A response from the Association for Science Education to the Royal Society's

Call for Views on Mathematical Futures

January 2021

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

Numerical computation including standard form, ratios and percentages, estimation, growth and decay; statistics, including averages, variation and tests of significance; probability including theoretical calculations and risk, using and understanding simulations; algebra including using formulae and solving algebraic equations; and graphs including time-series graphs and linear relationships, interpretation of gradients and intercepts.

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

Most, if not all, of the above

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

Yes, significantly, with a greater and necessary expectation for all citizens to take an informed interest in how science and social sciences work and impact on their lives. The current fast paced coronavirus pandemic and climate crisis, as examples of wicked challenges facing humanity, demonstrate the need for competence in interpreting statistics and graphical representations, understanding and calculating risks in determining responsible collective and individual responses including their ethical and moral dimensions.

The increased emphasis on mathematical literacy is recognised in the current mathematical content of GCSE and A level specifications of the sciences, but also in other subjects such as geography.

However, evidence such as that presented in Factfulness[i] suggests that the many people are ill equipped at interpreting data and evidence and make poor judgements as a result.

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

Active and scientifically literate citizens use mathematics to make informed decisions on their individual actions and behaviours, understanding the consequences of these decisions and contributing positively to community and wider society activities in addressing the challenges of our generation. These challenges are presented through the Sustainable Development Goals[ii].

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

To develop competence and fluency in using and applying mathematical ideas, language, tools and skills to reason, argue and justify positions following a line of enquiry and solve problems which are often complex and interdisciplinary.

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

Mathematics persists, alongside the sciences, in being perceived as a difficult subject for some young people, often from their primary years and extending into their secondary education. A major challenge is to present mathematics as accessible, creative and enjoyable, as well as relevant and essential for succeeding in everyday life and employment.

ASE's project, *The Language of Mathematics in Science*[iii], focused on understanding the underlying principles of the use of mathematics in school science. Running through the project were the themes of purpose, using judgements, understanding the nature of data, consistency of approaches and terminology between mathematics and science where possible - whilst also recognising that mathematics and science are different disciplines, each with its own purpose, traditions and practices which leads to some differences in the way language is used, and how mathematical ideas are introduced.

The project produced two publications. The first publication: *A guide for Teachers of 11-16 Science* follows a narrative running through the chapters from collection and processing of data to representation of data in tables, charts and graphs to looking at different kinds of data relationships to scientific models and algebraic equations, and leading to a final chapter on mathematics and the real world. The second publication: *Teaching Approaches* uses different accounts to outline different ways that science mathematics departments have worked together and illustrates various teaching approaches with examples of how children respond to different learning activities.

These publications and accompanying professional learning workshops were very well received but the challenges raised through the project's themes persist for 11-16 students, and for some of their science teachers in supporting their students' mathematical fluency of thinking within science.

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

1. Greater integration and application of mathematics in relevant subjects including science and geography within primary education, supported by teacher professional learning and development.
2. Greater collaboration between mathematics and science departments in 11-16 education, in achieving a common understanding and in sequencing the introduction and use of mathematical ideas in an appropriate way, supported by teacher professional learning and development.
3. Setting the expectation that all young people continue to study some mathematics post 16 in the drive towards all adults becoming functionally numerate.
4. Setting the expectation that all students of A level sciences (and those following vocational and technical routes) also take a level 3 mathematics qualification.
5. Professional learning and development for post 16 science teachers in supporting their students with the increased mathematical requirements of the A level specifications and examinations.

ASE has just started work on the following project, in working to address points 4 and 5 above:

Mathematics for Biology Teachers is a partnership project between ASE and the Advanced Mathematics Support Programme, supported by the Department for Education.

The project aims to:

- develop the capacities and confidence of biology teachers in their use of mathematics within the post 16 context,
- promote the value of studying level 3 mathematics to post 16 biology students,
- promote the provision of Core Maths by schools and colleges with uptake by a wider group of their post 16 students, and
- highlight the 'maths rich' nature of biology in different educational phases and careers.

During this project we will be running focus group discussions with biology teachers and school leaders. We will also be running online teacher CPD workshops, a podcast, creating briefing documents, signposting high quality teaching resources, and working with, we hope, the Royal Society, ACME and Royal Society of Biology, to encourage higher education biology colleagues to consider how they may best signal the value of studying post 16 mathematics alongside biology within their admissions requirements.

6. Consider adopting aspects of the PISA 2024 Strategic Direction and Vision for Science framework[iv] in future curriculum reforms. Of particular interest are the New Knowledge Areas of Socio-environmental Systems and Sustainability, the Development of Scientific Knowledge and its Misuse, and Informatics which emphasises the study of data and the structure and behaviour of information processing systems including computational models. The framework also adds two new Competencies – using scientific knowledge for decision-making and action, using probabilistic thinking of understanding probability and risk as central to most scientific issues and essential for informed decision-making – and expands two existing Competencies – evaluating and designing scientific enquiry including within complex systems, and interpreting data and evidence scientifically including interrogating large data sets as well as the ability to use scientific judgements for decision making.

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[i] Factfulness: Ten Reasons We're Wrong About the World – and Why Things Are Better Than You Think (2018) https://www.gapminder.org/factfulness-book/

[ii] Sustainable Development Goals (2015-2030) https://sdgs.un.org/goals

[iiiiii] The Language of Mathematics in (2016), supported by the Nuffield Foundation https://www.ase.org.uk/mathsinscience

[iv] PISA 2024 Strategic Direction and Vision for Science framework (2020) https://www.oecd.org/pisa/publications/PISA-2024-Science-Strategic-Vision-Proposal.pdf