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Nuffield Foundation submission to the 'Building our Industrial Strategy' consultation

1. The Nuffield Foundation welcomes the Green Paper and notes that many of its priorities lie at the core of the Foundation's charitable objectives. The Nuffield Foundation focuses much of its research as well as its capacity building programmes on the fostering of the scientific method and development of quantitative and data analytic skills in the education system at all levels. It considers the skills needed for transitions between the years of study and world of work in a modern digital economy.

2. The Nuffield Foundation is a charitable trust established in 1943 by William Morris, Lord Nuffield, the founder of Morris Motors. Its objective is to advance social well-being. We have for many years been an active funder of STEM projects, including research into mathematics and science education, curriculum development and support for the 'STEM pipeline'.

3. Our research focuses on shaping policy and practice in the education systems in the UK and we have a strong track-record in supporting opportunity and the development of scientific thinking and mathematical ability in young people. We currently do this by:

    - Funding research and innovation projects in education and social policy. We focus on educational practice and outcomes from the earliest years of child development through transitions from primary to secondary and on to further and higher education. We have also commissioned research on technical education. Funding student programmes to develop quantitative skills and research capacity in the Sciences and Social Science, most notably through our Nuffield Research Placements Programme. This provides over 1,200 Year 12 students each year, largely from disadvantaged backgrounds, with the opportunity to undertake research projects in science (including social science), technology, engineering, and mathematics (STEM) settings.
    - We also have introduced Q-Step, a £19.5m programme designed to promote a step-change in quantitative social science teaching and learning for undergraduates across 15 British universities. We co-fund Q-Step with the ESRC and HEFCE.
    - We have the capacity each year to make grants for new research and student programmes totaling around £10 million.

4. This experience, in particular our close working with employers on the Nuffield Research Placements and Q-Step Programmes, makes us well-placed to offer an informed view on skills that will support the UK economy now and in the future. The observations in our response below relate almost entirely to the second pillar in the Green Paper 'Developing Skills' although we raise another important area relevant to the strategy in which we are involved – access to government (and commercial) data in paragraphs 32-35.

The Foundation's work to support scientific and mathematical skills

5. The Nuffield Foundation supports the view that skill development underpins economic and individual prosperity and fulfillment[1]. However, whilst we would agree with the recent labour market assessment from the UK Commission on Employment and Skills (UKCES) that there is an economic need for more STEM skills, the gaps tend to be in quite specific occupational areas.[2] To some degree, this complements previous research which found that notable proportions of STEM graduates progressed to non-STEM occupations.[3]

6. More recently, we have focused on the development of scientific thinking *per se* and agree with the Organisation for Economic Cooperation and Development (OECD), that 'in the context of massive info flows and rapid change, everyone needs to be able to "think like a scientist'.[4] In addition, the Foundation has been a strong advocate for increased uptake and use of mathematics throughout education (and certainly beyond 16).[5] We concur with the Scottish Government's view that 'all of STEM is underpinned by Mathematics, which includes numeracy'.[6] Indeed, it seems clear that the UK needs to improve the numeracy levels of its graduates[7] and citizens more generally.[8]

7. Overall, we agree with the Green Paper's argument for the need to support the development of the characteristic qualities which 'STEM skills' encapsulate (critical thinking, quantitative abilities and scientific thinking) for as many young people as possible. We also agree with the need to use different and more discrete approaches to manage sector-specific skill gaps. We note the emphasis in the Green Paper on numeracy skills but also note its reference to a lack of literacy skills in the young adult population. We would argue that the shortfall in standards of literacy must also be a core objective for any successful skills programme in schools and colleges. Reflecting this specific-general perspective, the Nuffield Foundation has worked towards both goals in a number of ways that are set out below.

<u>Curriculum</u>

8. For many years the Nuffield Foundation's support for STEM skills in schools and beyond focussed on the development of science curricula, including many popular GCSE and A level courses[9] (from Nuffield Science to Twenty-First Century Science).[10] In collaboration

1 https://wol.iza.org/articles/for-long-term-economic-development-only-skills-matter
2 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/444048/High_level_STEM_skills_requirements_in_the_UK_labour_market_FINAL.pdf
3 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/32379/11-771-stem-graduates-in-non-stem- jobs.pdf
4 http://www.oecdmybrochure.org/edu/newsletter/
5 http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics_after_16_v_FINAL.pdf
6 http://www.gov.scot/Resource/0050/00509522.pdf
7 http://www.compareyourcountry.org/
8 http://www.oecd.org/skills/piaac/Country%20note%20-%20United%20Kingdom.pdf
9 http://www.nuffieldfoundation.org/sites/default/files/files/Half_a_century_of_curriculum_dev_v_FINAL_WEB.pdf
10 http://www.nuffieldfoundation.org/curriculum-projects#Science

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 that are used extensively by teachers and with notable impact.[11] 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.[12]

9. We would question an over-narrow policy approach that assumes that STEM skills are the preserve of STEM disciplines. Whilst the Government's concern for the loss of excellence in certain STEM disciplines was crystallised in the 'Strategically Important and Vulnerable Subjects' initiative, the original report also highlighted the need for more quantitatively trained social scientists.[13] 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.[14] The British Academy has also highlighted the way in which quantitative skills are increasingly seen as being central to many disciplines beyond the traditional suite of STEM subjects.[15]

Research and development

10. The Nuffield Foundation is committed to improving mathematics education for all and we fund many research projects in this area.[16] Our work has been influential in highlighting the problem of low participation in post-16 mathematics in England and Wales and in developing ways to address it.[17] For example, we have developed attractive and engaging mathematics teaching materials (Nuffield-funded 'Free Standing Mathematics' qualifications)[18] 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',[19] and 'Applying Mathematical Processes'.[20] These materials are widely used and well-regarded by teachers. The Foundation has also granted funding to a project aimed at evaluating and learning lessons from the introduction of Core Maths[21] in England, which we hope will support the development of the aims of the imminent Smith Review[22] of mathematics education in England.

11. The Foundation continues to commission work to tackle the international 'outlier' status of the UK in relation to student participation in post-16 mathematics education.[23] For example, we have funded development work to explore assessments aimed at supporting low attaining KS3 mathematics students[24] and is investigating the use of a Dutch approach called 'Realistic Mathematics Education' which might encourage post-16 progression for students who did not achieve a C Grade (at least) mathematics GCSE in England.[25] This

11 http://www.nuffieldfoundation.org/practical-biology, http://rsc.li/2iYeO0N, http://practicalphysics.org/
12 http://www.nuffieldfoundation.org/oliverbird
13 http://www.hefce.ac.uk/pubs/year/2011/201124/
14 http://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/992/992.pdf
15 http://www.britac.ac.uk/sites/default/files/Count-Us-In-Full-Report_0.pdf
16 http://www.nuffieldfoundation.org/mathematics-education-0
17 http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics_after_16_v_FINAL.pdf
18 http://www.nuffieldfoundation.org/nuffield-mathematics
19 http://www.nuffieldfoundation.org/key-ideas-teaching-mathematics
20 http://www.nuffieldfoundation.org/AMP
21 http://www.nuffieldfoundation.org/early-take-core-mathematics
22 https://www.gov.uk/government/news/south-asian-method-of-teaching-maths-to-be-rolled-out-in-schools
23 http://www.nuffieldfoundation.org/uk-outlier-upper-secondary-maths-education
24 http://www.nuffieldfoundation.org/low-attainment-mathematics-investigation-year-9-students
25 http://www.nuffieldfoundation.org/achievement-and-attitudes-gcse-mathematics-resit-classes

latter project is particularly important given the apparent failure of the 'retake' policy[26] introduced by the previous Government. Both projects will report in 2017.

12. In our contribution to Sir Adrian Smith's Review we have argued that there needs to be a change in emphasis in the curriculum in England if there are to be sufficient incentives for increasing numbers of students to continue to study mathematics post-16, including those who will not study STEM subjects at further or higher education. The removal of AS level may have the unintended consequence of reducing those continuing with mathematics beyond the age of 16 as noted by the Foundation's Director of Education, Josh Hillman, in 2014.[27]

13. Universities should consider taking a greater lead in requiring a post 16-mathematics qualification at university entry regardless of degree choice. Higher education providers should also consider new initiatives to embed critical thinking and the understanding of data analytics for all students (see paragraph 25 below).

Working with students and teachers

14. For over 20 years, the Nuffield Foundation has delivered programmes to enable around 1,200 young people each year to develop their scientific thinking and STEM skills in the later stages of secondary education. The **Nuffield Research Placements Programme** has been offering well-designed, substantive research placements to Y12/S5 students across the UK to help them develop and apply their skills in universities and other live research environments and in business. We have increasingly targeted young people from disadvantaged backgrounds, and begun to extend the programme beyond science, technology 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'.

15. The Nuffield Foundation has recently commissioned a longitudinal study of the NRP programme to independently evaluate the impact of NRPs on participating students' outcomes and inform the future development of the programme[28]. Early findings from surveys of the 2016 NRP cohort show that placement students (1,141) report positive changes in their skills and attributes, knowledge of and attitude toward STEM, and future education and career ambitions. In comparison to students (806) who took part in other STEM related extra-curricular activities, these benefits are more pronounced for NRP students. The placement experience helps to either to confirm their interest in STEM and future education and career ambitions, or to reassess their next steps. As the evaluation progresses we will have more information about the destinations of NRP students, including how these compare to a comparison group of students with similar characteristics who did not do a placement.

[26] http://www.jcq.org.uk/examination-results/gcses/2016/gcse-full-course-uk-by-age-2016
[27] http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics_after_16_v_FINAL.pdf
[28] http://www.nuffieldfoundation.org/nrp-longitudinal-study

16. We believe there are opportunities, through partnership funding, to expand this programme further across the United Kingdom.

17. 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[29] 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.

18. In a related move, we have also funded the development of materials to support the teaching of mathematics in the sciences. The publication 'The Language of Mathematics in Science: A Guide for Teachers of 11-16 Science'[30] was produced by the Association of Science Education (ASE), working closely with awarding bodies (AQA, Edexcel, Eduqas and OCR), which have all endorsed the guidance.

19. Since 2013, the **Q Step Programme** has been addressing directly the need to equip undergraduate students in the social sciences with the quantitative skills they will need to deploy in work and research. We believe this programme has great potential to embed quantitative thinking amongst undergraduates across the university sector.

20. 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 and sociology.

21. 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 nature of the typical student intake to social science programmes, many more female students will gain degrees with highly developed quantitative skills.

22. 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-

[29] http://www.nuffieldfoundation.org/data-skills-geography
[30] http://www.nuffieldfoundation.org/language-mathematics-science

on') and novel approaches to quantitative skills teaching. The funders have supported these posts for the first five years on the basis the universities undertake to continue funding for the following five years.

23. 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 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 and was cited by the Government as contributing to addressing the need for more graduates with data skills[31].

24. Q-Step is making a notable impact on the data-handling/quantitative skills of a large number of graduates who hitherto would not have been able to access teaching and learning which developed these abilities. In many cases, the Q-Step Centres and Affiliates are working closely with students to overcome their concerns over quantitative skills and this experience is benefitting students beyond the Programme (for example, through Manchester Metropolitan University's 'data buddy' scheme[32]). We are also working with National Numeracy to help Q-Step students benchmark and improve their numerical skills. [33]

25. We believe that Q Step, after its first phase of funding comes to an end in 2019, can be further developed to become a central and embedded aspect of social science degree courses across the UK. Making such teaching and learning available to as many students as possible, including those who will not go on to a research career, will enhance their employability in a digital economy. This will require a continuation of matched funding with the Nuffield Foundation if this idea is to develop beyond its current scale.

Technical education and apprenticeships

26. We note the intention to create new Institutes of Technology (IoT). The Foundation has commissioned the Institute for Public Policy Research (IPPR) to research the increasing number of options available to young people in England at age 14, including studio schools and university technical colleges (UTCs). The final report is due to be published shortly but the interim findings suggest that there is much to learn from these initiatives.[34] In particular, it is important that new options are not seen as the only ones or as choices of last resort for students whose attainment is a concern.

27. The increased focus on technical education in careers advice targeted at schools is of interest. This will require careful design if it is to achieve its goal of interesting more young people in this option. A randomised trial funded by the Nuffield Foundation observed that, in relation to choices concerning STEM subjects, 15-16 year olds responded to information

31 https://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/992/992.pdf
32 http://www2.mmu.ac.uk/qstep/supporting-data-literacy-/
33 http://www.nuffieldfoundation.org/adapting-national-numeracy%E2%80%99s-challenge-check-q-step-students-0
34 http://www.nuffieldfoundation.org/transitions-age-14

showing the relationship between university subject and labour market outcomes[35]. Similar signalling effects may well translate to technical education choices.

28. On the questions relating to apprenticeships, Nuffield-funded research by the Institute of Fiscal Studies suggests that the apprenticeship levy will not be able to meet the 3m target between 2015 and 2020 and that the proposed approach does not represent value for money.[36] We would therefore question the assertion that 'The new Apprenticeships Levy ensures business invests in apprenticeships, and it puts business in control of apprenticeship provision' but we do support the need to create an effective and valued system for training young people as an alternative to university. Other research we have commissioned suggests that there is high demand from adults for training and qualifications but that adult apprenticeships are inconsistent in terms of quality and substance and are often simply accreditation of existing knowledge and skills.[37]

The development of STEM skills

29. To finish our input to this consultation, we would like to suggest that the way in which we define and develop STEM skills requires revisiting. It is our view that the phrase 'STEM skills' is often used as a proxy for scientific/critical thinking and numerical/quantitative skills for a range of occupational needs.

30. The particular experience of the Q-Step Programme and the extension of the NRP Programme to embrace social science placements offer good evidence of interventions that directly develop individuals in ways that are usually outwith the scope of appraisals of the labour market need for STEM skills. The Nuffield Foundation, therefore, proposes 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. Developing these skills in a range of secondary school subject and in the arts and humanities in higher education could be an important and valuable future focus.

31. We believe that skills in data analysis and quantitative confidence are essential to the participation of informed citizens in a modern democracy, as well as being essential to a productive career in the modern economy. We would therefore like to explore further analogous initiatives to Q Step. The Nuffield Foundation will consider a Q Step type initiative to include younger age groups at school. It also believes there is a need to developing these skills amongst all students, including students of the Humanities. There is an opportunity to add to the benefits of normative reasoning and critical enquiry made possible by a Humanities degree an understanding of data analysis and quantitative reasoning essential to the study of contemporary culture and society. Building the digitally literate workforce necessary for UK industrial competitiveness will require a wider engagement with digital and data skills than can be achieved solely through STEM students.

35 http://www.nuffieldfoundation.org/effect-graduate-earnings-16-year-olds%E2%80%99-subject-choices
36 http://www.nuffieldfoundation.org/news/target-3-million-apprenticeships-and-new-funding-system-risk-poor-value-money
37 http://www.nuffieldfoundation.org/does-apprenticeship-work-adults

The importance of data access

32. STEM skills are a necessary but not sufficient condition for success in delivering this Government's Industrial Strategy. Access to data held by government and some held by commercial organisations is key to research which underpins innovation (as recognised in page 56 and elsewhere in the strategy).

33. Governments in the past decade have made strenuous efforts to widen such access and make such access easier for researchers; we applaud such efforts. However, our experience in funding research and working with other partners is that there remain significant obstacles to such access.

34. A particular case is the use of administrative data in combination with survey data. Surveys provide evidence that cannot be collected through administrative systems, and are necessary to ensure that innovation in policy, service delivery, and practice are informed by an understanding of the characteristics, behaviours, experiences and attitudes of individuals and organisations. We are working with partners to find ways to facilitate easier and safe access to and combined use of administrative and social survey data.

35. Furthermore, the Foundation is actively involved (again with partners) in formulating our contribution to data ethics issues: this builds upon our long-term experience with the Nuffield Council on Bioethics (jointly funded with Medical Research Council and Wellcome). We see these activities as contributing to the long-term success of the British economy.