

THE LEARNED SOCIETIES' GROUP ON STEM EDUCATION

MAY 2016

Briefing Paper for Members of the Scottish Parliament

The Learned Societies' Group on STEM Education¹ (LSG) welcomes the opportunity to engage with Parliamentarians and decision makers in Scotland on the reforms in Scottish education. The LSG brings together learned societies and professional associations to consider the provision of STEM education in schools. The LSG comprises representatives from the: Association for Science Education; BCS, The Chartered Institute for IT; Edinburgh Mathematical Society; Institute of Physics; Royal Society of Biology; Royal Society of Chemistry; Royal Society of Edinburgh; and Scottish Mathematical Council. In the sections that follow we highlight some key areas in which we have been active. In Section 1, we identify areas that in our view should have a high priority – an opinion that we believe is shared by many others. In Section 2, we identify our concerns about the need for further action in these areas. And in Section 3, we summarise the information we have gathered in coming to our conclusions.

Section 1: **We support the priority given to national aims for:**

- 1** *Improving attainment overall, while also closing the attainment 'gap' between the most and least disadvantaged children.*
- 2** *Maintaining high quality practical science work in schools.*
- 3** *Delivering National Qualifications courses and assessment.*
- 4** *Addressing gender imbalances in STEM areas.*
- 5** *Ensuring a sufficient supply of high quality STEM teachers in Scottish schools.*
- 6** *Establishing initial teacher education programmes and CPD that improve confidence and subject-specific expertise in science and mathematics, at both primary and secondary level.*
- 7** *Supporting the development of interdisciplinary learning as a central feature of life and work.*
- 8** *Recognising that international comparisons of attainments are highly relevant as evidence indicating specific areas in need of improvement.*

Section 2: **However, we have significant reservations about progress in these areas and suggest action needs to be taken urgently. These reservations include, for example:**

- The potential that the National Improvement Framework will have negative implications for learning in the sciences.*
- School science resourcing levels are not sufficient to meet the curriculum requirements.*
- Senior phase teaching in the sciences suffers from multi-course teaching.*
- The impact that the burden of internal assessment has had on the time available for teaching and learning, including practical work.*
- Senior phase curriculum structures resulting in reduced uptake in STEM qualification courses.*
- There has been a decline in the recruitment of STEM teachers.*
- Primary teachers have shown a lack of confidence in their teaching of science.*
- There needs to be greater embedding of interdisciplinary learning in school education.*
- There is substantial concern about the withdrawal of participation in the TIMSS international surveys following disappointing performances by Scottish pupils.*

¹ Information about the LSG is available at: https://www.royalsoced.org.uk/1076_LearnedSocietiesGrouponScottishScienceEducation.html

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

National Improvement Framework

The Framework's priority on improving attainment in literacy and numeracy could have, as an unintended consequence, an adverse impact on teaching and learning in the sciences. In introducing national standardised assessments in Scotland it is useful to consider the experience of the Standard Assessment Tests (SATs) in England. The Science SATs were abolished in England in 2009 (to allow teachers more time to focus on learning and teaching beyond narrow external assessments). National testing in literacy and numeracy has continued in England. However, Wellcome Trust research² shows that since the abolition of the science testing, almost two thirds of teachers surveyed felt that science was now regarded as being of lesser importance in their school when compared with mathematics and English. In implementing the National Improvement Framework the Government needs to set out how this potential consequence will be avoided.

Resourcing of Practical Science in Scottish schools

Recognising that very little data had been gathered about the funding of science in Scottish schools since the start of the century, the LSG investigated this issue in 2014. A further impetus to gather up-to-date information in Scotland was the work undertaken by the Science Community Representing Education (SCORE) on the resourcing of practical science at primary and secondary school levels in England³. The SCORE research highlighted an acute shortage in schools of essential equipment and consumables for practical work in science. There were concerns the situation may be similar in Scotland.

The LSG commissioned a survey from Pye Tait of 39 primary and 46 secondary schools into the state of funding and practical equipment resourcing for supporting the science curriculum in Scotland. While these were small samples, they nevertheless represent data from more than 12% of publicly-funded secondary schools.

The survey report⁴ indicated:

- *School science resourcing levels are not sufficient to fully and effectively meet the requirements of the curriculum.*
- *Equipment and consumable provision is not sufficient, including secondary schools experiencing difficulties in providing equipment to support the new Curriculum for Excellence courses.*
- *Funding allocated to science resourcing in school budgets is not sufficient, with 98% of surveyed schools stating that they draw on additional funding sources (including parental and teacher contributions) for practical activities.*
- *High levels of dissatisfaction, especially among secondary schools (80% of respondents), at the funding available for science practical work. In addition, 44% of secondary school respondents were concerned about the level of technician support for delivering practical science work*

Among the surveyed primary schools in Scotland the average annual spend on science per capita was £1.62 in 2013–14. This compares with an average *per capita* spend on science of £2.89 in 2011–12 in primary schools in England, as reported by SCORE. Among the surveyed secondary schools in Scotland, the average spend on science per capita was £7.33 in 2013–14. This compares with an average *per capita* spend on science of £10.12 in 2011–12 in state maintained secondary schools in England, as reported by SCORE.

The LSG is keen to ensure that pupils are provided with enthusing, high-quality learning experiences in the sciences, including invaluable practical work, where they can develop their experimentation and problem-solving skills. While the LSG recognises that its study provides an indication only of the Scotland-wide picture, it commends the Scottish Government to consider undertaking larger-scale research into the resourcing of school science. We recognise that presently the allocation of school budgets is the responsibility of education authorities and schools. There would seem to be a case to consider the respective accountabilities and responsibilities of the Scottish Government, education authorities and individual schools for the resourcing of science in schools. This approach would be in line with the recent report from the OECD on Curriculum for Excellence (CfE) which highlighted the mismatch between the statutory responsibilities of local authorities for school education and their ability to influence the strategic direction of the education reforms.

² *Primary Science Survey Report*; Wellcome Trust; December 2011

³ SCORE resourcing practical science reports (2013) information available at:
 Primary – <http://www.score-education.org/media/11808/score%20resourcing%20primary.pdf>
 Secondary – <http://www.score-education.org/media/11805/score%20resourcing%20secondary.pdf>

⁴ Both the summary and full survey analysis are available from: <https://www.royalsoced.org.uk/news/news.php?id=263>

Delivery of National Qualification Courses and Assessment

Given its established links to teacher networks, the development and delivery of science qualification courses has been a prominent area of activity for the LSG. The LSG recently responded to the Scottish Government's review on improvements to qualifications and assessment in the context of teacher workload concerns. We look forward to engaging in the implementation of the review findings. The LSG has commented on the following key areas:

Multi-course teaching

A prominent issue for the teaching of the sciences relates to the current practice of multi-course teaching of courses (i.e. where two or more distinct courses e.g. National 4, 5 (and Higher) are being taught simultaneously in one class). Science teachers have expressed concern that multi-course teaching does not allow them to fully support the needs and aspirations of pupils undertaking different levels of national qualifications. However, the learning outcomes, content and assessment of the new National courses at different levels can be substantially different, making multi-course teaching very demanding and undesirable. The Scottish Government along with Education Scotland and SQA recognise that this needs to be addressed. Making progress will depend on ensuring that local authorities and schools are given appropriate guidance and support on the way in which the senior phase (S4-S6) is structured, including on the timetabling of science courses.

Demands of Internal Assessment

STEM teachers have expressed widespread concern about the burden and time demands associated with internal assessment and the implications this has for the time available for learning and teaching. In seeking to reduce the assessment burden in STEM subjects, SQA has removed and consolidated some of the assessment standards and improved the communication of changes made to course documentation. We also understand that for session 2016/17 additional changes are planned by SQA to further ease the internal assessment burden. Ultimately, assessment should effectively support learner progression. We continue to encourage consideration to be given to practical approaches to reduce the burden of internal assessment, including exploring whether duplication in what is being assessed across different subject areas can be removed. Additionally, while course assessments in

the majority of subjects are marked externally, in the case of Computing Science, coursework has to be marked by the teachers internally (without any recompense). It is not clear to us why this should be the case and we are concerned that it is exacerbating the assessment burden. This anomalous position should be reviewed by SQA.

Uptake of STEM courses

Ensuring the provision of well-informed, high quality, careers advice at primary and secondary schools is very important in promoting STEM subjects and careers to pupils. The LSG is monitoring the implications of the national qualifications on the uptake and attainment in the STEM subjects. We are concerned about the potential for narrowing of the curriculum and the implications this has for studying the STEM subjects in the senior years at school. LSG analysis of the SQA Attainment Statistics⁵ indicates that the number of candidates presenting for STEM qualifications at SCQF levels 4 and 5 has declined between 2013 (last year of Standard Grades) and 2015. Over this period Computing-related (which includes Information Systems) presentations are down by 29.3%; Chemistry is down by 11.3%; Biology is down by 7.9%; Physics is down by 4.8%; and Mathematics is down by 3.9%. We also note that between 2014 and 2015 the number of Higher entries decreased in the STEM subjects. This downturn in Higher STEM presentations is particularly notable as they had generally been on the rise in the preceding period from 2011. There is a need to keep under review the evolving pattern of course uptake in the context of schools' S4-S6 curriculum structures, particularly the number of qualification courses that can be taken by learners in S4.

In this context, research⁶ undertaken by the University of Edinburgh indicates that subject choice in Scottish secondary school education is a key driver in social inequalities in entry to Higher Education. Within the research, the sciences are recognised as being key subjects in facilitating access to Higher Education. Subject choice in secondary education is therefore very important in relation to the national imperative to address the attainment gap in Scotland and widen access to university. The research states, "*Choices... require careful management to ensure that they do not end up reinforcing existing inequalities.*" This emphasises the requirement for clear information, guidance and support in relation to how the senior phase is structured.

⁵ SQA Attainment Statistics (August) 2015: <http://www.sqa.org.uk/sqa/64717.html>

⁶ Iannelli, C & Klein, M 2015; 'Subject choice and inequalities in access to higher education'; University of Edinburgh http://www.research.ed.ac.uk/portal/files/19338170/RB7_subject_choice.pdf

Improving STEM Gender Balance

One of the major challenges facing some STEM subjects is in improving the proportion of girls studying and progressing in them – particularly in physics, computer science and engineering. In physics in 2015 for example, the proportion of girls to boys in National 5 – Advanced Highers ranged from just 20% in Advanced Highers to 28% in New Highers. While on average the proportion of girls studying physics in Scotland is slightly higher than in the UK as a whole, there is still a significant gender imbalance which is restricting opportunity and preventing talented students progressing in the discipline.

Launched in December 2015, *Improving Gender Balance Scotland* is a joint partnership programme from Skills Development Scotland (SDS), the Institute of Physics and Education Scotland. Recognising the long-term and deep-seated gender imbalances in the study of the STEM subjects, the project seeks to challenge stereotypes, prevent early bias in career choices and break down barriers to support diversity in STEM subjects in the early years, primary and secondary schools.

STEM teacher recruitment

The supply of STEM teachers in Scotland has declined since 2008. Teacher Census data⁷, published by the Scottish Government, indicate that between 2008 and 2015 the number of publicly funded secondary school teachers declined by 22% in computing studies, 16% in mathematics, 9% in physics, 6% in chemistry and 1% in Biology. Since academic year 2014/15, Scotland's initial teacher education providers have been set subject specific targets (which are increasing) for student teacher recruitment with a view to better matching supply with demand. However, meeting these targets is proving to be very challenging and will require concerted effort from the organisations represented on the Teacher Workforce Planning Advisory Group, led by Scottish Government. The Government has recently launched a teacher recruitment campaign in STEM subjects. The LSG will monitor developments in this area and do what it can to promote STEM teaching as a career choice. Increasing STEM teacher recruitment will only be successful if teaching is perceived to be attractive (indeed, visible) in the face of competition from other (potentially more lucrative) career options.

Primary Science

*Teaching Scotland's Future*⁸ was clear on the need for science to feature prominently in initial teacher education programmes for primary teachers. In evaluating current school practice in the sciences, Education Scotland reported⁹ that a lack of confidence in teaching the sciences is still an issue for many primary teachers. This reinforces the importance of current primary teachers engaging in STEM-related professional learning and development opportunities throughout their careers. The provision of time, resource and support is crucial to enabling teachers to take up development opportunities.

Unfortunately, it is difficult to determine the exact number of primary teachers with a science background as this data is not routinely collected or published. The Royal Society of Chemistry has been running a campaign¹⁰ in Scotland to increase the supply of primary school teachers confident to teach science. As well as recommending the collection of improved data on the science background of teachers, the RSC is calling for the Scottish Government to commit that by 2020 every Scottish primary school (or school cluster for small primaries) should have access to a science subject leader, whose role is to support their colleagues in the teaching of science across a school.

Interdisciplinary Learning

A central and distinctive context for learning in CfE is *interdisciplinary learning* (IDL). There is accumulating evidence and argument to support the importance of IDL in imparting skills for learning, life and work, transferable and higher order skills, and the capacity to engage disengaged learners. Employers seek school leavers and FE/HE graduates with these enhanced skills and attributes. While IDL has been recognised as an important aspect of the curriculum for many years, it requires better understanding, articulation and exemplification if it is to be embedded in school education. A crucial part of this is that research is required to gauge how classroom teachers are construing IDL and to inform its development. Another important consideration is the recognition IDL is accorded in formal qualifications – teachers will look to SQA to provide leadership in IDL implementation.

⁷ Scottish Government Teacher census, supplementary data, 2015
<http://www.gov.scot/Topics/Statistics/Browse/School-Education/teachcensussupdata/teachcensus2015>

⁸ Report of a review of teacher education in Scotland; Graham Donaldson; Scottish Government; 2010
<http://www.gov.scot/Resource/Doc/337626/0110852.pdf>

⁹ The Sciences 3-18; Education Scotland; September 2013 Update
http://www.educationscotland.gov.uk/Images/Sciences3to182013Update_tcm4-817013.pdf

¹⁰ Royal Society of Chemistry: Primary Science in Scotland: the importance of subject knowledge
<http://www.rsc.org/globalassets/04-campaigning-outreach/campaigning/campaign-for-specialist-teaching/parliamentary-briefing-scotland.pdf>

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Along with STEMEC (the STEM Education Committee, which provides independent advice to Scottish Government on STEM education), the LSG has been coordinating a national programme and 5-year action plan to support the provision of IDL in schools. This is being taken forward by a national action group comprising senior representatives from key education organisations in Scotland, including Scottish Government, Education Scotland, SQA, GTCS, school leaders, teaching unions, HE and FE, initial teacher education institutions and parents' associations. Continued progress will be dependent on these organisations taking responsibility and being accountable for the implementation of IDL.

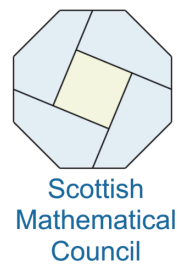
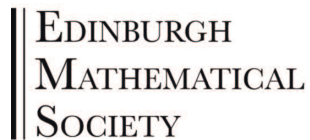
We look forward to monitoring and informing discussions around the delivery of STEM education in the new Scottish Parliament. In so doing, members of the LSG would be pleased to meet with MSPs to discuss how we can best contribute.

International Comparator Measures

The 2008 TIMSS Report, an international assessment of pupil attainment in maths and science at primary and secondary level, found that Scotland was behind the global average for science at P5 (ages 9–10) and S2 pupils (13–14 years old). Subsequently, Scotland has withdrawn from the TIMSS survey. It is therefore no longer possible to determine whether there has been a change in pupil attainment relative to international comparable measures. We strongly encourage the Scottish Government to re-enter TIMSS.

**For further information about the Learned Societies' Group,
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The Association for Science Education Charity No: 313123

BCS is a registered charity No: 292786

The Edinburgh Mathematical Society (EMS) is a registered Scottish charity, No. SC000241

The Institute of Physics is Registered charity number 293851
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