The British Academy

Response to Royal Society's Mathematical Futures Programme call for views

Response from the British Academy

The Royal Society's Mathematical Futures programme aims to build a new vision of mathematics education that anticipates needs and reinforces the role of mathematics in society, for economies, and for individuals, and strengthens diversity and equity. The programme is seeking to answer two core questions:

• What mathematical competences will be needed for society to thrive in the future?

• How should education systems develop these mathematical competences?

The programme is overseen by the Royal Society Advisory Committee on Mathematics Education and covers the phases between the start of compulsory education and entry into higher or further education. The programme aim is to look at mathematical competences across disciplines, not only from different areas of natural science and mathematics, but also from the social sciences and humanities.

In this call for views, they hope to garner a range of views, opinions, information and evidence on how mathematics, described in a broad sense, is changing, and what the impact of such changes may be on the future of education, society, and work.

1. Which mathematical competences are most useful to you (or your employees) and why?

We welcome the fact that this consultation takes a broad view of mathematics, because we agree that there are many competencies and skills which are relevant to the aims of this inquiry. Our research shows that graduates from SHAPE disciplines (Social Sciences, Humanities and Arts for People and the Economy), go into employment in a wide range of roles and sectors.[1] In Q12, below, we describe the quantitative skills we believe all citizens should have and which many SHAPE graduates develop alongside the core skills shared by all SHAPE disciplines, namely communication, collaboration, research and analysis, independence, creativity and adaptability.[2] There are, however, many additional skills which are specific to specialist roles, which may be developed in particular disciplines within SHAPE – such as geospatial technologies in geography or econometrics in economics.

[1] The British Academy (2020): Qualified for the Future.: quantifying the demand for arts, humanities and social sciences skills
[2] The British Academy (2017): The Right Skills: Celebrating Skills in the arts, humanities and social sciences

2. What are the most useful mathematical competences that citizens need now and why?

The British Academy uses the terminology of quantitative skills – the ability to reason using numbers.[3] Understanding and interpreting numbers and data requires a diverse range of skills that can be applied within specific disciplinary, applied or research contexts, or as a general citizen. There are many benefits to building quantitative skills in the UK population, including helping citizens to participate more fully in the democratic process; enhancing research in universities and in the workplace; and supporting the economy, taking advantage in particular of the advent of "big data". The skills themselves can range from basic arithmetic to handling advanced statistical analysis. Among other things, the possession of these skills allows for:

- confidence in the manipulation of numbers;
- an understanding of the possibilities and limits of measurement;
- understanding the role of evidence in testing and modifying our understanding of social processes

Number and data skills are not developed only through the study of maths. Basic mathematical skills are a prerequisite to any ability to handle or analyse data, but the quantitative skills concept argues that what is also needed is the ability to understand how the real-world problems that data tries to measure relate to the mathematical and analytical models which represent them; it is not simply about calculations but about the ability to reason with data, involving contextual understanding and interpretation.

3. Do you think the nature of mathematics, and the role it plays, have changed over the past twenty years? If so, how?

The past 20 years has witnessed an increase in the knowledge-base of the economy and a corresponding increased use of data, with new methods of data collection, analysis and technology. This has led to expanded demand for professional roles for people with quantitative skills in the labour market, even in non-technological occupations. In an age of rapid and far-reaching social and technological change, the big challenges facing society have shown to be only be resolved through the application of multiple perspectives and insights from a range of disciplines. Individuals who can combine quantitative, computing and analytical skills with business and ethical understanding and the ability to communicate gained through the study of the humanities and social sciences offer the hybrid skills set businesses need in an era of data-driven decision making.

The changes are also reflected in the research environment, in both universities and business. Research is increasingly interdisciplinary, requiring on the one hand researchers who can deploy both quantitative and qualitative research methods and integrate the findings in analysis, and on the other individuals who can gain sufficient understanding of the technical aspects of developments such as artificial intelligence to apply expertise of the social and human consequences to shape the legal, moral and ethical frameworks which need to be created as part of the new digital age. In all areas where personal data from individuals is collected and used, there is

[3] The British Academy (2015): Count us in

potential for both great benefit and great harm, which require insights beyond our current protocols for confidentiality and security, drawing on our knowledge of philosophy, law, psychology, anthropology and history, among other subjects.

4. Thinking about the needs of citizens, how should mathematics enable the next generation to participate in society?

The very foundation of liberal democracy is based on the understanding that citizens can make informed choices and hold their government to account on their perceived performance. In a world where *some* outcomes of collective action are quantifiable and, especially before elections, many political arguments are based on these, numeracy skills are crucial for interpreting information from various media to understand social, environmental and economic trends that inform such choices.

In this context, numeracy skills are highly important for the entire population. Support to develop numeracy skills is particularly required for the most excluded members such as refugees, and for those who have had poor experiences of conventional education. In the same way in which civil society groups play an important role in developing literacy, charities and their volunteers could support building numeracy skills of the most marginalised members of society. For those undertaking further education, colleges offering vocational and general adult education have a vital role to play in developing these skills.

5. What should be the main goals of mathematics education, and why?

The main goal of mathematics education should involve principally broadening, but also deepening the quantitative skills base of the population, enabling people to be comfortable in applying those skills in real world contexts to 'make sense' of the uncertain environment. The demand for number and data skills in the UK workforce will continue to grow, with changes in the nature of work as a result of increasing competitive pressures, the development of technology and growing availability and use of data.

It is not just in professions where a high level of numeracy is intrinsic to the nature of the role, such as economists and accountants where such skills are vital; there are many jobs where data literacy is an essential element, including nurses needing to calculate medical doses and civil servants responsible for reviewing evidence on the effects of government policies. More broadly, as the potential of data science continues to be realised, it is clear that work on and with data requires not just skills in statistics and computing but also domain specific knowledge across all subject areas to understand where and how data science techniques can be applied. In curriculum design, there should be an emphasis on enthusing students by endeavouring to ensure that teaching includes easily accessible examples relevant to the students and their broader study. Mathematics should be part of every educational curriculum at school, college and university.

Mathematics education needs to enable future and present generations to possess the skills to reason with numbers, which crucial for developing informed beliefs and opinions in both the economy, as well as in their role as citizens. This means embedding quantitative skills across the whole curriculum, rather than seeing mathematical competences as standalone skills.

6. What do you expect to be the challenges facing mathematics education in the next twenty years?

Future mathematics education needs to address both long running issues in the school system, which is tasked at developing core quantitative skills that every citizen should possess, as well as responding to wider technological changes in the economy and wider society.

At school level, the recruitment and retainment of qualified teachers remains the possibly most pressing challenge. Recent research has shown teacher related factors ('teacher effectiveness') as one of the major predictors for student attainment,[4] and this seems to be especially marked for maths. The Education Policy Institute has found that only around 46% of maths teachers hold a 'relevant degree', and attributes this to problems of both recruitment and retention.[5] This has both a socio-economic and regional dimension: in socially deprived schools outside London, just over one third of maths teachers at Key Stage 4 hold a relevant degree. More generally, analysis of the School Workforce Census has found that disadvantaged students are more likely to be taught by inexperienced, unqualified teachers or those who had studied a different subject.[6]

7. How could the challenges you have set out in your response to the previous two questions be addressed in practice?

These challenges can be addressed by widening of the curriculum and creative solutions to teacher shortages.

Future subject level reforms should aim at integrating data analysis into a wider range of subjects across the curriculum, including the humanities – for example, in relation to social and economic history – and strengthening development of quantitative skills where they already exist – for example, going beyond descriptive statistics in sociology. We have welcomed the introduction of the Core Maths qualification which enables students to continue to study maths alongside 3 full A levels, enabling them to develop a broad range of skills in their post-16 education.

The evidence collected by the Education Policy Institute suggests that the challenge of recruiting and retaining teachers with appropriate qualifications in quantitative subjects will require regionally based solutions rather than a one size fits all approach. Attracting graduates from within maths into teaching appears to be a particular challenge outside London, while within London the problem is one of retention. These solutions could include maximising the value that can be gained from teachers who have quantitative skills developed through other disciplines, such as the quantitative social sciences, and supporting them through professional development to teach core quantitative competences in the context of other subjects, thus also enabling students to understand how such skills can be applied to real-world problems.

[4] Hanushek, E. and Rivkin, S. (2012): The distribution of teacher quality and implications for policy, Annual Review of Economics, 4, pp. 131–57.

[5] Education Policy Institute (2018): The teacher labour market in England. Shortages, subject expertise and incentives. See also Allen, R and Sims, S (2018): How do shortages of maths teachers affect the within-school allocation of maths teachers to pupils? Nuffield Foundation.

[6] Allen, R and Sims, S (2018): Do pupils from low-income families get low-quality teachers? Indirect evidence from English schools. Oxford Review of Education, 44:4, 441-458, DOI 10.1080/03054985.2017.1421152

8. What else should the programme consider in order to answer the two core questions?

There are opportunities in involving SHAPE disciplines, and especially humanities, in the discussion of the future of mathematics.

SHAPE disciplines provide a rich context for the development of quantitative skills, and as well as providing opportunities for students to understand how such skills are applied to real-world problems, can also help to deliver them to groups traditionally underrepresented on conventional STEM pathways, including females and students from disadvantaged or ethnic minority backgrounds.

From a SHAPE perspective, quantitative skills offer the opportunity to develop new research methods and hence new types of research questions. There are many opportunities to pursue new approaches involving quantitative skills, especially in the humanities. Research methods in the digital humanities can allow novel research questions to be pursued, that require the analysis of a specifically large corpus, where traditional methods of document analysis or key word search fail.

In addition to the value for SHAPE students of developing quantitative skills, students studying mathematical subjects can benefit from studying aspects of SHAPE disciplines. For example, they could learn from sociology, languages, philosophy or law about methodological breath, understanding of human capabilities and limitations in communicating and processing quantitative information, understanding of societal needs for quantitative analysis, and awareness of the ethical and political dilemmas involved when decisions are based on quantitative evidence.

The British Academy would welcome opportunity to engage with the Mathematical Futures programme to explore the lessons learned from our programme of work on quantitative skills in the social sciences and humanities.

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