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LEARNED SOCIETIES' GROUP ON SCOTTISH STEM EDUCATION

BRIEFING PAPER FOR THOSE SEEKING ELECTION TO THE SCOTTISH PARLIAMENT

This briefing paper highlights what the Learned Societies' Group on Scottish STEM Education[1] believes are the most prominent issues for STEM education in Scotland and presents associated recommendations and calls for action. In Section 1, we identify issues that should continue to receive national focus; this includes sustaining progress in areas where Scotland has already achieved measurable improvements or success. In Section 2, we describe those issues on which progress has been slower and should therefore be afforded a high priority for remedial action. In Section 3, we offer context and supporting evidence in support of our positions in Section 2.

Section 1:

We support national aims to:

1. Improve progression into STEM subjects and careers, while also closing the attainment 'gap' between the most and least disadvantaged children.
2. Build a STEM-literate society and workforce and use it to deliver inclusive economic growth, as laid out by the STEM Education and Training Strategy.
3. Provide high-quality STEM provision for young people at all levels of education.
4. Address gender imbalances and other forms of underrepresentation in STEM areas.
5. Attract and retain teachers and support career-long professional learning for all practitioners, including in STEM.
6. Promote the value of computing science in preparing Scotland's pupils for a digital world and future, as highlighted by the Scottish Technology Ecosystem Review, or 'Logan Review.'
7. Support the development of interdisciplinary learning as a central feature of school, work, and life.
8. Consider the forthcoming outputs of the OECD review of Curriculum for Excellence (CfE) and how these can be enacted to the benefit of the education system.

Section 2:

However, we have concerns about a lack of progress in the below areas and suggest that they be considered a priority for remedial action:

- Senior phase curriculum structures – most notably a narrowing of subject choice at the senior 4 (S4) level – have resulted in a **reduced uptake of STEM qualification courses**.
- Senior phase teaching in the sciences has become increasingly characterised by **multi-course teaching**, which can have significant implications for teacher workloads and the quality of learning and teaching.
- There continues to be a **shortage of subject-specialist STEM teachers** in Scotland. This has been coupled with a sizeable **decrease in the number of school laboratory technicians** working in Scotland over the past decade. Teacher trainees and probationers have experienced significant disruption due to the pandemic, which may decrease their readiness for the classroom and confidence as they begin their teaching careers. In particular, trainee science teachers will have had fewer opportunities to develop skills in teaching practical work.

1 The LSG, whose remit involves identifying and promoting priorities for STEM education in Scotland, comprises representatives from the: Association for Science Education; BCS, The Chartered Institute for IT; Edinburgh Mathematical Society; Institution of Engineering and Technology; Institute of Physics; Royal Society of Biology; Royal Society of Chemistry; Royal Society of Edinburgh; and Scottish Mathematical Council. We can therefore offer a multidisciplinary perspective on Scottish STEM education. While there are many ways in which Scotland is currently succeeding at ensuring learners receive a strong grounding in STEM, we continue to call for action in key areas that will further enhance the quality and impact of this provision.

- **Access to subject-specific career-long professional learning (CLPL) is uneven, and overall continues to fall short** of what is necessary to build greater confidence and capacity in teaching these subject areas. This is particularly relevant among **primary teachers in some schools/local authorities**, but applies to teachers working at all levels.
- There remain **significant gaps in data** that are necessary in understanding how Scotland's education system is functioning in practice.
- The **COVID-19 pandemic** and its attendant repeated lockdowns have both exacerbated many of the above issues, including renewed questions around assessment approaches and attainment, and introduced new concerns such as the loss of laboratory time and opportunities for practical work. A coordinated national response with at least a 3- to 5-year view will be critical in ensuring progress towards key STEM targets does not stall or regress.

Section 3: A summary of the evidence and arguments that have led to these concerns and calls for action:

Subject choice and the uptake of STEM courses

The issue of reduced subject choice at the S4 level has received considerable Parliamentary attention and laid the foundation for a review of the Curriculum for Excellence (CfE) by OECD in 2020–2021. The LSG is concerned that reduced subject choice has made it more difficult for pupils to pursue STEM qualifications, including in the combinations necessary for a variety of career paths – from medicine through to information technology and architecture. This concern is reflected in an **observed decline in entries across several STEM subjects at SCQF levels 4 and 5 between 2014 and 2020**, including an 18.6% decline in Chemistry entries, a 17.5% decline in Physics entries, and a 28% decline in Computing-related entries.[2] The LSG calls for **greater flexibility in curriculum delivery and in the timing of qualifications, particularly across the early senior phase**. This would enable schools to adopt a wider range of curriculum approaches in line with learner needs that allow more courses to be taken at the S4 level.

The issue of reduced subject choice is particularly pressing in light of evidence that points to greater declines in deprived areas.[3] Research undertaken by the University of Edinburgh indicates that subject choice in Scottish secondary school education is a key driver of social inequalities in entry to higher education and that the sciences are key subjects in facilitating access to higher education.[4]

Multi-course teaching

'Multi-course teaching' refers to the practice of teaching more than one course in the same classroom during the same timeslot, most often in the National 4/National 5 (N4/N5) combination. This means that teachers are effectively teaching two or more different courses simultaneously. **Multi-course teaching is particularly problematic among the STEM subjects due to the highly structured course content and, in the sciences, the need for teachers to also supervise pupils undertaking practical laboratory work**. Recent surveys by the Royal Society of Chemistry revealed that multi-course teaching is prevalent across secondary school chemistry, characterising nearly half of all classrooms. Significantly, of those classes containing N4 students, 92.7% were multi-course and of those containing N5 students, 65.8% were multi-course.[5] The LSG continues to advocate for solutions to the multi-course teaching issue, including **redesigning N4/N5 units to make them more coherent and thus better suited to simultaneous instruction; more simply, giving N4 and N5 units more distinct names could better signal their inherent differences and discourage schools from delivering them in the same timeslot.** Tackling related issues such as teacher shortages will also work to alleviate the need for multi-course teaching.

2 'Computing' in this context includes Computing, Computing Studies, Computing Science, and Information Systems.

3 'Shapira, M. & Priestley, M. (2019) Do schools matter? An exploration of the determinants of lower secondary school subject choices under the Scottish Curriculum for Excellence. Review of Education, Vol. 8(1), 191-238. https://doi.org/10.1002/rev3.3180

4 'Iannelli, C. & Klein, M. (2015). Subject choice and inequalities in access to higher education. University of Edinburgh. https://www.research.ed.ac.uk/en/publications/subject-choice-and-inequalities-in-access-to-higher-education

5 More information on this study can be obtained directly from the Royal Society of Chemistry at educationpolicy@rsc.org.

STEM teacher and technician workforce planning

STEM teachers

While total teacher numbers are currently the highest they have been since 2008, there are fewer Computing (down by 22%), Maths (down by 13%), and Physics (down by 7%) teachers now than there were then.[6] This comes against a backdrop of the introduction of new routes into teaching including bursaries aimed at encouraging new entrants into STEM teaching.

Teacher workforce planning needs to be underpinned by accurate data. This includes having a clear picture of teacher need across individual subjects and in different parts of Scotland. It is also important that data is collected and published on the number of Initial Teacher Education (ITE) entrants that complete their courses and enter the teaching profession, and not only the ITE intake figures.

It is also important that we generate a **better understanding of motivations for entering into and staying in the teaching profession and use this to enhance the visibility and attractiveness of teaching as a career choice**.[7]

School technicians

School technicians are vital to the delivery of safe and effective practical laboratory work in secondary schools and they have been instrumental in supporting school science during COVID-19. Worryingly, **their numbers have been in decline for several years**, with data revealing a decrease of 333 STEM technicians over a ten-year period between 2010 and 2020.[8] Shortly before the pandemic, it was reported there were 879 full-time equivalent STEM technicians working in Scotland.[9] Dwindling numbers of technicians coupled with issues surrounding adequate resourcing of school science can combine to erode the quality of practical lab work. This is made more concerning by the fact that the pandemic has placed additional constraints on the amount and type of practical work that is possible. Practical work is a cornerstone of high-quality STEM education and it is crucially important that the resources and facilities are in place to support it.

Career-long professional learning (CLPL) in STEM

It is recognised that teacher expertise has the greatest effect on student achievement. It is therefore vital that practitioners are supported in developing the knowledge and self-assurance to deliver engaging, inspiring, and inclusive STEM teaching that primes pupils to be successful in these subjects. This requires:

- science and maths to feature prominently in ITE programmes for primary teachers, given that a lack of confidence in STEM among primary teachers has been a longstanding issue in Scotland. The LSG also supports introducing a requirement for all ITE entrants to hold a minimum SCQF level 5 qualification in science.
- teachers at all levels and at all stages, in all schools, having access to high-quality and continuous career-long professional learning (CLPL), covering both subject-specific knowledge and pedagogy. The Institute of Physics has embarked on a campaign of raising the profile of subject-specific CLPL and calling for progress towards a 'sustained world-class system of subject-specific professional development' across the UK, as outlined in its recent *Subjects Matter* report.[10]

Data

There **remain significant gaps in the data that preclude our understanding of crucial issues** such as teacher workforce planning, the resourcing of practical lab work in schools, and the performance of Scotland's learners with respect to international comparisons. Regular and systematic data collection must become an indispensable feature of the educational system if Scotland is to devise the most effective improvement interventions. This also includes the gathering of qualitative data that can help to place quantitative figures in a more meaningful context.

6 Scottish Government. (2021). Teacher census supplementary statistics: secondary school teachers by main subject taught and sex 2008-2020. https://www.gov.scot/publications/teacher-census-supplementary-statistics/

7 In this regard, we cite Professor Judy Robertson's study (commissioned by Skills Development Scotland) of computing science undergraduates as a particularly useful example. Robertson, J. (2019). Towards a sustainable solution for the shortage of computing teachers in Scotland. The Centre for Research in Digital Education. https://www.research.ed.ac.uk/en/publications/towards-a-sustainable-solution-for-the-shortage-of-computing-teac

8 Rodger, H. (2019, 29 December). Fears over Scotland's scientific future as STEM technicians fall. The Herald. https://www.heraldscotland.com/news/18126882.fears-scotlands-scientific-future-stem-technicians-fall/

9 *ibid*

10 Institute of Physics. (2020). Subjects Matter. [online] Retrieved from: https://www.iop.org/sites/default/files/2020-12/Subjects-Matter-IOP-December-2020.pdf

COVID-19

The disruption of successive exam diets due to COVID-19 and the development of an alternative certification model have provoked an **ongoing national discussion about the assessment system in Scotland and whether it is fit for purpose**. Issues including the burden of internal assessments and the relative value of assignments were the subject of sector debate well before the onset of the pandemic and have only grown in importance as the system has been forced to abandon its traditional approaches to assessment in favour of various contingencies. Some of these changes could very well prove to be for the better and could have a lasting place in Scottish assessment, while others may pave the way for further reforms. While continued inquiry is needed, some early lessons – such as the impacts of digital poverty on attainment – can already be incorporated.

There is also a critical need to consider how student progression has been impacted by COVID-19. The **pandemic may have left learners insufficiently prepared to progress to further educational and career destinations or else fundamentally altered their intended progression pathways**. It is possible that disruptions to learning may have disproportionately impacted those studying STEM subjects due to suspensions to lab work and practical placements. It will be important for schools and receiving institutions to work together to arrive at a common understanding of the standards that can reasonably be expected of incoming students and how any gaps in knowledge or skills can be filled. **Sustained action will be necessary to ensure that 'COVID cohorts' do not experience enduring disadvantage.**

We look forward to contributing to discussions around the delivery of STEM education in the new Scottish Parliament. Members of the LSG would be pleased to meet with MSPs to discuss how we can best contribute.

Additional Information

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