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**Nuffield Foundation and Professor John MacInnes (on behalf of the Q-Step Centres at the Universities of Edinburgh and Glasgow) submission to the Scottish Government's *Science, technology, engineering and mathematics: consultation on a strategy for education and training***

1. The Nuffield Foundation is a charitable trust established by William Morris, Lord Nuffield, the founder of Morris Motors. Our aim is to improve social well-being and we do this by:
  - Funding research and innovation projects in education and social policy. In 2015 we funded 34 new projects with a total value of £5 million.
  - Building research capacity in science and social science, most notably through Q- Step, a £19.5m programme designed to promote a step-change in quantitative social science training for undergraduates (co-funded with the Economic and Social Research Council (ESRC) and the Higher Education Funding Council for England (HEFCE)), and Nuffield Research Placements (NRP), which provide over 1,100 Year 12 students each year with the opportunity to undertake a STEM research project in a professional environment.
2. Since its inception in 1943, the Nuffield Foundation has been an active funder of STEM projects, including research into mathematics and science education, curriculum development and support for the 'STEM pipeline' (through programmes such as Nuffield Research Placements). On a day-to-day and strategic basis, our work is intrinsically linked to the education systems in the UK and we have a strong track-record in supporting social equity and the development of scientific thinking and mathematical ability for young people. This experience makes us well-placed to offer an informed view on STEM education and training.
3. In considering this issue, it is also important to take stock of what the available labour market evidence tells us about the availability of STEM skills for work and research. The most recent labour market assessment from the UK Commission on Employment and Skills (UKCES) does indeed identify an economic need for more STEM skills, however the gaps tend to be in quite specific occupational areas.<sup>1</sup> To some degree this complements previous research which found that notable proportions of STEM graduates progressed to non-STEM occupations.<sup>2</sup>

<sup>1</sup>[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/444048/High\\_level\\_STEM\\_skills\\_requirements\\_in\\_the\\_UK\\_labour\\_market\\_FINAL.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/444048/High_level_STEM_skills_requirements_in_the_UK_labour_market_FINAL.pdf)

<sup>2</sup>[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/32379/11-771-stem-graduates-in-non-stem-jobs.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/32379/11-771-stem-graduates-in-non-stem-jobs.pdf)

4. Our submission deals with each of the consultation questions in turn, noting where our work has particular relevance or where we wish to reflect on some of the underlying assumptions.

## Q1 Definition

5. For many years the Nuffield Foundation's support for STEM skills in schools and beyond focused on the development of science curricula.<sup>3</sup> In collaboration with the learned societies, we have also sought to address concerns about the development of practical science skills in school by developing protocols and guidelines which are used extensively by teachers and with notable impact.<sup>4</sup> The Foundation has also acted to address STEM skill shortages in other areas, such as the development of postgraduate research skills in the field of rheumatism.<sup>5</sup>
6. More recently, we have focused on the development of scientific thinking *per se* and would agree with the Organisation for Economic Cooperation and Development (OECD) which recently commented that 'in the context of massive info flows and rapid change, everyone needs to be able to "think like a scientist".<sup>6</sup> In addition, the Foundation has been a strong advocate for increased uptake and use of mathematics throughout education (and certainly beyond 16).<sup>7</sup> We certainly agree that 'all of STEM is underpinned by Mathematics, which includes numeracy'. Indeed, it seems clear that Scotland, as with the UK *per se*, needs to improve the numeracy levels of its graduates and citizens more generally.<sup>8</sup>
7. However, the definition of STEM used in the consultation document tends to imply that STEM skills are the preserve of STEM disciplines alone. We would disagree and hope that some of what follows shows why scientific thinking and managing data and numerical fluency can be encouraged in many parts of the curriculum.
8. Whilst the UK Government's concern for the loss of excellence in certain STEM disciplines in Higher Education was crystallised in the 'Strategically Important and Vulnerable Subjects' initiative, the original report also highlighted the need for more quantitatively trained social scientists.<sup>9</sup> The Nuffield-ESRC-HEFCE funded Q-Step Programme was developed to address this need and was recently cited as a way of helping to meet the economic need for more numerically able graduates.<sup>10</sup> Equally, the British Academy has highlighted the way in which quantitative skills are increasingly seen as central to many disciplines beyond the traditional suite of STEM subjects.<sup>11</sup>
9. We therefore propose that the conception of 'STEM skills' and 'STEM careers' needs to be broader than simply including the traditional set of subjects and career pathways – quantitative skills acquired as part of social science training being a case in point.

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<sup>3</sup> [http://www.nuffieldfoundation.org/sites/default/files/files/Half\\_a\\_century\\_of\\_curriculum\\_dev\\_v\\_FINAL\\_WEB.pdf](http://www.nuffieldfoundation.org/sites/default/files/files/Half_a_century_of_curriculum_dev_v_FINAL_WEB.pdf) and <http://www.nuffieldfoundation.org/curriculum-projects#Science>

<sup>4</sup> <http://www.nuffieldfoundation.org/practical-biology> , <http://rsc.li/2iYeO0N> , <http://practicalphysics.org/>

<sup>5</sup> <http://www.nuffieldfoundation.org/oliverbird>

<sup>6</sup> <http://www.oecdmybrochure.org/edu/newsletter/>

<sup>7</sup> [http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics\\_after\\_16\\_v\\_FINAL.pdf](http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics_after_16_v_FINAL.pdf)

<sup>8</sup> <http://www.compareyourcountry.org/> and <http://www.oecd.org/skills/piaac/Country%20note%20-%20United%20Kingdom.pdf>

<sup>9</sup> <http://www.hefce.ac.uk/pubs/year/2011/201124/>

<sup>10</sup> <http://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/992/992.pdf>

<sup>11</sup> [http://www.britac.ac.uk/sites/default/files/Count-Ups-In-Full-Report\\_0.pdf](http://www.britac.ac.uk/sites/default/files/Count-Ups-In-Full-Report_0.pdf)

## Q2 Aims and priorities

10. Attempts to increase the proportion of young women studying and persisting with STEM subjects have tended to yield complex and disappointing results<sup>12</sup>, and unfortunately Scotland is no exception. Data from the Scottish Qualifications Authority show that the gender balance in entries to Higher in most STEM subjects has hardly shifted over the last two decades. However, the increasing importance of STEM skills in other disciplines which young women are more likely to take up means that a better strategy may be to give more attention to STEM skills within these subjects.
11. Our experience in higher education is that attempts to persuade young people to take up STEM subjects can falter because of young people's lack of confidence in their own abilities and skills in numeracy and mathematics. In addition, young people form their views of STEM early and those views remain fixed<sup>13</sup>. Were more efforts made to show how 'enabling' STEM subjects could be, then this situation may be made more manageable. More effective are strategies that focus on skill development in a context where students realise that they can develop these skills and can also see their immediate relevance and application. NRP students are increasingly encouraged to take up social science placements involving data analysis and Q-Step undergraduates draw heavily on sometimes neglected and dismissed numerical skills and abilities.

## Q3 Outcomes

12. We believe that STEM learning, especially its underpinning in mathematics, is relevant to almost all subjects and disciplines, rather than the STEM subjects themselves.
13. Given that previous attempts to improve the gender balance have been disappointing, we would welcome revising the third outcome to include raising the profile and importance of STEM skills, in particular data skills, across all subjects, including those that will continue to attract a majority of young women.
14. We welcome the Curriculum for Excellence statement that support for numeracy should be the responsibility of all teachers. (In passing, although the Scottish Survey of Literacy and Numeracy 2015 (Numeracy)<sup>14</sup> indicates good levels of confidence amongst teachers to fulfil this goal, evidence of the effectiveness of this strategy and how it is being developed in practice would be welcomed.)
15. However, in our view, this is best facilitated when students experience a consistent approach across subjects. To underpin this, the Foundation supported the Association of Science Education to develop '*The Language of Mathematics in Science: A Guide for Teachers of 11-16 Science*'<sup>15</sup> This document shows how the language of mathematics varies across STEM subjects and will help teachers across the sciences and mathematics develop a better and shared understanding of the mathematics requirements and approaches in their respective subjects. This approach could be extended to other subjects.

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<sup>12</sup> [https://royalsociety.org/~media/Royal\\_Society\\_Content/policy/projects/leading-way-diversity/picture-uk-scientific-workforce/070314-diversity-report-executive-summary.pdf](https://royalsociety.org/~media/Royal_Society_Content/policy/projects/leading-way-diversity/picture-uk-scientific-workforce/070314-diversity-report-executive-summary.pdf) and [https://royalsociety.org/~media/Royal\\_Society\\_Content/education/policy/state-of-nation/SNR2-full-report.pdf](https://royalsociety.org/~media/Royal_Society_Content/education/policy/state-of-nation/SNR2-full-report.pdf)

<sup>13</sup> <http://www.kcl.ac.uk/sspp/departments/education/research/ASPIRES/ASPIRES-final-report-December-2013.pdf>

<sup>14</sup> <http://www.gov.scot/Resource/0050/00500749.pdf>

<sup>15</sup> <http://www.nuffieldfoundation.org/language-mathematics-science>

16. This, of course, requires the time and resources for head teachers to encourage a shared understanding among staff about how to make connections across the curriculum and develop teaching that reinforces the learning of skills across as well as within subjects, and we refer to our work on geography below (paragraph 23). We know from much pedagogical research that meaningful curriculum change depends upon the linked reform of assessment, since the latter is so often the main driver of both pupil and teacher priorities. More importantly however, is adequate and regular teacher professional development to support the implementation of any new approach to teaching and learning.

#### Q4 Scope

17. We reference below some of the initiatives the two Scottish Q-Step centres have taken on teacher training, including for early years' teachers and welcome the emphasis on education as a way of increasing the number of people in all sectors of economy and areas of society with key STEM skills. The Nuffield Foundation is committed to improving mathematics education for all and we fund many research projects and student-facing activities with this aim.
18. In terms of post-16 mathematics uptake, Scotland has always been a better performer than the remainder of the UK but still some way behind that of other developed nations.<sup>16</sup> It is notable that while the proportion of school leavers with three or more Highers has risen from 37% to 42% since 2010/11, the proportion with Higher or Advanced Higher Mathematics has risen rather more slowly from 22% to 24%.
19. Between 2006 and 2016 the proportion of mathematics entries as a proportion of all Higher entries declined from 10% to 8% for girls and from 14% to 11% for boys. This seems to be a reverse of a trend in England where A-level mathematics has become the most popular subject choice post-16.<sup>17</sup>
20. Over the last five years just under half of Scottish school leavers have obtained a pass at SCQF level 5 in Mathematics but of those, just over a half have not gone on to achieve a pass at level 6 (Higher). Such students may go on to further or higher education, or employment that need STEM skills, but may spend up to two years in school without studying mathematics, during which time the skills they learned earlier will weaken.
21. Our work has been influential in highlighting the problem of low participation in post-16 mathematics in the UK and in developing ways to address it.<sup>18</sup> For example, we have developed attractive and engaging mathematics teaching materials (Nuffield-funded 'Free Standing Mathematics' qualifications)<sup>19</sup> which can be used to support post-16 mathematics education. We have also funded the development of other teaching resources designed to enhance the mathematics curriculum in school, such as 'Key ideas in teaching mathematics', and 'Applying Mathematical Processes'.<sup>20</sup> These materials are widely used and well-regarded by teachers.

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<sup>16</sup> [http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics\\_after\\_16\\_v\\_FINAL.pdf](http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics_after_16_v_FINAL.pdf)

<sup>17</sup> <https://www.gov.uk/government/news/a-level-results-day>

<sup>18</sup> [http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics\\_after\\_16\\_v\\_FINAL.pdf](http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics_after_16_v_FINAL.pdf)

<sup>19</sup> <http://www.nuffieldfoundation.org/nuffield-mathematics>

<sup>20</sup> <http://www.nuffieldfoundation.org/key-ideas-teaching-mathematics> <http://www.nuffieldfoundation.org/AMP>

## Q5 Current actions

22. For over 20 years, the Nuffield Foundation has delivered programmes to foster young people's interest in developing their scientific thinking and STEM skills in the later stages of secondary education. Nuffield Research Placements (NRP) have been offering well-designed, substantive research placements to Y12/S5 students across the UK to help them develop and apply their skills in live research environments. Since 1996, this programme has offered opportunities to over 16,000 young people, working in partnership with the organisations that provide placements. We have increasingly targeted young people from disadvantaged backgrounds, and have begun to extend the programme beyond science and engineering into data sciences and social sciences. In doing this, our aim is to demonstrate that STEM skills are increasingly necessary for a range of study and career pathways outside the traditional understanding of 'STEM careers'.
23. Our work with secondary school students is complemented by a Nuffield-funded research project being undertaken by the Royal Geographical Society (RGS). This two-year project<sup>21</sup> aims to raise the quantitative teaching skills of geography teachers and is a response to the revised GCSE and A-level curricula that place a greater emphasis on data skills. Due to finish in September 2017, this project will:
- Work across higher education and schools to inform both sectors of changes and opportunities.
  - Produce high quality quantitative skills teaching materials for GCSE and A level complemented by a national programme of CPD.
  - Involve collaboration with awarding organisations, those involved in initial teacher education, other learned societies and geographers in Q-Step Centres to secure sustainability for quantitative teaching skills in geography.
24. In partnership with the ESRC and HEFCE, the Nuffield Foundation is working to address the issue of quantitative skills development for social science undergraduate students. The Q-Step Programme is now in its fourth year of operation and provides undergraduates at 18 universities across the UK (Q-Step Centres and Affiliates) with quantitative skills training that is fully integrated into subjects such as: education; geography; international relations; law; linguistics; political science; population health; PPE; social policy and sociology. Q-Step Centres and Affiliates have developed new modules and new degree programmes. In the most recent year, almost 700 new undergraduate students began degree programmes and over 5,000 students were taking one or more of the new modules. A further benefit of Q-Step is that, by the very nature of the typical student intake to social science programmes, many more female students will gain degrees with highly developed quantitative skills.
25. The most notable way in which Q-Step has been able to effect change is by supporting existing and additional (over 50) academic staff to develop integrated (as opposed to 'bolt-on') and novel approaches to quantitative skills teaching. This contextualisation of quantitative skills, and the cumulative exposure to quantitative analyses, is central to engaging students and helping them to understand both their own potential and the opportunities open to them through the acquisition of these skills. Work placements are a major feature of Q-Step, providing students with the

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<sup>21</sup> <http://www.nuffieldfoundation.org/data-skills-geography>



opportunity to explore and apply their skills in active research environments (not unlike Nuffield Research Placements). Q-Step is funded until 2018/19, and the universities have committed to maintaining the newly-created posts for five years beyond that point.

26. Members of the Q-Step Centre at the University of Edinburgh currently deliver a number of new degree programmes and modules with quantitative skills embedded within them. A growing number of students each year have the opportunity to develop their skills from basic to advanced social statistics, data analysis and survey methods. In 2015/6 it ran a peer-assisted learning scheme supported by the Edinburgh University Student Association and in 2016/7 it is trialling an alternative peer-mentoring scheme, with years 3 and 4 peer-mentoring those in years 1 and 2.
27. The Q-Step Centre at the University of Glasgow is equally innovative in its integration of data analysis into six social science programmes and manages this with a broad student intake. A particularly novel approach embeds quantitative analysis in initial teacher education. The emerging primary school teachers qualify with enhanced numeracy skills *and* the ability to manage and understand the increasingly complex data generated by schools and the education system more generally. At Edinburgh Q-Step staff contribute to programmes within the School of Education.
28. Both Centres make use of employer work-placements to shape and test students' quantitative skills. For example, eight students from Edinburgh completed placements with the Scottish Government, Audit Scotland, Museums Scotland, ScotCen, Ipsos-Mori and other organisations. Employer (and student) evaluation of the placements was uniformly very positive, with one ScotCen placement student authoring a chapter in a Scottish Government publication<sup>22</sup> and another to a publication in a peer-reviewed scientific journal. Six Glasgow students also undertook placements within research teams, leading to a peer-reviewed publication co-authored by the student, and two students being included on a successful research proposal to a major funder.

## **Q9-14 Proposed actions**

29. 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. We think it may be more effective to strengthen STEM skills within the subjects that girls and women continue to prefer to study. This is facilitated by the way in which these skills are becoming more important within these subjects in any case, so that our efforts work with and benefit from existing trends.
30. Universities could, using the experience of Q-Step where relevant, help with mathematics based CPD across the school curriculum (learning from our work on geography). 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 of (for example) 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.
31. As noted above, the two Scottish Q-Step Centres have built strong relationships with employers in order to deliver a successful programme of student placements. This model could be developed to support many aspects of the STEM strategy. For

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<sup>22</sup> <http://www.gov.scot/Resource/0050/00505798.pdf>

example, student placements at organisations such as 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.