

# A vision for meaningful **data education** across the four nations of the UK (Summary)

## A report prepared for the Joint Mathematical Council of the UK

### Introduction

We live in an increasingly data driven world. The UK's citizens are both *sources* of data arising from our digital footprints, as well as *consumers* of data and they need to be able to critically engage with data and ask questions of the information presented. However, despite relatively high performance in the *uncertainty and data* subdomain of PISA 2022, UK learners' capabilities do not appear to transfer successfully to the growing needs of UK society. There is increasing demand for specialist data skills at all competency levels across all industrial sectors and in all regions of the UK, but preparing learners to meet this demand is lagging behind.

This document summarises the full report prepared for the Joint Mathematical Council of the UK. It is concerned with the data education that all learners in the four nations of the United Kingdom (UK) should experience and the data skills they should acquire in school between the ages of 4 and 16. We use data education to mean the conditions at system- and classroom-level that all learners need in order to develop the data skills required for further *advanced* study and/or employment.

The report builds on substantial thinking that has taken place in the UK over last five years and blends this with some international and further thinking to consider the following research questions:

1. What are the data skills that learners should have developed by a) by the end of primary school, b) the age of 14, c) the end of formal education in the UK?
2. What is the evidence base on effective practices in developing data skills in mathematics (and elsewhere in the curriculum)? Are these small-scale insights and/or examples of effective system-wide data skills development?
3. What resources do we need to achieve meaningful improvement in data education across the four nations?

# Data skills

Data skills are necessary for making sense of our complex and multi-disciplinary world. Working with data in school has the potential to engage learners in meaningful mathematical activity. To meet the future needs of UK society's citizens and the demands for workforce skills, data education should be more prominent in the national curricula of each of the four nations, and be expanded to include data skills that go beyond simple statistical manipulation.

Being able to construct and interpret varied data visualisations are increasingly important data skills. Whilst bar charts, pie charts and box plots are often used to communicate data, learners need to develop the skills, including using digital technologies, to construct visualisations and make sense of, and question, the varied representations of data that they encounter. Data skills need to include constructing and interpreting varied visualisations beyond the more traditional graphical representations.

When collecting, analysing, interpreting and communicating with data in the real world (in contrast to the school world) it is done with purpose. The problem, plan, data, analysis and conclusion (PPDAC cycle), as shown in Figure 1, should form the basis of the data education from early years to school leaving age.



Figure 1: The problem-solving cycle (PPDAC: problem, plan, data, analysis and conclusion)<sup>1</sup>

Processing data with ethical consideration is not explicit in the planning and data collection stages of the problem-solving cycle. Learners need to be aware of the ethical issues associated with leaving data footprints and the ways in which their data is used (e.g. for marketing) and whether they want their data to be used in this way. Data skills need to include awareness and understanding of ethical acquisition and processing of data (*data stewardship*).

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<sup>1</sup> Wolff, A., Gooch, D., Cavero Montaner, J. J., Rashid, U., & Kortuem, G. (2016). Creating an Understanding of Data Literacy for a Data-driven Society. *The journal of community informatics*, 12(3), 9-26. doi:10.15353/joci.v12i3.3275

## Current practices in data education

Countries that are generally seen as successful or interesting in their approach implement data education at system and classroom level. At system level, countries and states are developing curricula where data skills feature prominently or form part of interdisciplinary or project-based learning. There are examples where data skills, although part of the mathematics curriculum, are also integrated into other curriculum content. In these countries, data education is also supported at classroom level. For example, they encourage teachers to use innovative teaching practices, make use of digital technologies and invest in educational initiatives to support teachers and learners. There is little evidence related to how well these initiatives work in practice and therefore we need more research about this.

In the UK, at system-level, the prominence of data education in each of the four nations must be raised. This can be achieved by identifying a single *Ambassador for data education* to advocate for high-quality, meaningful data education across all four nations of the UK and in all phases of education from EYs to school leaving age and beyond.

If data education is to integrate data skills into other curriculum content, this will demand that all teachers across all subjects provide a meaningful data education, including the effective use of digital technologies such as CODAP<sup>2</sup> or Tinkerplots<sup>3</sup>. However, it is well recognised that most teachers, including many secondary mathematics specialist teachers, do not have the confidence or knowledge to teach data skills effectively. This implies the need for significant professional learning to broaden teachers' own knowledge of this growing discipline and to build their confidence in teaching approaches including their use of a range of appropriate digital technologies for working with data. By bringing together teachers across disciplines, and across phases, there is the potential to develop a coherent view of how cross-disciplinary data skills progress over time.

At the classroom level, curriculum materials to support teachers to teach data skills are currently widely available online. For some, teachers will require additional support in the form of high-quality professional development. A single online curated repository of quality-assured and freely available data education curriculum materials and signposts to high-quality professional learning opportunities is needed.

Research literature on data skills and data education largely involves secondary and post-16 settings and outside of the UK. Further UK-centric research is needed to understand how learners develop data skills in national contexts in early years, primary and secondary settings and develop effective teaching practices. Policy makers need to find system-level mechanisms to address prioritising data education, but there is limited evidence about what works, and what does not work, at scale. Further research to understand and address barriers to successful data education policy implementation in the context the UK is needed.

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<sup>2</sup> <https://codap.concord.org/>

<sup>3</sup> <https://www.tinkerplots.com/>

## Data education in the UK

The four nations' curriculum expectations for data skills vary in the earlier phases of education but converge by the time learners reach the school leaving age. Overall, there is little attention to the purpose for collecting and analysing data and as such there is no sense of relevant contexts within which working with data should arise. Curriculum expectations tend to focus on statistics (and probability) and ignore broader skills such as problem solving, decision making, critical thinking, data processing and data stewardship. Future reforms of GCSE Mathematics or Scottish National 3/4/5 examinations should include a compulsory component for *all* learners involving foundational data skills.

Whilst some expectations in the UK curricula specifications involve using digital technologies, these are for younger learners and by the time learners reach 16 years of age, they have disappeared. The reason for this might be that current assessment arrangements do not accommodate digital data manipulation.

How data skills are assessed drives how they will be taught. National assessments currently bear only minor relationships to the skills and experiences described in the full PPDAC cycle and cannot assess learners' capabilities to identify a problem, construct a question and plan how to answer it by collecting and preparing data, analysing and interpreting data and then using data and visualisations to tell stories.

The majority of data in the workplace is generated and processed in a digital space, so it is pragmatic to teach data skills using digital technologies, wherever possible. Digital assessments of data skills projects should be trialled for school leaver examinations across the four nations of the UK.

Data education is a priority for governments of all four nations and when the five-year strategy of the UK Statistics Authority is renewed in 2025/6, they should include an objective related to data education.

Our review of reports relevant to data education in the UK has not found any substantial evidence of current practices in schools. To gain a better understanding of data education in the four nations of the UK it might be useful to conduct state-of-the-nation reviews by getting directly into schools, observing data education in practice and discussing with teachers and school leaders how data education is incorporated into school activities.

# A vision for meaningful data education across the four nations of the United Kingdom

Our vision includes specifying an aspirational and coherent progression of data skills and competencies defined at three points in learners' data education. These are organised using the following framework: *conducting iterative and holistic enquiry; posing questions; solving data-driven problems; data stewardship; handling data; data representation; statistical thinking and methods; probabilistic reasoning and using aids and tools.*<sup>4</sup>

Our proposed set of data skills<sup>5</sup> for the end of primary and end of lower secondary emphasise relevance and purpose throughout with relevance gradually expanding out from learners' immediate experiences as they grow. We also propose that the scale (size) of a data set increases over the period of a learner's data education. Probability is experienced first-hand by the youngest children in their everyday lives, beginning to understand probability is an important data skill and should be developed from the primary school onwards.

Experience of all elements of the PPDAC cycle should begin in the early years. Young learners are naturally curious about their environment. They gather information and make sense of it by playing with and exploring collections of objects and or repeat events to establish patterns or solve problems. These experiences are the beginnings of statistical inference. Our youngest learners can also experience the beginnings of data stewardship through discussing what it means to get a fair vote when choosing to do something in class. We do not make any recommendations for competencies in the early years, but we do advocate purposeful and relevant experiences of working with data throughout the early years.

Our proposed data skills are aspirational and there might need to be compromises in other areas of mathematics and other subject curricula to accommodate them. However, working with data provides a meaningful context within which to use and apply skills learned in other mathematical domains, such as arithmetic and measurement, and therefore we argue that there is potential to leverage the prioritisation of data education by simultaneously improving the profile of mathematical and statistical problem-solving, application and reasoning.

## Recommendations

### *Data skills*

- Data education should be more prominent in the national curricula of each of the four nations and be expanded to include data skills that go beyond simple statistical manipulation. These skills should:
  - include constructing and interpreting varied visualisations beyond the more traditional graphical representations.

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<sup>4</sup> For a full explanation of these categories, see 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*. Retrieved from <https://royalsociety.org/~media/policy/projects/maths-futures/intersection-mathematics-data-statistics-computing.pdf>

<sup>5</sup> See section 5 in the main report for the set of data skills.

- be developed by experiencing the whole of the PPDAC problem-solving cycle starting with relevant and purposeful enquiry and working with increasingly larger data sets during learners' data education.
- include awareness and understanding of ethical acquisition and processing of data (*data stewardship*).
- Reform GCSE Mathematics or Scottish National 3/4/5 examinations to include a compulsory component for all learners involving foundational data skills to ensure that all learners are taught the necessary data skills for when they are employed or prepare them for further study, for instance for Core Maths.
- Digital assessments of data skills projects should be trialled for school leaver examinations for across the four nations of the UK.
- The proposed data skills should be used to stimulate discussion about what skills are included in national curricula in each of the four nations of the UK to develop a meaningful data education.

### *Effective practices in developing data skills*

- Ensure that foundational data skills are specified coherently across all subject curricula, for all phases from the beginning of primary education, using consistent terminology for each phase of study.
- All teachers of all subjects should have the opportunity to participate in professional learning to broaden teachers' own knowledge of this growing discipline and to build their confidence in teaching approaches including their use of a range of appropriate digital technologies for working with data. By bringing together teachers across disciplines, and across phases, there is the potential to develop a coherent view of how cross-disciplinary **data skills** progress over time.
- Further research to understand how learners develop data skills in national contexts in early years, primary and secondary settings and develop effective teaching practices to further develop their skills.
- Further research to understand barriers, and possible solutions, to successful data education policy implementation in the context the UK.

### *Resources needed*

- Identify and appoint a single *Ambassador for Data Education* across all four nations of the UK, such as in the US, to advocate for high-quality, meaningful data education
- Create a single online repository for curated quality-assured and freely available data education curriculum materials and signposts to high-quality professional learning opportunities.
- The UK Statistics Authority include an objective for engaging with stakeholders in data education in the next five-year strategy plan, to assist in emphasising the importance of data education across the four nations.
- Conduct state-of-the-nation reviews, by getting directly into schools, observing data education in practice and discussing with learners, teachers and school leaders how data education is incorporated into school activities.

Laurie Jacques and Marie Joubert

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