ROYAL STATISTICAL SOCIETY

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Response to Scottish Government consultation on strategy for education and training in Science, Technology Engineering and Mathematics (STEM)

The Royal Statistical Society (RSS) is a learned society and professional body for all statisticians and data analysts, with more than 8,000 members in the UK and across the world. As a charity, one of our key strategic goals is to support education in order for society to be more statistically literate.[1] Therefore in addition to offering courses and professional development for our own profession, we seek to engage a much wider range of people through our statistical literacy initiatives,[2] and through our *Data manifesto* and engagement with government policy.[3] In keeping with this work, we welcome the opportunity to respond to this consultation on a STEM education and training strategy for Scotland.[4]

Q 1: "What is STEM?

Science, Technology, Engineering and Mathematics education and training seeks not only to develop expertise and capability in each individual field but also to develop the ability to work across disciplines and generate new knowledge, ideas and products through inter-disciplinary learning.

- Science enables us to develop our interest in, and understanding of, the living, material and physical world and develop the skills of collaboration, research, critical enquiry and experimentation.
- Technologies cover a range of fields which involve the application of knowledge and skills to extend human capabilities and to help satisfy human needs and wants, operating at the interface of science and society. This covers business, computing science, chemicals, food, textiles, craft, design, engineering, graphics and applied technologies.
- Engineering a specific branch of the technologies, draws on scientific methods and knowledge to address and solve real-world problems.
- All of STEM is underpinned by Mathematics, which includes numeracy, and equips us with the skills we need to interpret and analyse information, simplify and solve problems, assess risk and make informed decisions.

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[1] Royal Statistical Society Strategic Plan 2014-2018 [PDF], available from: http://www.rss.org.uk/Images/PDF/about/strategy-summary_flr.pdf

[2] Royal Statistical Society, 'Statistical literacy' [webpage], available at: http://www.rss.org.uk/RSS/Influencing_Change/Statistical_literacy/RSS/Influencing_Change/Statistical_literacy.aspx

[3] Find our note on Education and skills for the data economy here: http://www.rss.org.uk/Images/PDF/influencing-change/2016/Manifesto-Briefing-Note-10-Education-skills-data-economy-FINAL-25-Nov-2016.pdf

[4] Online at https://consult.scotland.gov.uk/stem/a-stem-education-and-training-strategy/

- Similarly, digital skills play a huge and growing role in society and the economy and enable the other STEM disciplines. Digital skills embrace a spectrum of skills in the use and creation of digital material, from basic digital literacy, through problem solving and computational thinking to the application of more specialist computing science knowledge and skills that are needed in data science, cyber security and coding."

Do you agree with the definition provided of STEM for the purposes of this Strategy?
Changes that are being driven by information technology and digital innovation have created many new skills along with new and sometimes confusing ways to describe them, such as 'data science', 'digital skills' and 'informatics'. We find it helpful to think of statistics as a problem solving activity that seeks to glean information from data, and which is underpinned by mathematics, especially the mathematics of probability. New forms of data and analysis driven by digital innovation mean that these skills are increasingly important in subjects beyond traditional subject disciplines in science, technology, engineering and mathematics. Chemistry, life and pharmaceutical sciences and medicine, many of the social sciences and also the growing field of 'digital humanities' similarly require scientific skills and what we term 'data skills'. In employment it is not just numeracy, but the ability to use, analyse and evaluate data that has become a key skill requirement in almost all sectors.

We highlight the importance of the distinction between foundational scientific and data skills and STEM subjects in our response to some of the consultation questions below. We welcome the recognition that maths underpins all of STEM, and also the specific reference to numeracy. However, we would also welcome explicit reference to both data skills and statistics, although the authors may intend that these subjects are included within 'digital skills'. Extracting meaning and value from data is a skill that is fundamental to a fast growing proportion of jobs in the digital economy. Numeracy alone, without some knowledge of appropriate ways to draw conclusions from data, is not enough to develop these skills. A strengthening of Numeracy Across Learning and recent reforms to mathematics teaching, such as the introduction of Lifeskills Mathematics and the stand-alone Statistics Award (SCQF 6) have given increased attention to statistics; this is welcomed and is of special relevance to Continuing Professional Development in teaching.

Many children have 'digital skills' in the sense of facility with the web, social media and so on. However, these skills have little to do with dealing with *data*, which is what lies at the core of STEM, and the kind of skills the Strategy wishes to promote. We think it would be useful to set out in a little more detail what 'digital skills' comprise, and ensure that sufficient emphasis is given to the production, evaluation, analysis and interpretation of data, and the quantitative reasoning skills that it requires.

Q2 Aims and Priorities: Do you think the aims of this Strategy[5] and the four priority themes are the right ones to address the challenges identified?

As currently formulated, the two aims and the wording of priority 3 could have the unintended and unfortunate consequence of encouraging partners in the delivery of the strategy to think of 'STEM inspiration and enthusiasm' on the one hand, and 'specialist STEM skills' on the other as two distinct areas. In our experience efforts to persuade pupils or students (including under-represented groups) to learn these skills because of the benefits they bring are far less effective than when learners actually discover and see these benefits in their own learning experience. Otherwise too many learners conclude that these benefits are for others with greater aptitude for these skills to enjoy. This requires that teachers are able to make connections between the skills they teach and their practical application in learners' own experience. Then enthusiasm is generated from being able to master a new and attractive skill.

Over the last two decades many efforts have been made to encourage young women to study STEM subjects. However, as the data included in Table 1 (attached) show, the proportion of students entering SCQF level 6 (Higher or its equivalents) exams in Maths, Chemistry and Physics in Scotland who are female has remained virtually unchanged over the last twenty years, while in Computing it has fallen from around one quarter to one sixth. The data revolution provides a new and vital opportunity to engage young women, since many of the subjects that they continue to choose to study, including the biological, life and social sciences, are ones where these STEM skills are now necessary and becoming ever more important.

Q3. Are these success criteria right? If not, tell us what criteria we should use instead.

Consistent with our comments on Q1, we would see scientific and data skills as relevant to almost all disciplines, not just those traditionally defined as STEM, and think that the wording of outcome 1 should make this clear.

Consistent with our comments on Q2, we are not clear that the actions proposed in the strategy would deliver outcome 3, when previous efforts to shift this balance have been unsuccessful, not only in Scotland but elsewhere. However, recasting this outcome in term of skills rather than named qualifications, would help direct efforts to ensuring that the skills prioritised by this strategy are given proper attention within the subjects that young women will continue to want to study.

As currently formulated, it is not clear what metrics, milestones or other criteria could be used to evaluate progress or 'success'. We would welcome at least some measureable or quantifiable

[5] At http://www.gov.scot/Publications/2016/11/4147/0

indicators of progress, especially those which record practical changes. For example, more detail on what 'relevant and engaging STEM learning' comprises and how it is to be achieved would be helpful. Currently the development of STEM skills in Scotland has a fragile and fragmented evidence base. Remedying this deficit would facilitate better monitoring of progress and decisions about priorities.

We agree with the Curriculum for Excellence statement that support for Numeracy should be the responsibility of all teachers, and agree with the Maths Excellence Group (MEG) that 'young people must be able to apply the key mathematical skills and understanding they have acquired in new, non-routine and relevant contexts'[6]. However, this requires that teachers have the time and support to develop projects across different school subjects and to ensure that school pupils experience a consistent approach in the development of these skills: something that can often be hampered, for example, by the way in which the language of maths varies across STEM subjects, as the recent Association for Science Education report *The Language of Mathematics in Science: A Guide for Teachers of 11-16 Science*[7] showed. We strongly endorse the MEG recommendation that 'School leaders should consider [h]ow to develop a shared understanding and agreement among all teachers of key numeracy concepts, definitions, terminologies and teaching methodologies. This is essential to ensure that learners can make the desired connections in their mathematical learning across the curriculum areas.' We know from much pedagogical research that meaningful curriculum change depends upon the appropriate reform of assessment, since the latter is so often the main driver of both pupil and teacher priorities, it was thus disappointing to see the very limited change in the assessment material for the new Higher Mathematics.

We acknowledge the continued provision of Advanced Higher Statistics and the introduction of the Statistics Award at SCQF Level 6, but note that there is much scope for further development given the low numbers currently studying these qualifications.

Q4 Scope: Do you think the scope of the Strategy is right? Tell us if you think it should exclude something or include anything else. For example, should it include training and development that employers provide for their workforce?

We welcome the emphasis on teacher education and teachers' professional development, including for early years teachers, and on ensuring that all teachers take responsibility for numeracy. We also think that the scope should include some more comprehensive discussion of

[6] Excellence in Mathematics Report from the Maths Excellence Group, Available at: http://www.gov.scot/Resource/Doc/91982/0114466.pdf

[7] R. Boohan *The Language Of Mathematics In Science A Guide for Teachers of 11–16 Science*, Association for Science Education, Association for Science Education, 2016. Available at http://www.ase.org.uk/documents/language-of-mathematics-in-science-1/

skills shortages and resources. The emphasis on education to enlarge the skills pool is welcome, but again we feel that some more specific plans for how this is to be done would be helpful. In particular, more might be said about Continuing Profession Development for those involved in STEM skills delivery at all levels of education, and about the resources available to those agencies responsible for the delivery of the strategy. Developing the statistics components of the maths curriculum, and ensuring that teachers both in mathematics and in other subjects are comfortable with the use and interpretation of data is a major challenge.

Q5 Current Actions: Give us your views on whether you think the actions already underway across the sectors on STEM fit well with the Strategy and will contribute positively to it.

For higher education, the 'Q-Step' programme for the social sciences run by the Nuffield Foundation, ESRC and HEFCE is a welcome initiative. The programme administers £19.5 million in funding to promote and implement a step-change in quantitative social science training in the UK. We think that there are strong potential links between Q-Step and schools and colleges implementing relevant post-16 programmes. However, Q-Step is delivered in only two universities in Scotland (Glasgow and Edinburgh), only directly reaches undergraduate courses, and is only for social science disciplines. We question whether training in quantitative methods forms a large enough part of all the subjects that use them, and we would appreciate greater monitoring and funding for this, particularly to prepare people in life sciences, medical sciences and social sciences.

For delivery within schools, Census at School https://www.stem.org.uk/elibrary/collection/3317 has provided good examples and tasks for pupils to improve understanding of a data gathering process, its purpose and benefits to society. This project is currently being reviewed in preparation for the Census programmes in 2021. Another resource which focuses on Scotland's Census 2011 has recently been promoted by Education Scotland through their GLOW portal. The modules on "Using open data to develop statistical literacy in schools" provide a professional learning opportunity that focuses on the use of Scotland's census as data for use in the classroom. This resource supports practitioners to address both Numeracy across learning, and enhancing learning and teaching through the use of digital technology, but perhaps its location on the National Numeracy and Mathematics Hub is restrictive and as such fails to reach across learning practitioners who would most benefit from such a professional learning opportunity. Other outreach offers from Scottish universities on statistics are substantial and include 'Massive Open Online Courses' which are open for anyone to sign up to. We look forward to the RSS conference taking place in Glasgow this year, which features a session about promoting statistical literacy in Scottish schools.

Q8 Implementation: What else should Government do to ensure a more coherent approach and maximise impact?

Developing a successful strategy and judging its results depends upon robust and accessible data. It is unfortunate, for example, that statistics on entries and performance in examinations in STEM subjects provided by the SQA do not make it possible to examine how many boys or girls entered or passed from schools. (E.g. data are provided by gender for schools and colleges together, and by schools and colleges separately but for both genders.) It is sometimes a cumbersome process to piece together trends over time from individual annual reports, and statistics on Scottish Education are produced both by Education Scotland and the SQA, which adds to the difficulty. However, such data is vital to any assessment of both existing challenges and future progress. It would be helpful were the STEM strategy to set out the key data that is relevant to its success, and facilitated its publication in an accessible format.

While the strategy makes clear that everyone has a part to play in raising the standard and broadening the reach of STEM skills in Scotland, successful implementation would be helped by ensuring that key individuals have a specific responsibility for delivering its constituent parts and reviewing progress, and have the time and resources to do so effectively. Changing attitudes and practices and building partnerships takes time, and will be more likely to happen when individuals and organisations have specific goals and clear priorities.

Qs 9-14 on Proposed actions

Hitherto efforts to overcome the gender balance in STEM skills has focused on encouraging girls and women to study STEM subjects, but with disappointing results. While these efforts must continue, we need to ensure that additional efforts are made to strengthen foundational scientific and data skills within the subjects that girls and women currently continue to prefer to study. This is facilitated by the way in which these skills are becoming more important within those subjects in any case, so that our efforts work with and benefit from existing trends.

The supply of suitably qualified and trained teachers is critical to the successful delivery of these skills. This goes beyond the need for specialist teachers in mathematics. Teachers of the sciences, social sciences and the humanities also need to incorporate numerical evidence and data into their teaching. Therefore, the recruitment, retention and professional development of data-literate teachers is important. This will require a strategic approach to considering the teaching workforce, at primary, secondary and college level. A key consideration of this strategic approach would be to ensure geographic equity, where teachers with expertise in the mathematical and data sciences are employed in all regions of Scotland.

Universities could, using the experience of Q-Step where relevant, help with maths based CPD across the school curriculum. This might be through the development of teaching and learning materials (for pupils and for teachers), provision of CPD sessions, and knowledge transfer around the advantages and pitfalls on-line learning. These are all areas where Q-Step has built up a pool of knowledge about how best to deliver these skills from a narrow teaching skills base.

The Scottish STEM ambassadors programme could be widened from the core STEM subjects to include other disciplines that rely on the skills this strategy supports, and help to demonstrate to pupils the relevance of mathematics and data skills to almost all post-school study, future employment, and in becoming effective contributors and responsible citizens in Scotland and wider societies.

The two Scottish Q-Step centres have established a successful programme off student placements with employers, that is a good example of links between HE and employers. This model could be developed to support many aspects of the STEM strategy. For example, student placements at the SQA could help with the task of providing data to inform and evaluate the strategy. However, the staff time and commitment needed to develop such links effectively should not be underestimated.

Attached:
Table 1 Entries to Higher in STEM and related subjects by gender, Scotland 1996 to 2016 as Excel Spreadsheet.

[Response ends]

Submitted by the Head of Education and Statistical Literacy, Royal Statistical Society, 31 January 2017.