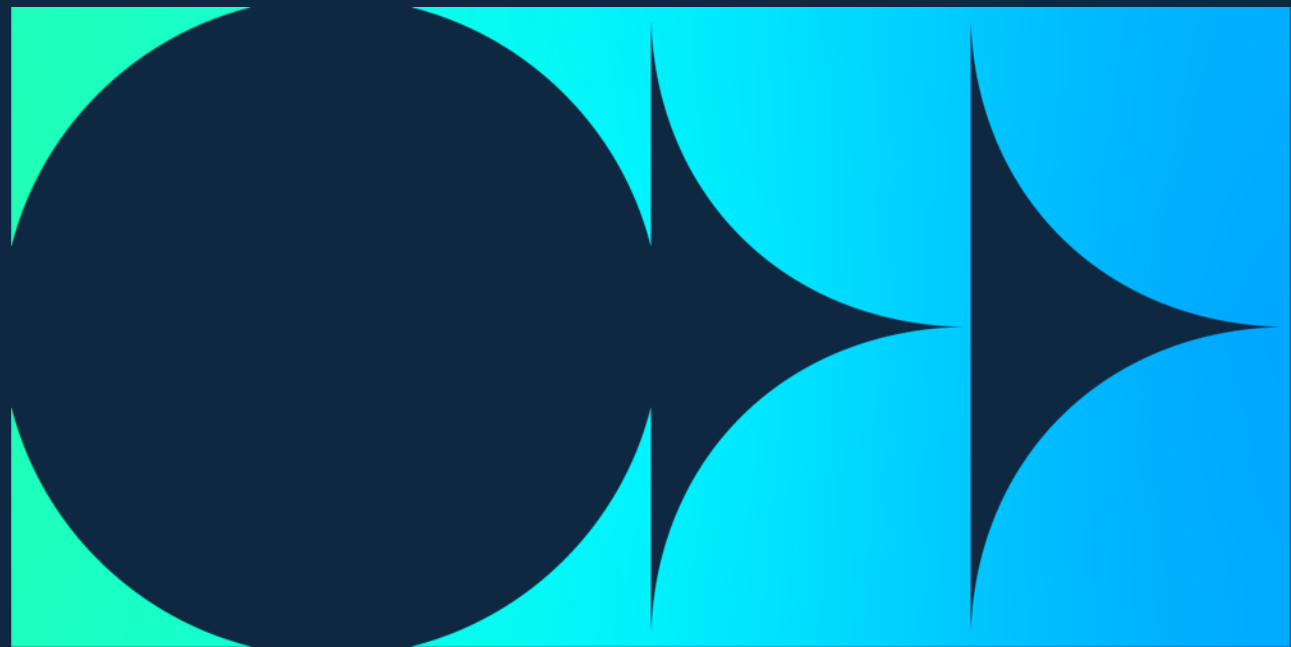
Steps towards a greater role for data education in the curriculum (in England)

Cathy Smith and Vinay Kathotia

ProDaBi Colloquium
01 July 2026



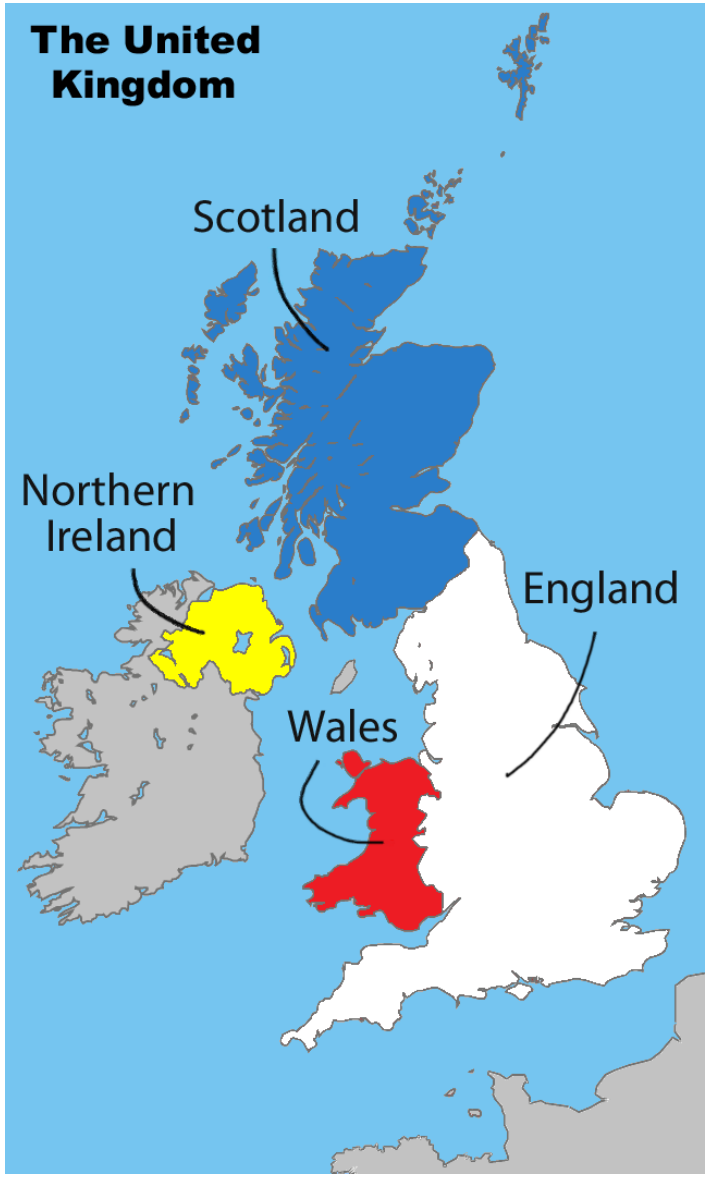
The Open University

Overview

1. Introduction – UK/England context
2. Work for the Royal Society Mathematical Futures programme
3. Our model for data-driven education
4. Emerging principles for data education
5. Rapid Review for England's National Curriculum Review
6. Progressions and themes
7. Potential next steps

Northern Ireland Curriculum (2007/2028)

Curriculum for Wales cwricwlwm i Gymru (2022)



Scotland: Curriculum for Excellence (2010/19)

England: National Curriculum (under review 2025-6)

The (UK) Royal Society Mathematical Futures Programme

Established in 2020 with a 20-year time horizon…

Why is change needed?

Because the world has changed; mathematical and data sciences and their applications are everywhere.

Students need critical digital literacy skills for employment and citizenship.

Mathematics education (5-18) has not kept pace.

Drivers for change in England

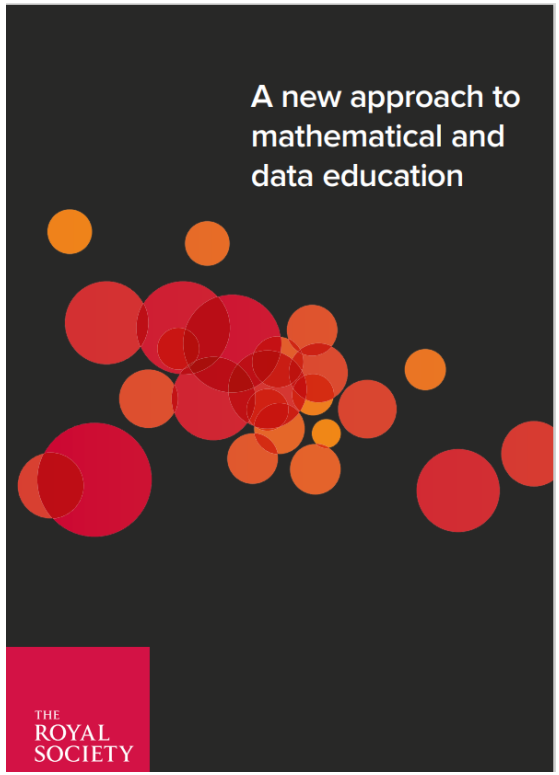
Our education system should equip all citizens with the capabilities they need to lead fulfilled lives. England's present system lets too many down.

- The present system serves some well, but too many are left behind (28% do not reach expected level at age 16; around half study no new maths 16-18)
- Low levels of numeracy mean that many people struggle to navigate daily life, from budgeting, to analysing claims made in the media.

Framing questions:

1. What mathematical competencies will be needed for citizens and society to thrive in the future?
2. How should our education system develop these mathematical competencies?
3. What changes can be put in place to move towards that future?

Key messages



The Royal Society, 2024

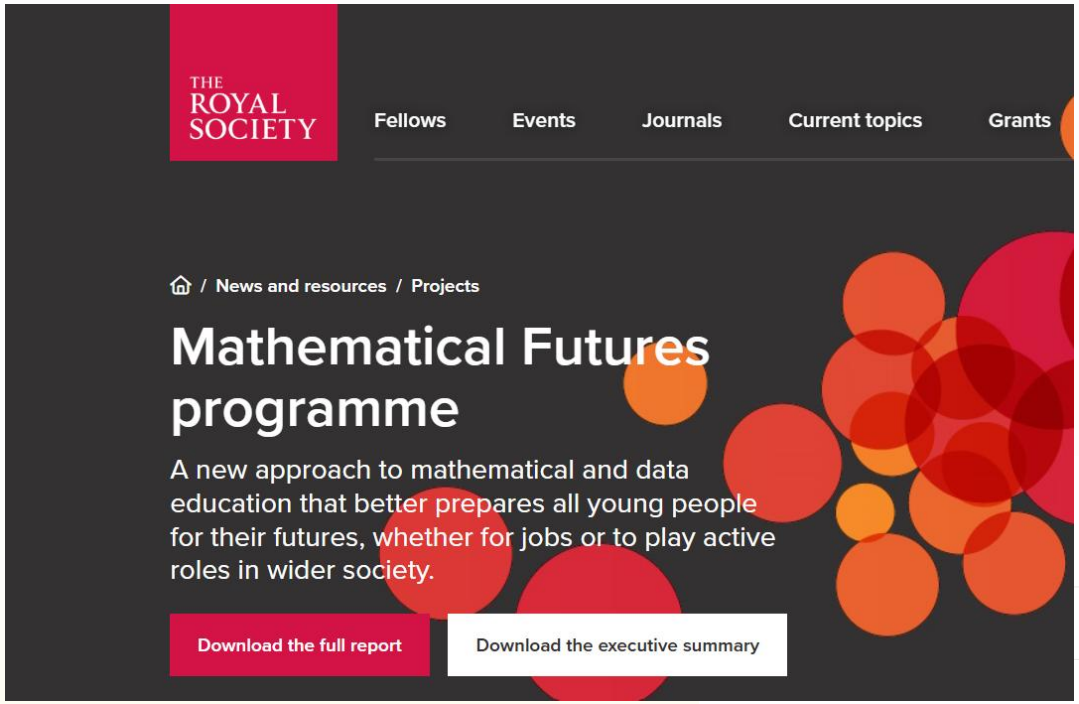
"The scope of mathematical education needs to change from 'mathematics' to what we have called **mathematical and data education** (MDE); a combination of mathematics, statistics and data science, underpinned by computational tools."

MDE can/should take place across the curriculum.

Overview

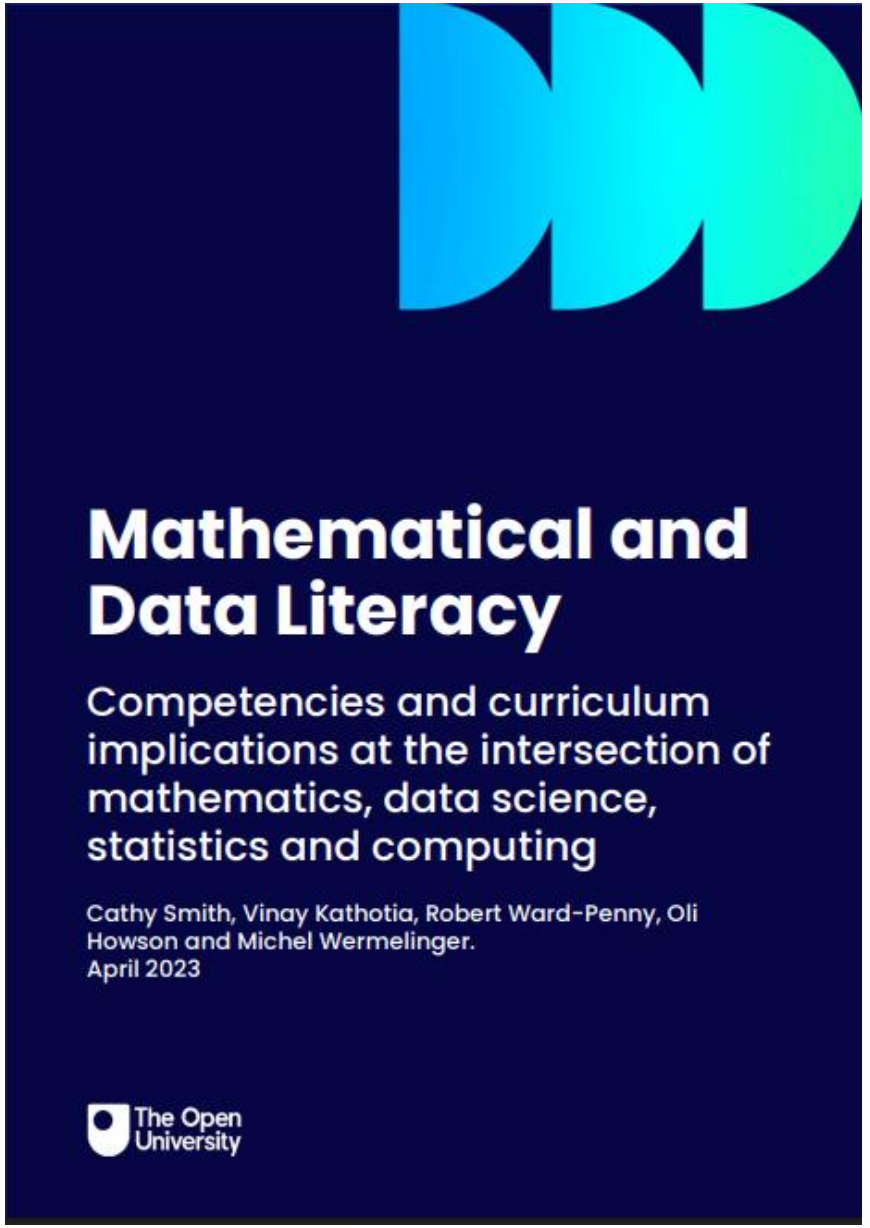
1. Introduction – UK context
2. Our work towards the Royal Society Mathematical Futures report
3. Our model for data-driven education
4. Emerging principles for data education
5. Rapid Review for England's National Curriculum Review
6. Progressions and themes
7. Potential next steps

Mathematical Futures



Additional downloads

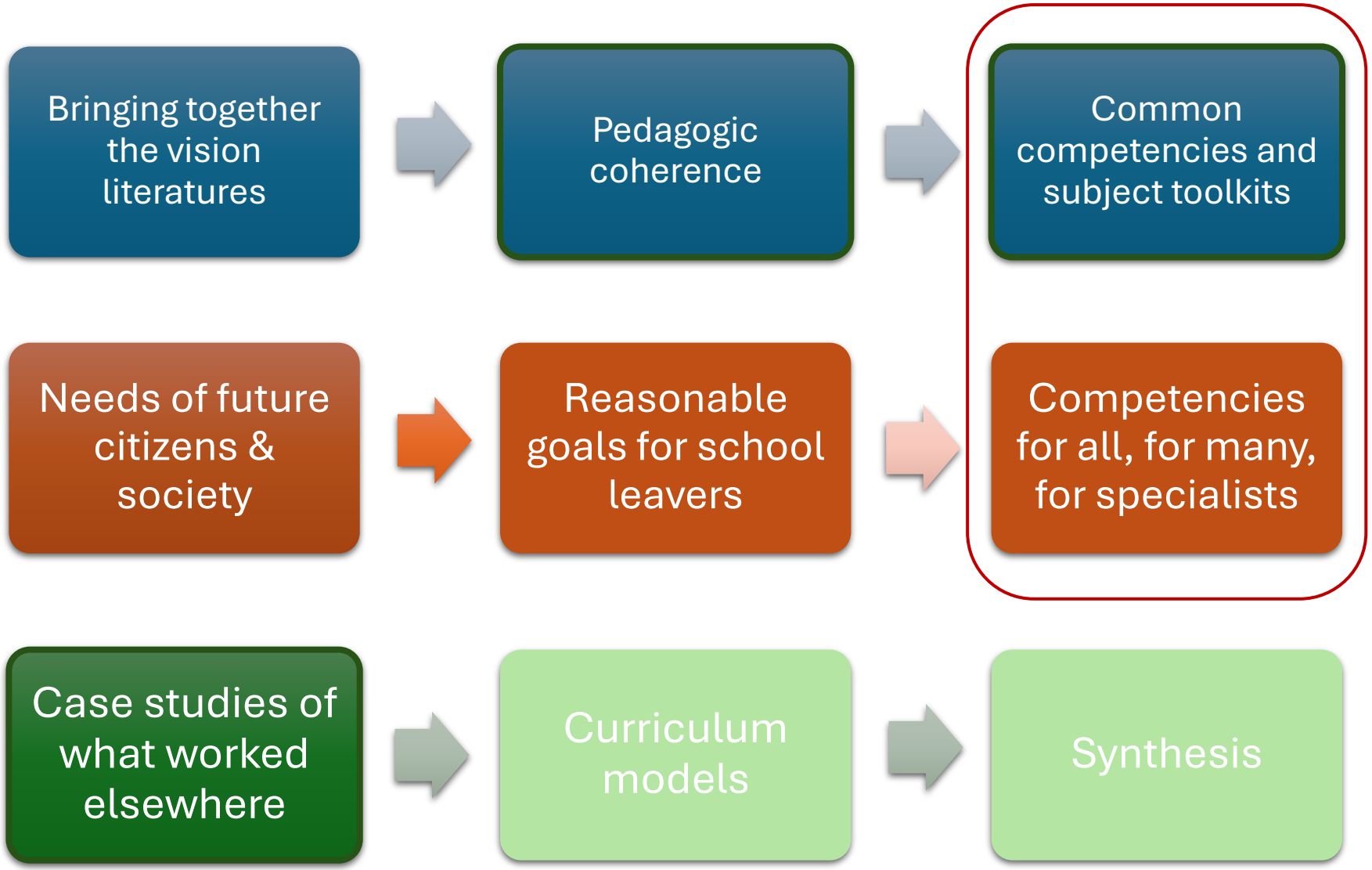
- A new approach to mathematics and data education - Discussion paper
- Call for views on the future importance of mathematics in education
- Call for views responses
- Call for views: methodology technical note



The Open University

Project stages

(Jan – April 2023)

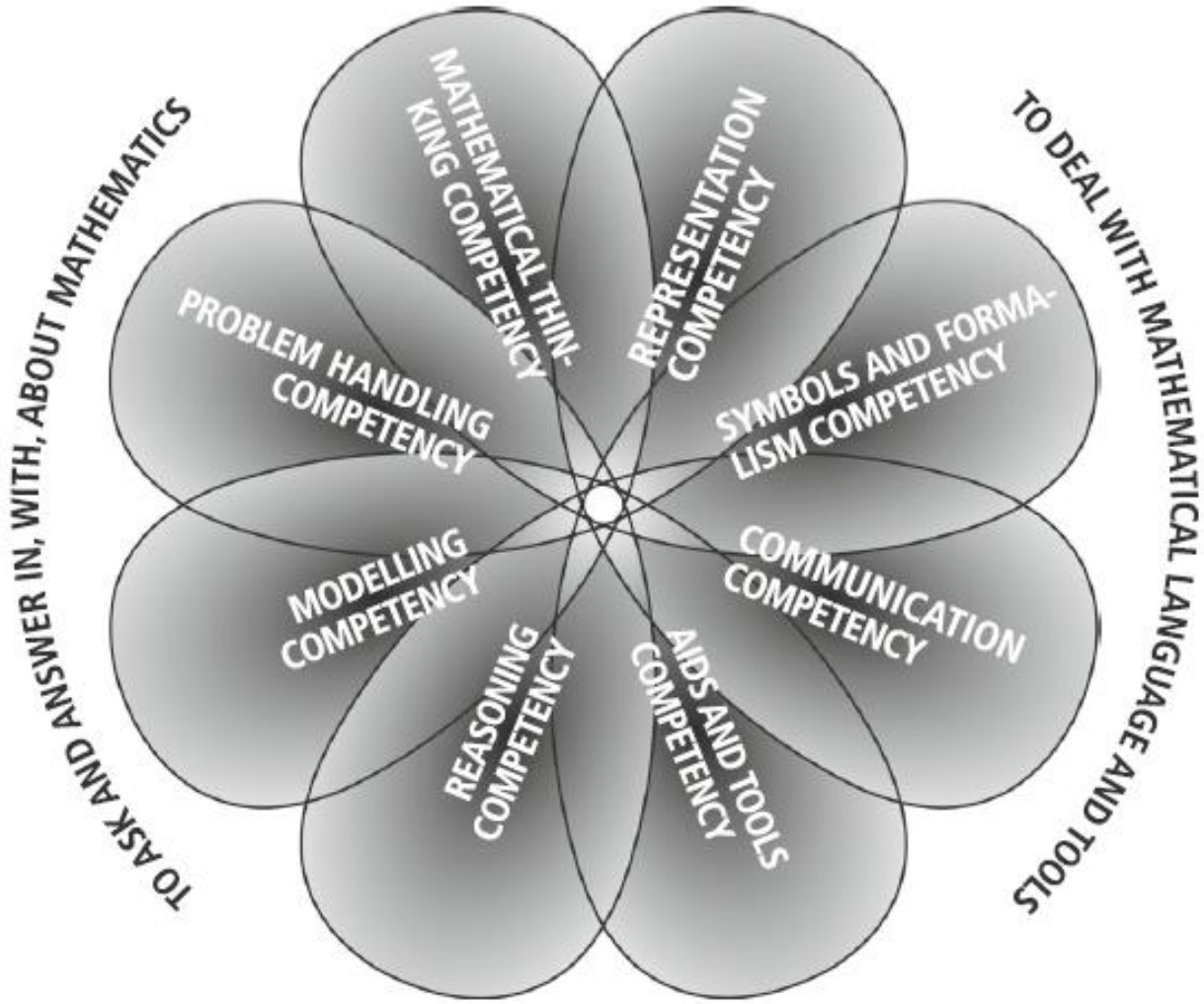


The Open University

A starting point for mathematical competencies

The Danish KoM framework addresses both:

- problems arising in (and about) mathematics itself
- problems which answer questions relating to an external, often real-world domain, with (and about mathematics)



Source: Niss and Højgaard (2019)

Case Studies

1. Ontario curriculum pathways
2. ‘Mathematics and Statistics’ in Aotearoa New Zealand
3. International Baccalaureate ‘Analysis’ and ‘Applications’ pathways
4. ProDaBi – Project Data Science and Big Data in German schools
5. Scotland’s post-15 National Progression Awards in Data Science
6. MEI supplementary post-16 courses in Data Science
7. Royal Geographical Society and Core Maths
8. Cross-curricular perspectives in Civic Statistics
9. Bootstrap (US) integrating computing with other subjects
10. Urban Data School

Categorising competencies: For all, for many, for specialists

Mathematical and Data Literacy for all	Preparing to use data and technologies in the workplace	Preparing to develop specialised mathematical and computational tools
For personal decision making To understand and critique numerical claims	Implementing mathematical models and making decisions based on these Reviewing, judging and choosing models	Learning mathematical / statistical / data science methods that allow creation of discipline-specific tools

The Open University

Iterative and holistic enquiry: conduct investigations using the full mathematical/statistical enquiry cycle in situations enabling access to multiple variables and technological tools

Mathematical and Data Literacy for all	Preparing to use data and technologies in the workplace	Preparing to develop specialised mathematical and computational tools
All students can: conduct investigations using the full enquiry cycle in domains related to health, personal finances, civics, including using data that has been gathered from familiar digital interactions (e.g. YouTube views), attending to the context and variability in the data.	**Most students can:** ALSO use the full enquiry cycle in situations requiring detailed knowledge from another school subject.	**Specialists can:** ALSO use the enquiry cycle with attention to sophisticated tools and formal reasoning appropriate to mathematical modelling / statistical reasoning / computing.

The Open University

Positions we reached

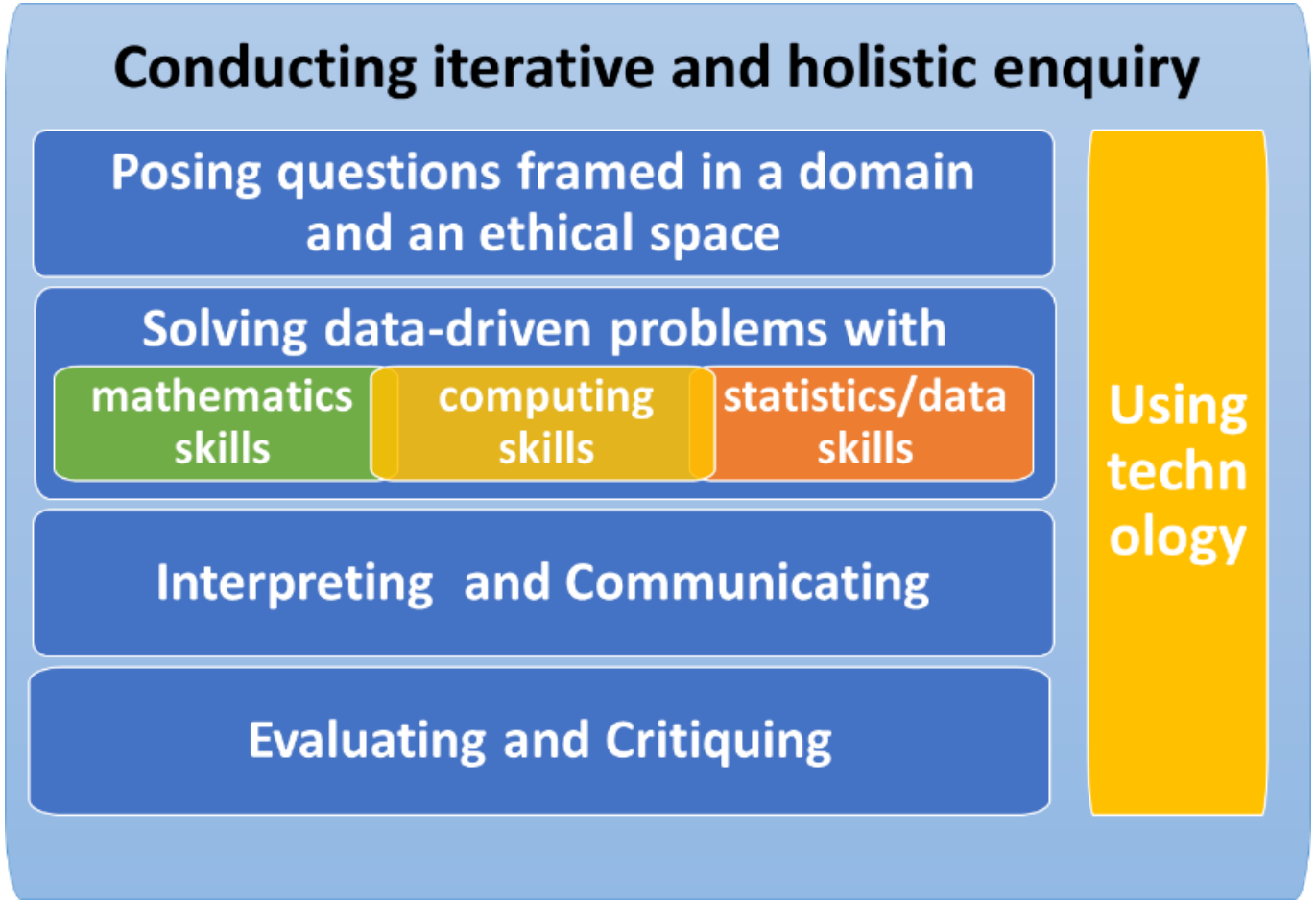
- For school curriculum purposes, data science and statistics can be the same;
- Increased use of data-handling technology is essential but programming can be taught separately;
- Domain knowledge matters; a challenge in/to current mathematics teaching in England.
- Data science does not introduce ethics to mathematics, but it does highlight that we often ignore it.

The Open University

Overview

1. Introduction – UK context
2. Work for the Royal Society Mathematical Futures programme
3. Our model for data-driven education
4. Emerging principles for data education
5. Rapid Review for England's National Curriculum Review
6. Progressions and themes
7. Potential next steps

Common competencies and subject toolkits



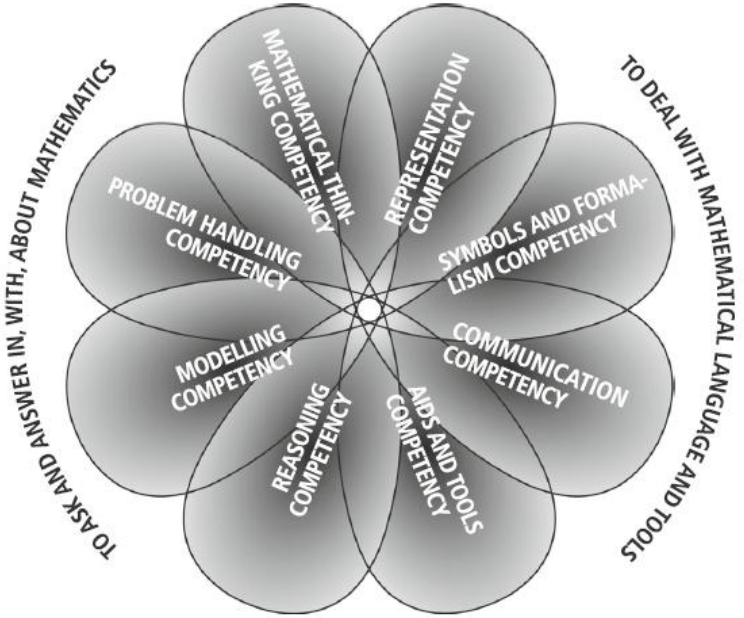
Proposed this model …

as a starting point for extended conversation amongst educators

To provide a common framework for MDSC

Could be different but should be intelligible and agreeable to the main stakeholders.

Common competencies and subject toolkits



The mathematics toolkit for solving data-driven problems involves:

- Using quantities and methods
- Analysing covariation
- Reasoning mathematically
- Using mathematical representations
- Using mathematical aids and tools.

Common competencies and subject toolkits

The mathematics toolkit involves: Using quantities and methods; Analysing covariation; Reasoning mathematically; Using mathematical representations; Using mathematical aids and tools.

The statistics/data science toolkit involves:

- Data stewardship
- Handling data
- Data representation
- Statistical thinking and methods
- Probabilistic reasoning
- Using computational aids and tools.

The computing toolkit involves: Computational thinking (including developing algorithms); Using algorithms; Programming; Representing and manipulating data; Safe use of technology; Using a range of aids and tools including emerging technologies.

The aesthetic challenge of accepting uncertainty

Since the availability of modern computing (1950s), there is scope for a shift in how we do and use mathematics.

"Data analysis must use mathematical argument and mathematical results as bases for judgment rather than as bases for proof or stamps of validity." (Tukey, 1962)

> "Maybe it is our Victorian ideas about the need for certainty of axiomatization that are naïve and unrealistic. Maybe the task ahead of us is to live rigorously with uncertainty." (Kac et al., 1992)

Kathotia, Smith and Ward-Penny (under review)

Overview

1. Introduction – UK context
2. Work for the Royal Society Mathematical Futures programme
3. Our model for data-driven education
4. Emerging principles for data education
5. Rapid Review for England's National Curriculum Review
6. Progressions and themes
7. Potential next steps

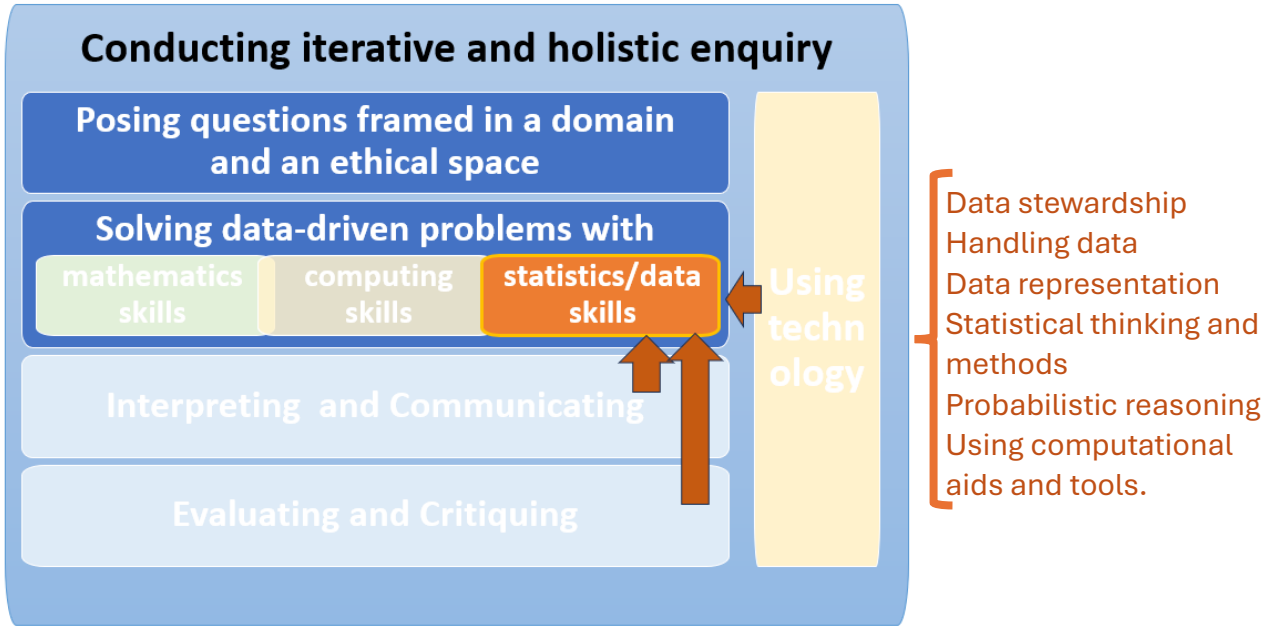
The Royal Statistical Society

Roundtable discussion and statement : Statistics and data within the Maths to 18 proposals (2023)

Post-election briefing (2024) asks for a new approach to mathematics education with a more fulfilling curriculum placing a greater emphasis on data.

The Joint Mathematical Council (JMC) of the UK

A vision for meaningful data education across the four nations of the UK (Jacques & Joubert, 2024)



Proposes an additional set of data skills for the end of primary and lower secondary that accompany the school leaver competences in Smith et al. (2023).

Focuses now on data education, using a simplification of our MDSC model

Principles for data education

Summarising the emerging consensus with six core principles (2026):

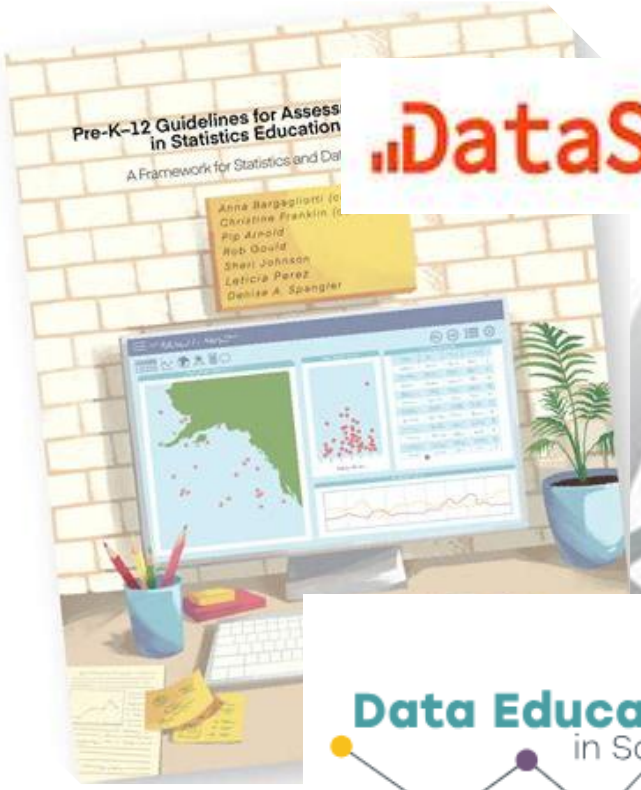
1. Students should meet real data (authentic context, adequate complexity)
2. Students need to engage in the full investigative cycle, including posing and refining questions
3. Working with data is broader than statistical analysis (e.g. stewardship, communication)
4. Statistical thinking involves dealing with variability
5. Uncertainty is a foundational principle. Mathematical/statistical methods enable us to accept uncertainty, treating it with increasing precision and confidence.
6. Use of technology is integral to data education. Data education addresses complexity using technology *and* using the power/simplicity of mathematics.

What does this mean for teachers? What are priority areas for professional development?

https://www.menti.com/alu22szqfnst

- Drawing evidenced and cautious conclusions from variable data
- Ethical data stewardship
- Development of learner-authentic questions https://www.stem.org.uk/resources/library/collection/3317/1)
- Framing questions and planning data collection that can answer them
- Cleaning, organising and grouping data sets for a given use
- Making choices of representation
- Critically evaluating misleading representations
- Appropriate balance between off-screen and digital approaches to data recording, representation, analysis, and reporting
- Awareness of where, when and how data literacy is supported in areas of the curriculum beyond mathematics

Journey so far



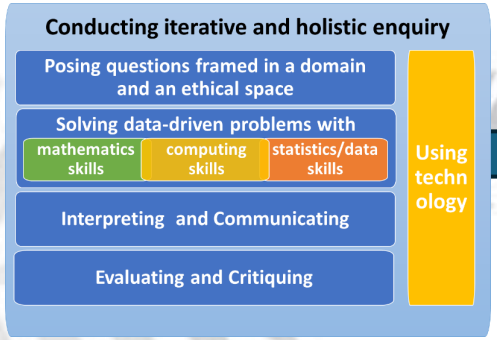
DataScience4 everyone

Data Education in Schools

ProDaBi
Projekt Data Science und Big Data in der Schule

Inspirations …

The Royal Society



Smith et al. (2023)

Mathematical Futures Report (2024)

AIDEA 2025

JMC

RSS

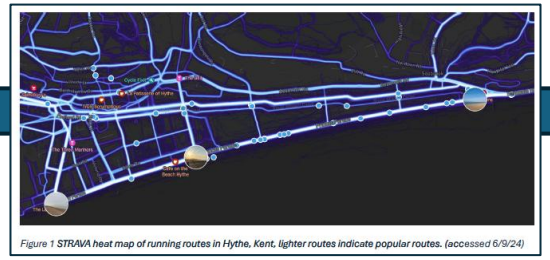


Figure 1 *STRAVA heat map of running routes in Hythe, Kent, lighter routes indicate popular routes. (accessed 6/9/24)*

Jaques & Joubert (2024) A vision for meaningful data education across the four nations of the UK

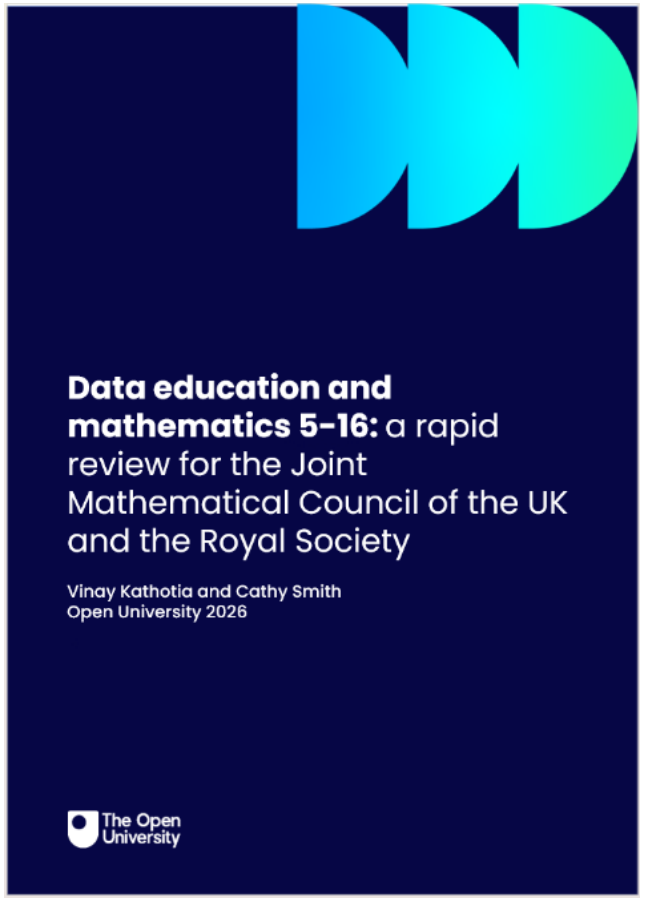
Overview

1. Introduction – UK context
2. Work for the Royal Society Mathematical Futures programme
3. Our model for data-driven education
4. Emerging principles for data education
5. Rapid Review for England's National Curriculum Review
6. Progressions and themes
7. Potential next steps

Creating a world-leading curriculum (England)

- Statutory curriculum since 1998. Last reviewed in 2011-2013.
- Review of whole curriculum (independent review: 2024-25)
- Rapid! Development 2026, publish 2027, first teaching 2028
- Evolution not revolution
- Coherence, specificity, progressions
- Digital tool for showing connections
- Brief mention of digital skills, AI literacy, and 'how to use data to complete tasks and solve problems' (DfE, 2025).

- Small window to inform data education in the curriculum: JMC and RS commissioned a Rapid Review (January 2026)



Seven data education competencies

- Statistical (holistic and iterative) enquiry
- Data stewardship
- Handling data
- Statistical thinking and methods
- Probabilistic reasoning
- Data representation
- Using aids and tools

Ended up with over 100 statements (of different granularity) of what students should be taught that, taken together, characterise these competencies.

Structure for listing competencies

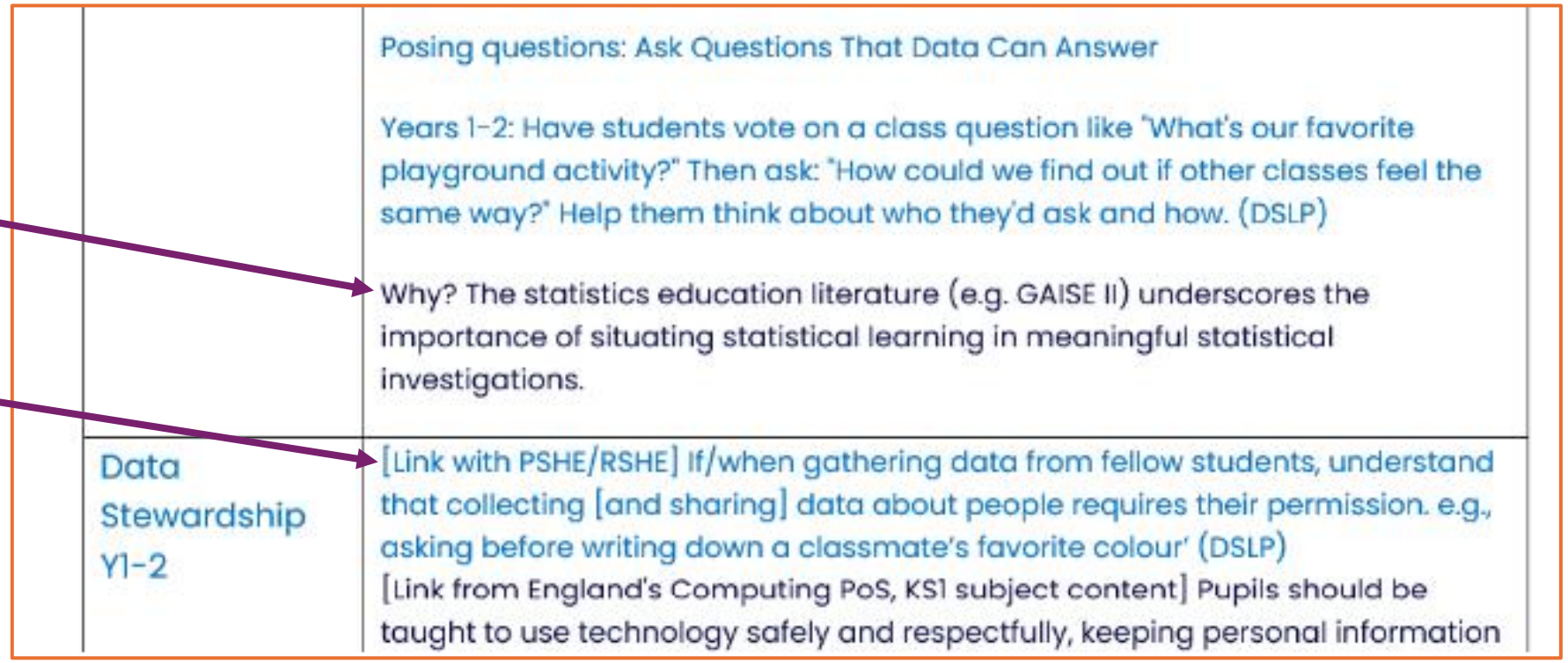
- For Yrs 1-2, 3-4, 5-6, 7-9, 10-11.
- England NC Maths statements at top.
- Content likely new in maths shown in light blue
- Key source where relevant

During Years 1 and 2

England's NC statement	Starting in Year 2, pupils should be taught to: • interpret and construct simple pictograms, tally charts, block diagrams and simple tables • ask and answer simple questions by counting the number of objects in each category and sorting the categories by quantity • ask and answer questions about totalling and comparing categorical data. Non statutory: Pupils record, interpret, collate, organise and compare information (for example, using many-to-one correspondence in pictograms with simple ratios 2, 5, 10).
Statistical enquiry Y1-2 (and sub-strand on Posing questions)	[Link with Science] The Years 1-2 strand on 'Working scientifically' in England's Science NC includes 'asking simple questions and recognising that they can be answered in different ways' and 'gathering and recording data to help in answering questions.' The (non-statutory) Notes and guidance state 'Pupils in years 1 and 2 should explore the world around them and raise their own questions. They should experience different types of scientific enquiries, including practical activities' [Use] the statistical enquiry cycle to understand issues relevant to their immediate locality and context, using primary data they have collected. (JJ)

Structure for listing competencies

- Justification of choices at bottom of cell. (Why?)
- England NC links with other subjects
- Content likely new in maths shown in light blue.



		Posing questions: Ask Questions That Data Can Answer Years 1-2: Have students vote on a class question like "What's our favorite playground activity?" Then ask: "How could we find out if other classes feel the same way?" Help them think about who they'd ask and how. (DSLP) Why? The statistics education literature (e.g. GAISE II) underscores the importance of situating statistical learning in meaningful statistical investigations.
	Data Stewardship Y1-2	[Link with PSHE/RSHE] If/when gathering data from fellow students, understand that collecting [and sharing] data about people requires their permission. e.g., asking before writing down a classmate's favorite colour' (DSLP) [Link from England's Computing PoS, KS1 subject content] Pupils should be taught to use technology safely and respectfully, keeping personal information

Progressions in statements

Competency	Theme	Years 1–2	Years 3–4	Years 5–6	Years 7–9	Years 10–11
	addressing limitations				Identify when a data visualisation cannot be interpreted accurately due to missing information such as scale or variable name.	
Probabilistic reasoning	Make predictions with evidence and caution	[Link with Oracy] Make predictions with evidence and caution, using language of uncertainty (likely, unlikely, may be, because).	[Link with Oracy] Make predictions with evidence and caution, using language of uncertainty (likely, unlikely, certain, impossible, chance, may be, because) and names of relevant variables.		Use probabilities to determine how many times I expect an outcome or event to occur. Communicate the probabilities of events in context (e.g. health outcomes) using natural frequencies and probabilities. [Link to proportional reasoning so likely England Year 9].	[Link with financial literacy] Communicate the probabilities and risks of events in context : make informed choices based on probability and consequences e.g. decide between flood defence systems based on cost and probability.
	sample_spaces and theoretical probabilities of outcomes			[Link with number - follows from correspondence problems currently Y3 & 4] Identify all the outcomes of a future event, for example tossing two coins, netball match.	Generate theoretical sample spaces for single experiments with equally likely, mutually exclusive outcomes and use these to calculate theoretical probabilities for outcomes and events. [Link to proportional reasoning so likely England Year 9].	Interpret contextual statements and diagrams to construct sample spaces for combined/joint experiments, recognising when the sample space has equally likely outcomes (e.g. rolling two fair dice) and when outcome probabilities differ (e.g. true/false results on two medical tests), and use these representations to calculate probabilities.
	Calculate with probabilities				Understand that the probabilities of all possible outcomes sum to 1. [Link to proportional reasoning so likely England Year 9].	Decide whether simple combined/joint events are independent or dependent. Calculate their probabilities using tree diagrams, two-way tables and other representations. **{Calculate and interpret conditional probabilities using expected frequencies with two-way tables, tree diagrams and Venn diagrams}.**
	use random experiments for a purpose		[Link with Citizenship] Use chance experiments for fair (equally likely) choices		Record, describe and analyse the frequency of outcomes of simple chance experiments involving equally likely and unequally likely outcomes e.g. spinner, selecting a person from a panel. Use results to calculate estimated probabilities of future outcomes and events. [Link to proportional reasoning so likely England Year 9].	Identify situations when distinguishing from random chance is important eg medical trials. Use probabilistic reasoning to make sense of outliers or other unusual/ unexpected features of data.
	understand how repeating trials increases confidence				Understand that sets of repeated trials from the same experiment may vary. Extend chance experiments to at least 100 trials (aggregating results or using a simulation) and compare the experimental probability of an outcome to its theoretical probability. [Link to proportional reasoning so likely England Year 9].	Estimate the probability of an event by carrying out chance experiments repeatedly using a simulation and decide a criterion for stopping the trials and communicate the probability **{as an interval}** e.g. the estimated probability of two wins, one loss is 0.4 **{between 0.36 and 0.41}.**

Variability is central to statistical thinking

Theme	Years 1–2	Years 3–4	Years 5–6	Years 7–9	Years 10–11
Variability	Collect and record multiple measures of the same numerical attribute using non-standard units and describe the variability e.g. use hands to measure tree girth. [Link to measurement]	Collect and record multiple measures of the same numerical attribute using units based on standard units, e.g. use 5ml spoons to measure capacity, and describe the variability. [Link to measurement]		Identify outliers as data points that are much bigger or smaller than most data points and consider the reasons for removing or keeping these.	Anticipate, recognise and account for variability in data, including via error or chance, [and in sampling] and appreciate how it shapes analyses and predictions; Explain how removing or including outliers affects the range, median and mean. {Estimate medians and means for grouped data sets}.

Implications for England’s curriculum review

Coherence, e.g.

- Connected curriculum (across-subjects) tool shows data-driven skills and experiences
- Identify and require use of mathematical and statistical skills within data-driven activities in other subject areas

Sequencing and progression, e.g.

- Proportional reasoning is foundational both for data analysis and probability measure
- Measuring is foundational for variability

Implications for England’s curriculum review

Specificity, e.g.

Expand the explicit statistical content within mathematics to include statistical enquiry and the creation, collection and handling of data.

Ensure that all examples and guidance in the statistics section address statistical thinking and cannot be taught or assessed purely as an exercise in mathematics.

Students from Year 5 onwards should compare groups using related data sets and the shape of distributions (variability).

Students of all ages should demonstrate probabilistic reasoning by making predictions from evidence and with caution.

Little steps towards a greater role …

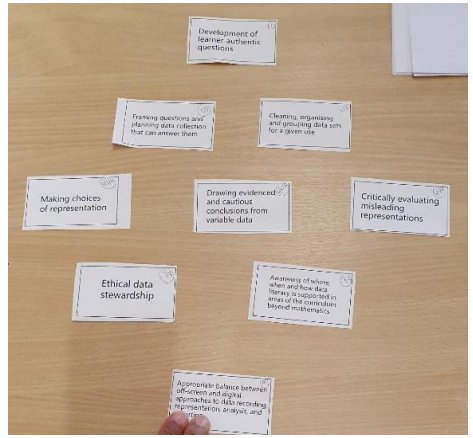
The new curriculum will:

- Identify maths concepts needed for data skills so they can be developed in maths before being met in other subjects
- Establish a common language about data skills across subjects to aid teachers' planning
- Change the non-statutory guidance for all subjects to include the whole data cycle
- Recommend citizenship projects that consider data

Royal Society Expert panel discussions …

TOP areas for teacher development

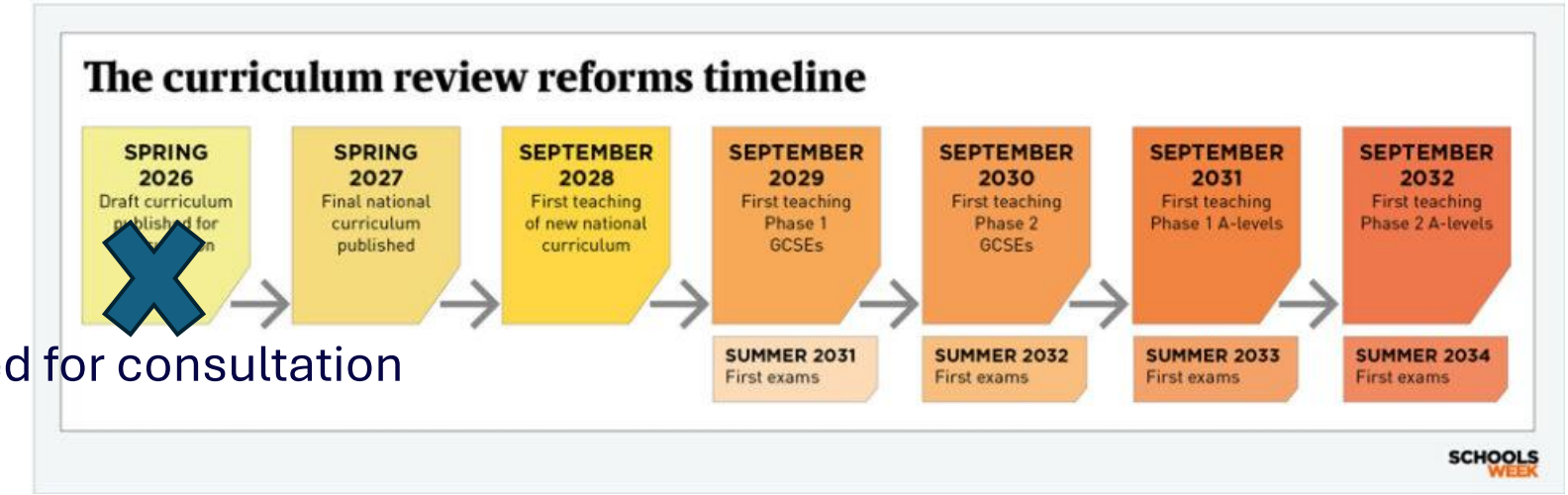
- Awareness of where, when and how data literacy is supported in areas of the curriculum beyond mathematics
- Development of learner-authentic questions
- Drawing evidenced and cautious conclusions from variable data



BOTTOM areas

- Appropriate balance between off-screen and digital approaches to data recording, representation, analysis, and reporting
- Cleaning, organising and grouping data sets for a given use
- Ethical data stewardship

The future



Autumn 2026
Curriculum published for consultation

Source: BISI

Spring 2027
Changing attitudes to children's digital worlds

Starting to be considered:

- Development and trialling of resources
- Assessment
- The enacted curriculum
- Teaching capacity and professional development

Is there time for research?

Not even started:

- Integration of technology

Thank you!

References

DfE. (2025). 'Government response to the Curriculum and Assessment Review'. Department for Education, England. https://assets.publishing.service.gov.uk/media/690b2a4a14b040dfe82922ea/Government_response_to_the_Curriculum_and_Assessment_Review.pdf

Jaques, L., & Joubert, M. (2024). *A vision for meaningful data education across the four nations of the UK*. The Joint Mathematical Council of the United Kingdom. https://www.jmc.org.uk/2024/11/16/a-vision-for-meaningful-data-education-across-the-four-nations-of-the-uk/

Kac, M., Rota, G.-C., & Schwartz, J. T. (1992). *Discrete Thoughts*. Birkhäuser Boston. https://doi.org/10.1007/978-0-8176-4775-9

Kathotia, V., & Smith, C. (2026). *Data education and mathematics 5-16: a rapid review for the Joint Mathematical Council of the UK and the Royal Society.* The Open University. https://www.jmc.org.uk/wordpress-cms/wp-content/uploads/2026/02/Rapid-Review-of-Data-Education-within-Mathematics-5-16-FINAL.pdf

Kathotia, V., Ward-Penny, R., & Smith, C. (under review). Data Science, Mathematics and the Cohesive Potential of a Critical Questioning Paradigm.

Niss, M., & Højgaard, T. (2019). 'Mathematical Competencies Revisited'. *Educational Studies in Mathematics* 102, no. 1: 9–28. https://doi.org/10.1007/s10649-019-09903-9.

Smith, C., Kathotia, V., Ward-Penny, R., Howson, O., & Wermelinger, M. (2023). *Mathematical and Data Literacy: Competencies and curriculum implications at the intersection of mathematics, data science, statistics and computing*. The Open University. https://royalsociety.org/-/media/policy/projects/maths-futures/intersection-mathematics-data-statistics-computing.pdf

Tukey, John W. (1962). 'The Future of Data Analysis'. *The Annals of Mathematical Statistics* 33, no. 1: 1–67.

The Royal Society. (2024). *A new approach to mathematics and data education*. https://royalsociety.org/-/media/policy/projects/maths-futures/new-approach-to-mathematics-and-data-education.pdf