- If teachers are to devote an increasing proportion of their time towards professional and curriculum development (OECD recommendation 3.1, which we continue to endorse), then teaching capacity must be correspondingly increased and teacher wellbeing duly prioritised. If teachers are to meet these expectations, they will need access to ongoing, well-designed support, including subject-specific support. High quality subject-specific professional learning is very effective at improving the quality of teaching and learning, and therefore the outcomes of young people and the performance of the education system as a whole.

Introduction

1. Formed in 2012, the Learned Societies' Group on Scottish STEM Education (LSG) brings together the learned societies and professional associations with a focus on the provision of STEM education at school.¹ We are pleased to engage with Scottish Government and the Convention of Scottish Local Authorities' (CoSLA) national discussion on education to deliver a call to action to realise a renewed vision for Scottish education. As our remit pertains specifically to teaching and learning across the STEM subjects, we have elected to answer the questions largely from this perspective. However, we recognise that several of the issues identified by the questions transcend disciplines and other boundaries and so we have also included more cross-cutting observations as appropriate. Our response is founded on the shared view that learners should be given ample opportunities to engage with STEM, that the STEM subjects should be afforded appropriate focus within the curriculum, and that a scientifically literate citizenry will be critical to addressing the societal challenges that Scotland will face now and into the future. We would be pleased to meet with Scottish Government and CoSLA to discuss our views in more detail and look forward to continuing to engage with other facets of the education reform agenda.

Question 1: What kind of education will be needed by children and young people in Scotland in the future?

2. The LSG believes **the future learning system will need to fulfil a number of objectives:** providing all learners with opportunities for growth, success, and personal fulfilment; producing school leavers able to become citizens and apprentices whose skills align with the needs of the economy and our society; and teaching young people how to think critically about the world around them and devise creative solutions to our most enduring societal challenges.

Question 2: How do we make that a reality?

3. From the outset, the LSG would acknowledge that there are numerous education reform initiatives and review exercises that are currently underway. These appear to be running in parallel rather than converging on a set of common aims. Although it sounds self-evident, we would strongly argue that these **multiple strands of inquiry be appropriately aligned and cross-referenced** to arrive at a clear and unified set of recommendations on the way forward. As it stands, it is unclear to what extent these activities will inform one another and several of them have potentially conflicting timelines. This is especially unfortunate when the OECD identified confusion about the workings of the curriculum as a key factor holding back progress; the reform programme itself seems to suffer from a similar weakness, though this too is solvable.

4. Literacy and numeracy rightfully occupy a central place within the Scottish curriculum. Issues surrounding literacy may seem less relevant to STEM than to other subjects. However, **a learner's command of reading and writing has significant implications for how well they are able to understand - and therefore access - STEM learning.** STEM examinations and texts can use sophisticated terminology and learners with a lower proficiency in reading and writing may face difficulties in parsing the precise meaning of a specific term or question. Learners for whom English is a second language may be at an even greater disadvantage. These shortfalls can compound over time such that learners may eventually drop these subjects. A Twitter survey conducted by Ben Rogers and reported by *Education in Chemistry* magazine gathered responses from over 100 scientists and engineers, asking them how they had learned to read professional texts.²

¹ This response has been signed off by: BCS, the Chartered Institute for IT; Edinburgh Mathematical Society; Institute of Physics; Institution of Engineering and Technology; Royal Society of Biology; The Royal Society of Chemistry; Royal Society of Edinburgh; and the Scottish Mathematical Council. More information about the LSG is available at: <https://rse.org.uk/about-us/governance/standing-committees/learned-societies-group/>

² <https://edu.rsc.org/ideas/how-to-teach-reading-in-science/2010065.article>

The majority (almost 85%) indicated they had taught themselves how to read technical information, rather than being taught by teachers during their secondary schooling. While this self-taught approach may work for students who are particularly motivated, others may find it daunting. We would therefore support the continued prioritisation of literacy as a vital precursor to academic achievement across a range of subjects, including the STEM subjects.

5. It may also be appropriate to **reevaluate how literacy is taught in schools to ensure it reflects current best practice**.

6. The LSG submitted a response to the Scottish Government's consultation on enhanced data collection for education improvement. Its overarching observation was that **meaningful baseline data across a range of metrics is scarce**, certainly in the public domain, making it difficult if not impossible to diagnose issues or to track improvements. For example, we noted that certain Key Performance Indicators (KPIs) found within the STEM Education and Training Strategy lack a corresponding publicly available dataset, making it virtually impossible to determine whether, and to what extent, progress is being made.³ Other KPIs are not disaggregated by subject, making it difficult to know whether trends are manifesting differently across them.⁴ Before we can look to devise and enact the changes necessary to transform the system in the manner described in our response to question 1, we need to understand what is currently working well and what is not. This can only be achieved through a commitment to **well-informed, extensive, and integrated data-gathering**.

7. Another area of growing interest to the LSG is the **teaching of the ethics of knowledge, both within the STEM subjects but also more broadly**. From a STEM perspective, this also includes an understanding of scientific integrity and why we should trust the work of reputable scientists, as well as specific considerations around data ethics. Rather than merely absorbing knowledge, learners should be able to think critically about its origins, strengths, weaknesses, and eventual applications. Questions such as 'who is benefiting from this knowledge?' and 'does it have the potential to be harmful?' become particularly resonant in a time of manipulated narratives and 'fake news' which make it increasingly difficult to separate fact from fiction. Having been raised in the age of ubiquitous Internet and social media, we might assume that younger generations are

inherently adept at avoiding the pitfalls of misinformation and deliberate disinformation. Worryingly, mounting evidence suggests this is not always the case. For example, Stanford University measured the ability of high schoolers in the United States to evaluate digital sources pertaining to everything from American politics to climate change. As just one example, over 96% of the 3,446 students sampled did not think that the fossil fuel industry having ties to a climate change website might undermine the site's credibility.⁵ The LSG is currently scoping a piece of work in this domain and would be pleased to have further conversations about its envisaged plans should the Scottish Government be receptive to this.

Question 3: How can every child and young person's individual needs be supported and addressed in the future?

8. The LSG does not offer a particular position on this question, other than to agree with the general premise.

Question 4: What is one thing that needs to stay and why?

9. **There are several strengths within the Scottish education system. It is important that these are maintained and built upon further.**

10. **Practical laboratory work is an important component of a high-quality STEM education.** Learners who are given a chance to consolidate and apply theoretical concepts in a practical setting generally display better engagement and knowledge retention than those that do not. It can also encourage curiosity and a keenness to learn among pupils for whom classroom-based STEM learning can be seen as less motivating.⁶ The Covid pandemic severely impacted learners' access to practical laboratory work, the effects of which are still being remediated. LearnSci surveyed teachers from around the world to ask about the observed impacts of disruptions to practical lab work among their students. Responses included a drop in tactile and manipulative motor skills; weaker experimental design; the loss of basic lab skills; poorer teamworking skills; and reduced confidence.⁷

³ As two examples, there is no corresponding dataset underpinning the KPIs of 'Increase the cumulative hours of STEM professional learning accessed by early years, schools, college and CLD practitioners annually', and 'Increase the numbers of placements and internships with employers for college learners within STEM curricular areas' or the aim of 'significant reductions in the equity gaps in participation and achievement in STEM learning, engagement, study, courses and training across all sectors in relation to gender, deprivation, rurality, race, disability and for care leavers'. *STEM strategy: key performance indicators*. <https://www.gov.scot/publications/stem-strategy-key-performance-indicators/>

⁴ As an example, the KPI of 'Reduce the gap between the percentage of school leavers with 1 or more award in STEM subjects at SCQF level 6 or better from the least and most deprived SIMD quintiles to 31 percentage points by 2020 and to 25 percentage points by 2022' is not disaggregated by subject.

⁵ <https://sheg.stanford.edu/students-civic-online-reasoning>

⁶ <https://www.iop.org/sites/default/files/2019-09/practical-work-in-science.pdf>

⁷ <https://www.learnsci.com/post/recent-practical-science-school-lessons-and-the-challenge-faced-by-first-year-university-stem-teaching-staff>

Recommendations were also made for how first-year STEM university educators could accommodate and address these deficits.

11. This is not to suggest that there is no room for improvement. Not all practical work is alike and some methods are more effective than others.^{8,9} **We would therefore like to see an enduring commitment to the principle of laboratory work with the scope to make changes where current approaches are found to be inadequate.** For example, the nature of the Assignment arrangements in SQA National 5 and Higher courses in the sciences are not considered by many teachers in our community to be fit-for-purpose assessments or to promote good practical, analysis, or report-writing skills. The detailed situation and associated cost will necessarily vary by subject.

12. **Curriculum for Excellence's (CfE) ethos of breadth** remains one of its defining characteristics and a rightful point of pride. As one positive example from the STEM subjects, Computing is generally satisfactorily integrated into the curriculum throughout Broad General Education (BGE) and into the early senior phase, though a noticeable drop-off occurs past this stage. **We would like to see this subject breadth retained in any future system. However, as was described in our response to the OECD review of CfE,^{10,11} this theoretical breadth is often constrained in its delivery due to factors such as timetabling restrictions and teacher shortages.** In order for schools to maintain a breadth of curriculum offer within a restricted timetable and staffing environment, multi-course teaching has often been introduced. This has the potential to be detrimental to both the learner experience and to teacher workload. The prevalence of multi-course teaching, the teaching of incompatible different courses simultaneously by one teacher in one classroom, should be ended in all but the most extreme situations, such as in very small remote schools operating with much reduced class sizes. Additionally, subject choice limitations are more pronounced in disadvantaged areas, compounding existing issues like the poverty-related attainment gap.¹² These problems must be overcome if learners are to truly benefit from the subject choice and flexibility that CfE aims to offer.

13. A strength of Scottish education is its relatively well qualified and committed teacher workforce with the requirement for degree level qualifications, initial teacher

education (ITE) and probationary period, masters level qualifications for headship, and comprehensive GTCS Professional Standards. However, **the LSG remains concerned about the relatively low level of entrance qualifications in the STEM subjects for those entering primary teacher ITE and variability in the quantity of STEM subject provision within primary ITE.^{13,14,15} In addition, recruitment of secondary teachers in most of the STEM subjects has consistently fallen below Scottish Funding Council targets for many years.^{16,17}** It is important that, without diminishing standards, flexible entry routes are explored, including the development of high-quality accredited courses providing the subject knowledge for teaching required to allow existing teachers to gain GTCS registration in an additional STEM subject. It is also important to develop a national programme of high-quality subject-specific professional learning to enhance the professional capacity of all teachers, not only within the STEM subjects. We would also like to add that all of the constituent societies in the LSG provide a range of support for practitioners, resources, professional development, and networking opportunities. These respective strengths are synergised through collaboration in the context of the LSG, making us uniquely placed to support the profession in a number of ways.

14. **We welcome the explicit commitment to scientific literacy for all as exemplified in policies such as the STEM Education and Training Strategy.** While the first iteration has fallen short of many of its targets, the system should remain committed to the principle of delivering high-quality STEM education for all, not just graduates.

15. **Related to ensuring Scotland maintains a high-quality teaching workforce committed to the professional values of social justice, trust, respect, and integrity, it is important that equity, diversity, and inclusion issues are addressed by practitioners throughout the education system.** This includes low socio-economic background and all protected characteristics such as age, disability, gender, LGBT+, race, and religion. The work begun by the IOP Improving Gender Balance Scotland pilot project, with its emphasis on whole school and cluster equity approaches, and continued by the Education Scotland Improving Gender Balance and Equities team as part of the Scottish

⁸ <https://www.gov.uk/government/publications/research-review-series-science/research-review-series-science#practical-work>

⁹ <https://www.gatsby.org.uk/uploads/education/reports/pdf/good-practical-science-report.pdf>

¹⁰ <https://rse.org.uk/expert-advice/advice-paper/learned-societies-group-response-to-professor-ken-muir-education-reform-consultation/>

¹¹ <https://rse.org.uk/wp-content/uploads/2022/04/RSE-AP-Curriculum-for-Excellence-Review-2020.pdf>

¹² <https://bera-journals.onlinelibrary.wiley.com/doi/full/10.1002/rev3.3180>

¹³ <https://rse.org.uk/expert-advice/advice-paper/lsg-response-gtcs-consultation-professional-standards-new-code/>

¹⁴ <https://www.gov.scot/publications/supporting-scotlands-stem-education-culture-science-engineering-education-advisory-group/pages/2/>

¹⁵ <https://www.gov.scot/publications/stemec-report-2016/>

¹⁶ <https://www.gov.scot/publications/teacher-workforce-planning-advisory-group-initial-teacher-education-intake-figures-2021/>

¹⁷ <https://www.gov.scot/publications/initial-teacher-education-2020-student-teacher-intake-statistics/pages/pgde-secondary-and-alternative-route-intake-figures/>

Government's STEM Education and Training Strategy, must be continued wherever inequity exists and the programme should be retained and built upon in the successor organisation to Education Scotland.^{18,19}

Question 5: What are the most important priorities for a future Scottish education system?

16. We believe the most important priorities for a future Scottish education system are captured by our response to question 1.

17. To achieve these priorities, **it is important that Scottish education benefits from a much clearer curriculum framework, especially for ages 3-15 before young people begin to specialise in their studies.**

The OECD in their review of CfE recommended that the curriculum should specify much more clearly what children and young people should be expected to know, to do, and to understand. This should place a greater emphasis on the development of important knowledge, or concepts, in a coherent and progressive way that enables future study and the development and application of skills, what has been referred to as a knowledge-based, skills-oriented²⁰ curriculum. The development of knowledge frameworks for every subject area would allow for improved transitions between schools, focused professional learning, and collaborative resource development, and empower teachers to focus on improving their pedagogy and developing a local curriculum suited to their context and learners but nevertheless covering the expected important knowledge concepts and skills. Several of LSG's member organisations have spent time developing curriculum frameworks to inform education reform in Scotland and other UK nations. These frameworks draw on the disciplinary expertise of their members and committees, as well as expert input on teaching and learning. Each has published their work so far: *Royal Society of Biology's Evolving 5-19 Biology: Recommendations and framework for 5-19 biology*²¹, *Royal Society of Chemistry's The Elements of a Successful Chemistry Curriculum*²², and Institute of Physics' *Framing Future Physics Curricula*.²³

18. **One added element should be a curriculum (and the pedagogy used in its fulfilment) that is not adversely impacted by the corresponding system of qualifications and assessment for certification.** Assessment is a vital part of teaching and learning and should be used

to support rather than influence its aims. Good use of formative and diagnostic assessment should play a significant and ongoing part of the life of learners. However, the style of high stakes assessment often used for certification can have unintended detrimental consequences for curriculum, teaching, and learning. No matter how aspirational Scotland's vision for the future of education may be, if curriculum development does not proceed in tandem with the reform of assessment and qualifications, the former will continue to be led by the latter – the central criticism of curriculum performance delivery identified by the OECD. While we are supportive of the independent review of qualifications and assessment being led by Professor Louise Hayward, we do wonder how the findings of these different strands of inquiry (i.e. the national discussion on education and the aforementioned review) will be assimilated into a coherent set of recommendations, particularly as the national conversation is due to report before the Hayward review. The LSG's response to the OECD review²⁴ posed several questions with respect to assessment and qualifications which we believe remain germane to the present reform agenda:

- With increased staying-on rates among young people in education - whether that be in schools, colleges, or other education settings - is it necessary to have successive 'two term dashes' to a diet of national examinations in each of the last three years of secondary school?
- Linked to the preceding question, how do we achieve greater diversity in approaches in S4-S6 and parity of esteem for different pathways, so that the totality of achievement in S4-S6 becomes the focus?
- Is the current extent and balance of assessments in national qualifications appropriate, with the relatively long examinations and assignments that are at times not fit for purpose, and where similar skills are assessed multiple times across several subjects?
- What use should be made of teacher assessment, especially given the experience during the Covid-19 pandemic, and what further support do teachers need to ensure objective assessment? What is the role for unit assessments in providing objective measures of student performance?
- What use should be made of online assessments, and what infrastructure and professional support needs to be put in place to facilitate these?

¹⁸ <https://education.gov.scot/improvement/learning-resources/improving-gender-balance-3-18>

¹⁹ <https://www.gov.scot/policies/science-and-research/stem-education-training/>

²⁰ <https://theteachingdelusion.com/2021/10/09/a-5-minute-guide-to-knowledge-vs-skills/>

²¹ https://www.rsb.org.uk/images/Evolving_5-19_Biology.pdf

²² <https://www.rsc.org/new-perspectives/talent/chemistry-curriculum-framework/>

²³ <https://spark.iop.org/framing-future-physics-curricula>

²⁴ <https://rse.org.uk/expert-advice/advice-paper/learned-societies-group-response-to-the-oecd-review-of-curriculum-for-excellence/>

Question 6: How can we ensure that everyone involved in education in Scotland has a say in future decisions and actions?

19. We strongly endorse the need for sustained widespread engagement and are able to offer multiple routes to reaching many of these stakeholder groups through our individual societies' networks. Not only do we represent academics and teachers, we also advocate for the best interests of our subjects and so are able to offer subject-specific perspectives that may not otherwise be captured through more general consultation exercises. Stakeholders consulted should also include members of the public and young people, and the LSG is in a strong position to facilitate such interaction in the STEM areas.

20. The large number of parallel consultation exercises currently taking place raises the issue of whether all stakeholders have the capacity to fully engage with these and respond in a considered manner and whether sufficient time is allowed to enable a well-debated consensus to form as to the priority issues. In its review of CfE, the OECD recommended moving to a cyclical curriculum review model of perhaps eight or ten years. This would have the benefit of providing curriculum stability between reviews allowing teachers and other practitioners to concentrate on improving pedagogy, and resource and other support providers to invest in work, knowing this will be worthwhile, and consistent data to be gathered over several years to evaluate progress made. However, such a cyclical process gives the opportunity to have well planned and transparent consultations to determine issues to be addressed when it comes time for the next review. These reviews should offer both opportunities for wide consultation but bring those with appropriate knowledge and experience together, drawing from classroom teachers, school leaders, academics with appropriate research, curriculum, and pedagogical knowledge, as well as other stakeholders such as business and industry representatives, to ensure curriculum and assessment reviews result in changes of a high but realistic standard.

Question 7: How can children and young people be cared for and supported in the future? (i.e. physical and mental wellbeing)

21. The LSG does not offer a particular position on this question, other than to agree with the general premise.

Question 8: How can the right of every child and young person to have opportunities to develop their full potential be achieved in future?

22. From a STEM perspective, we are interested that young people are able to access a wide range of learning and career opportunities. Although CfE promises breadth and flexibility, this has not always translated to learners having access to the full range of qualifications, awards, and personal development opportunities that exist in practice. We hope that the next iteration of the STEM Education and Training Strategy reinvigorates Scotland's commitment to closing equity gaps in STEM participation. As it stands, due to data constraints of the sort mentioned in our response to question 2, it is difficult to conclude the extent to which this intention has been realised, though certain markers (such as around gender balance) suggest enduring disparities.²⁵ **In addition to facilitating access to STEM opportunities, young people should be provided with comprehensive and accurate careers advice to illustrate the wide array of STEM pathways and destinations available to them and to raise their aspirations as to what may be possible.** There is a role for improved data in dispelling misconceptions about STEM careers and pathways in an effort to encourage greater participation as well as evidencing the wider benefits and contributions of the STEM subjects to society.²⁶ For example, improving gender representation in traditionally male-dominated and higher-earning STEM roles could have positive indirect effects on reducing the gender pay gap.²⁷

23. Young people also do not all have an understanding of the full set of current and future career opportunities, especially those in STEM. For example, out of 549 11-18-year-olds surveyed by the Royal Society of Chemistry, only 38% felt that studying chemistry can lead to lots of jobs in sustainability and climate change.²⁸ This misperception applies both to those jobs requiring degrees but also the support roles that are essential to support the development and application of science and technology to real world problems like climate change. This should be a real area of focus going forward.

24. There are many opportunities for rewarding careers in industries based on the STEM subjects.^{29,30,31} Many of these jobs do not require university degrees but good STEM-based vocational qualifications. It is important that the opportunities available to young people through study in the further education sector are properly communicated to schools, parents and carers,

²⁵ <https://www.gov.scot/publications/stem-education-training-strategy-refresh/pages/4/>

²⁶ <https://royalsociety.org/~media/education/policy/vision/reports/ev-9-vision-research-report-20140624.pdf>

²⁷ <https://rse.org.uk/expert-advice/advice-paper/lsg-enhanced-data-collection-for-educational-improvement/>

²⁸ <https://www.rsc.org/new-perspectives/sustainability/a-sustainable-chemistry-curriculum/>

²⁹ <https://www.iop.org/strategy/productivity-programme/physics-and-economy#gref>

³⁰ <https://www.iop.org/sites/default/files/2019-04/role-of-physics-in-supporting-economic-growth-scotland.pdf>

³¹ <https://www.gov.scot/publications/scotlands-national-strategy-economic-transformation/pages/5/>

and the young people themselves through good career advice and guidance.³² There is still work to be done in promoting parity of esteem between further education (FE) and higher education (HE) routes.

Question 9: How can children and young people be helped to learn about our changing world, so they feel able to positively contribute?

25. Young people are becoming increasingly anxious about climate change. A recent study conducted across ten countries and led by Bath University³³ reported that three-quarters of young people (16-25) surveyed said they thought the future was frightening with over half (56%) believing that humanity is 'doomed.' Similarly, the Royal Society of Chemistry found that 79% of 11-18-year-olds see climate change and sustainability as a priority for the chemistry curriculum.³⁴ Professor Ken Muir, in his report *Putting Learners at the Centre: Towards a Future Vision for Scottish Education*³⁵, described climate change as a 'key driver influencing the future of our education system', prompted by young people's growing unease and dismay at an observed lack of global action in tackling environmental issues.

26. Climate change and sustainability matters should be given more deliberate and consistent focus within the curriculum in order to satisfy the concerns of learners and prepare them to design and implement the solutions required to continue mitigating the climate emergency.

This is just one example of how the voice of young people should be sought, respected, and elevated to give them agency over their education and futures. Learning for Sustainability is a good start but is variably implemented across classrooms.

27. Since the early days of CfE, the role of knowledge within the Scottish curriculum has been debated³⁶, including its relationship to both skills development and to assessment. According to Professor Mark Priestley, teachers have not received adequate nor consistent guidance in implementing CfE, leaving the role of knowledge open to interpretation. In its response to the OECD review of CfE, the Royal Society of Edinburgh concluded that the role of knowledge under CfE has 'never been well-established', going on to say this ambiguity is problematic as 'learning cannot take place in the absence of knowledge acquisition' and that 'skills cannot exist in isolation.'³⁷ As has been described in question 5, much

clearer curriculum frameworks are required with greater specificity of what children and young people should be expected to know, to do, and to understand as they progress through their education.

28. The STEM subjects are particularly reliant on learners having built up the requisite knowledge base in order to comprehend and manipulate more advanced concepts. This can only be achieved by a coherent progression from one stage of learning to the next. **From the LSG's perspective, knowledge must continue to hold a prominent - if not principal - place in the curriculum as cumulative knowledge gain is the mainstay of STEM learning and attainment.**

29. With the discussion of knowledge comes the question of interdisciplinarity. As a collection of largely subject-specific learned societies, we are understandably in favour of learners receiving a broad but enduring exposure to the individual STEM subjects to provide them with the foundation to support further progression. It is only after this disciplinary infrastructure is in place that truly meaningful interdisciplinary learning can occur. **Scotland should continue to uphold the value of disciplinary knowledge whilst making space for interdisciplinarity in order to keep pace with the changing nature of the labour market and indeed the 21st century.** The causative factors behind society's greatest modern challenges - from climate change to an ageing population to digital transformation to regulating the use of personal data - are multifaceted and will not be addressed through siloed thinking. Present and future learners must continue to receive a thorough grounding in the subjects as well as the chance to creatively apply this knowledge. The Royal Society of Edinburgh has done considerable work on embedding interdisciplinary learning across Scotland's schools, using the analogy of 'pillars' (the disciplinary foundations) and 'lintels' (the interdisciplinary connections) to illustrate how interdisciplinarity can serve to enhance rather than undermine the disciplines.³⁸

Question 10: Do you have any other comments that you would like to provide about a vision for the future of Scottish Education?

30. Although Scotland's vision of building a learner-focused system is laudable, it must not come at the expense of teacher wellbeing. Implementing the full suite

³² <https://www.iop.org/careers-physics#gref>

³³ [https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196\(21\)00278-3/fulltext#seccestitle130](https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(21)00278-3/fulltext#seccestitle130)

³⁴ <https://www.rsc.org/new-perspectives/sustainability/a-sustainable-chemistry-curriculum/>

³⁵ <https://www.gov.scot/publications/putting-learners-centre-towards-future-vision-scottish-education/>

³⁶ <https://core.ac.uk/download/pdf/18621258.pdf>

³⁷ <https://rse.org.uk/expert-advice/advice-paper/rse-education-committee-response-to-oecd-review-of-curriculum-for-excellence/>

³⁸ <https://rse.org.uk/expert-advice/advice-paper/interdisciplinary-learning-in-schools/>

of recommendations from the OECD review and the Muir review will place increased burdens on teachers, such as greater investment in curriculum design and development (e.g. as specified in OECD recommendation 1.4). A recent survey of over 16,000 Scottish teachers indicates seven out of ten Scottish teachers report feeling stressed 'frequently or all of the time' in their job, with staffing challenges cited as a primary cause for this strain.³⁹ As these figures indicate, the issue of teacher recruitment and retention is crucial. **If teachers are to devote an increasing proportion of their time towards professional and curriculum development (OECD recommendation 3.1, which we continue to endorse), then teaching capacity must be correspondingly increased and teacher wellbeing duly prioritised.**⁴⁰ This will be very challenging in many of the STEM subjects, where schools are already experiencing severe teacher shortages. There needs to be more research into how to resolve these challenges, building on existing research on addressing the shortage of Computing Science teachers in Scotland⁴¹ and a commitment to implementing the recommendations of such research.

31. If teachers are to meet these expectations, they will need access to ongoing, well-designed support, including subject-specific support. For example, delivering the fundamentals of the STEM subjects in primary schools requires deeper STEM subject expertise in primary teachers than is currently common. At the secondary level, keeping up with subject developments to ensure up-to-date curricula is particularly challenging in the STEM subjects, which are fast-moving, and requires access to sustained career-long professional learning.

32. High quality subject-specific professional learning is very effective at improving the quality of teaching and learning^{42,43} and therefore the outcomes of young people and the performance of the education system as a whole. Research, including Education Scotland's practitioner⁴⁴ surveys of career-long professional learning

in the STEM subjects, has shown consistently that teachers at all stages from early learning to secondary would most like additional professional learning in: improving pedagogy in the subject(s) they teach; in improving skills progression; and in curriculum making. These last two perhaps reflect the lack of a clear curriculum structure which sets out what knowledge and skills children and young people need to be able to know, do, or understand, and therefore ambiguity over what teachers ought to teach. The Institute of Physics, working with other subject bodies across the whole curriculum and not just the STEM subjects, has called for a national system of subject-specific professional learning for all teachers at all levels enabling a move to teachers having an entitlement and access to subject-specific professional learning for at least 50% of their professional learning time. A recent research study which was supported by the Wellcome Trust^{45,46,47} has shown that implementing a programme to support subject-specific professional learning resulted in improvements in all measures and an overall increase in teachers engaging in professional learning. The provision of high-quality subject-specific professional learning in the STEM subjects has also been shown to improve teacher retention and job satisfaction⁴⁸, an important consideration when recruitment of student teachers in many of the STEM subjects continues to fall below targets^{49,50}, and there are difficulties recruiting teachers in the STEM subjects in many geographical areas.⁵¹

Additional information

33. Any enquiries about this advice paper should be addressed to Daria Tuhtar, Policy Manager, at dtuhtar@theRSE.org.uk.

³⁹ <https://www.tes.com/magazine/news/general/survey-shows-scale-stress-among-teachers-scotland>

⁴⁰ <https://www.ase.org.uk/rise-retention-initiative-science-education-programme>

⁴¹ <https://www.research.ed.ac.uk/en/publications/towards-a-sustainable-solution-for-the-shortage-of-computing-teac>

⁴² <https://www.iop.org/about/publications/subjects-matter#gref>

⁴³ https://www.researchgate.net/publication/356459829_Subjects_Matter_for_Scotland_An_Evidence_Paper

⁴⁴ <https://education.gov.scot/media/x0oespxy/stem-professional-learning-survey-2020-21-findings-elc-primary-asn-and-secondary.pdf>

⁴⁵ <https://www.shu.ac.uk/sheffield-institute-education-research/projects/wellcome-cpd-challenge>

⁴⁶ <https://education.gov.scot/media/g50hiodf/stem-professional-learning-survey-2018-19-findings-elc-primary-asn-and-secondary.pdf>

⁴⁷ <https://www.tandfonline.com/doi/full/10.1080/13664530.2021.1989481>

⁴⁸ <https://cms.wellcome.org/sites/default/files/science-teacher-retention.pdf>

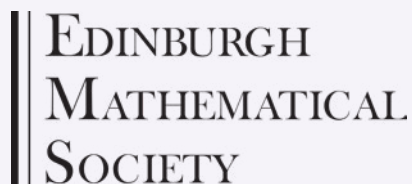
⁴⁹ <https://www.gov.scot/publications/teacher-workforce-planning-advisory-group-initial-teacher-education-intake-figures-2021/>

⁵⁰ <https://www.gov.scot/publications/initial-teacher-education-2020-student-teacher-intake-statistics/>

⁵¹ https://archive2021.parliament.scot/S5_Education/Inquiries/20170502NorthernAllianceResponseTeacherWorkforce.pdf



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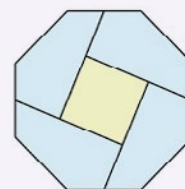


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