ROYAL STATISTICAL SOCIETY

DATA | EVIDENCE | DECISIONS

Key recommendations for the statistics curriculum in the UK

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The RSS seeks to influence education curriculum and policy to improve the quality of the teaching, learning and assessment of statistics and data. Members of the Education Policy Advisory Group (EPAG) sought to summarise education guidance documents from world-leading examples and provide key recommendations for the statistics curriculum in the UK. Many of our recommendations are UK-wide, while those relating to the GCSE and A-level system are relevant for England, Wales and Northern Ireland.

The authors reviewed guidance from the USA (Guidelines for Assessment and Instruction in Statistics Education, GAISE II) and the New Zealand (NZ) statistics curriculum. The resulting recommendations acknowledge key structural and societal differences with the UK and have taken this into consideration where relevant. The authors provide some general comments, followed by more specific recommendations. These recommendations represent changes we feel should be adopted in the current statistics curriculum in the UK.

Statistics education in the United Kingdom commences in primary education, providing students with a foundational understanding of quantitative reasoning and data analysis. In primary schools, statistical concepts are integrated into the mathematics curriculum, introducing students to the basics of collecting, organising, and interpreting data. As students' progress to secondary education, the focus on statistics becomes more specialised, encompassing topics such as probability, statistical inference, and data interpretation.

However, a critical examination reveals variations and challenges in statistics education across different countries. In comparison to the USA, the UK's approach tends to be more integrated into the broader mathematics curriculum rather than having dedicated courses solely focused on statistics at the secondary level. In the USA, for instance, statistics education often involves specialised courses at both high school and higher education levels, emphasising statistical thinking and data analysis. On the other hand, NZ has been recognised for its innovative statistics education approach, with a strong emphasis on real-world applications and problem-solving. Especially in the context of the recently announced curriculum review, it is helpful to look at examples from other countries.

One criticism of statistics education in the UK lies in the lack of emphasis on practical applications and real-world scenarios. In contrast to the USA and NZ, where there is a greater focus on applying statistical methods to solve authentic problems, the UK's curriculum may be perceived as more theoretical. Striking a balance between theoretical knowledge and practical application is crucial for preparing students to navigate the complexities of the data-driven world effectively. Continuous efforts to align statistics education in the UK with global best practices and adapt to the evolving demands of the field will be essential in addressing these concerns and ensuring that students are well-equipped for the challenges of the 21st-century data landscape.

The recommendations that follow should be used with the GAISE II and NZ curriculum summary document and have been produced to reflect the documents they have been based on. Where key areas of the GAISE II and NZ curriculum refresh documents have been used, they have been left in the table below, for ease of reference.

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Key recommendation for the UK	GAISE II	NZ curriculum refresh - mathematics and statistics
General recommendations for the statistics curriculum across all levels in the UK: • A stronger emphasis on the use of information communication technologies, such as visualisation software, including free programmes such as iNZight (https://lite.docker.stat.auckland.ac.nz/) when teaching statistics across all levels. This should start in primary school (year 5) and be embedded throughout the curriculum across disciplines at the secondary level. • A stronger emphasis needs to be placed on the use of real-world contexts, which should include cultural and interesting contexts, in the teaching of statistics across all levels. This should start in primary school (year 5). • Better connections need to be made with statistics and other disciplines at the primary and secondary level, in the teaching of statistical concepts, data collection and analysis. • The statistical elements within A-level mathematics (across all exam boards in England) are very procedural and formulaic in focusing on learning	Published in 2020, key author is Christine Franklin (American statistical association ambassador for statistics from K-12, i.e., from 5-18 years of age). Described as a set of recommendations for the teaching of statistics from K-12. Written to enhance the statistics standards associated with the National Council for Teachers of Mathematics. Recommendations are presented in three levels: A (elementary, ages 5-11), B (middle school, ages 11-14) and C (high school, ages 14-18). NZ approaches to teaching statistics, along with curriculum framework at the pre-university level has heavily influenced the GAISE II documentation. Examples used in the document (to exemplify key recommendations) include non-traditional data and multivariate data.	Published in 2023, written by the ministry for education, NZ government. In NZ there are no exam boards, the ministry set the curriculum for schools to follow (from 5-18 years of age). NZ use the same year system as the UK, i.e., year 7 is 11-12 years of age. This document covers the teaching of mathematics and statistics from age 5-18. Only the teaching of statistics will be covered from the NZ curriculum refresh document. The curriculum refresh places a strong emphasis on the use of technology, and the linking of contexts to both Māori cultural and spiritual examples, in the teaching of statistics. The learning area of mathematics and statistics weaves together the effort and creativity of many cultures that over time have used mathematical and statistical ideas to understand their world.

statistical techniques whereas the quantitative reasoning elements that should be part of this qualification are not given enough emphasis. These key elements (quantitative reasoning skills, as well as investigative cycle skills and statistical literacy skills), are essential and much sought-after skills across a range of disciplines at university and also across a significant range of job and career pathways. The statistical elements within A-level mathematics should include a stronger emphasis on the investigative cycle (or the Problem, Plan, Data, Analysis, Conclusion [PPDAC] cycle as taken from the NZ curriculum) statistical literacy and quantitative reasoning elements. It is recognised that GCSE statistics is not a widely adopted subject, however the skills mentioned above should be included in GCSE mathematics (if the subjects are not going to be split into separate disciplines) and embedded more deeply from year 7). We propose one of the following options at the secondary level: a) Mathematics and statistics are split, so that they are taught as separate disciplines at secondary school level, with statistics becoming a compulsory subject from year 7, up to year 13. We		The document makes clear connections to social constructivism as a guiding principle in the teaching of mathematics and statistics (the linking of social and physical environments as being crucial to the learning process) although this is not made explicit.

propose that GCSE statistics be made a compulsory subject for all students at key stage 4. Removing statistics from the current GCSE Mathematics curriculum will make space for GCSE Statistics to be made a compulsory subject. Teachers from a wide range of disciplines could contribute to the teaching of statistics from year 7 to year 11 () b) The current GCSE Mathematics to include a greater emphasis on the PPDAC problem solving cycle, statistical literacy and quantitative reasoning elements, as mentioned above. We also recommend these elements are integrated into the existing mathematics curriculum from year 7 to year 9. c) Another option would be to have both separate GCSEs in Mathematics and Statistics (as in option 1) and a combined GCSE (as in option 2). Students would choose whether to take the two separate GCSEs or the combined GCSE. Statistics has a poor subject identity, whilst its presence at university across disciplines is ubiquitous. Many students come underprepared and anxious when they encounter statistics at university or in the workplace. By allowing statistics to exist as a		

separate subject, it will follow in the footsteps of countries like NZ, and soon to be the USA, who recognise it aligns much better to disciplines like computer science and data science.		
Key document points that could be adopted in the teaching of statistics in the UK: • Clearer connections to the PPDAC cycle and the importance of statistical literacy should be emphasised and explained at the primary level, as well as the use of ICT and the use of visualisation software. • Context is so important in the teaching of statistics, the use of dice, cards and coins should be limited. These examples may not be appropriate for cultural or religious reasons. Using real world examples should be encouraged and adopted at the primary level and embedded and used throughout secondary level. This could include the use of cultural contexts. • Carrying out calculations by hand should continue to be phased out, as schools in the UK continue to use technology to carry out calculations and also to analyse data. The focus should be on key statistical concepts, statistical literacy and the use of interesting contexts.	Key points include the following: • The importance of asking questions throughout the statistical problem-solving process (formulating a statistical investigative question, collecting or considering data, analysing data, and interpreting results), and how this process remains at the forefront of statistical reasoning for all studies involving data • The consideration of different data and variable types, the importance of carefully planning how to collect data or how to consider data to help answer statistical investigative questions, and the process of collecting, cleaning, interrogating, and analysing the data • The inclusion of multivariate thinking throughout all Pre-K–12 educational levels • The role of probabilistic thinking in quantifying randomness throughout all levels • The recognition that modern statistical practice is intertwined with technology,	Document states that the most effective teaching of mathematics and statistics follows a strengths-based approach that creates opportunities for all students to learn and progress. Such an approach recognises that all students exist within their whānau (family) and culture and includes parity for mātauranga Māori (Māori knowledge). When planning how to support progress, teachers can ask: what opportunities do students have to: • Learn new mathematics and statistics concepts and practices? • Use mathematics and statistics to investigate relevant tasks? • Communicate and critique mathematical findings and understandings? • Understand the interrelated nature of skills and concepts in mathematics and statistics? Practise the mathematics and statistics that they have learned?

	and the importance of incorporating technology as feasible • The enhanced importance of clearly and accurately communicating statistical information • The role of assessment at the school level, especially items that measure conceptual understanding and require statistical reasoning involving the statistical problem-solving process	When planning tasks, teachers can ask: • What are the cultural contexts that will resonate with my students? • How can I support students to engage with a context's whakapapa (ancestral links), tikanga (customary practices or behaviours), and significance while honouring and maintaining the integrity of both the mathematics and the context? As they prepare, teachers can work through the tasks themselves and ask: • How can I help students find the joy in this learning? • How can I help build the resilience of students? • How can I value and reward persistence? • How can I help students see the broad relevance of this work to their lives, including purposeful contexts, mathematical skills, social skills, knowledge, cognitive development, and cultural competence?
Further recommendations for the teaching of statistics in the UK: • The NZ curriculum refresh and GAISE II documents make clear connections to	• Questioning throughout the statistical problem-solving process • Different data and variable types • Multivariable thinking throughout Levels A, B, and C	The document covers 5 key areas (referred to as "Big Ideas" labelled - Understand):

social constructivism (Vygotsky, 1978) as a guiding principle in the teaching of mathematics and statistics (the linking of social and physical environments as being crucial to the learning process, and the importance of cultural and contextual real-world examples used in the teaching of statistics) although this is not made explicit. Consideration should be given to the benefits of using these learning theories, as well as the works of key educational psychologists such as John Dewey (Dewey, 1916), when designing conferences, training workshops and sessions for statistics teachers. • Consideration should be given as to how cultural connections could be made in the teaching of statistics at primary and secondary levels. This could include a look at the historical context of the different nations within the United Kingdom, and how data has been used over time. It could also include an overview as to the origins of epidemiology, as an interesting example of how data was used to track illness and disease spread.	• Probabilistic thinking throughout Levels A, B, and C • The role of technology in statistics and how it develops throughout the Levels • Assessment items that measure statistical reasoning	**1.** The world is full of patterns and structures that we use mathematics and statistics to understand. **2.** The world is characterised by change and variation that we use mathematics and statistics to understand. **3.** Mathematical and statistical logic and reasoning enable us to identify and explain relationships and to justify conclusions. **4.** The interface between mātauranga Māori (Māori knowledge) and mātauranga mathematics and statistics (mathematical and statistical knowledge) offers opportunities for insights that uphold the integrity of each knowledge system. **5.** Mathematics and statistics have a continuous, evolving human history. Statistics and Probability are the two areas of the document related to the teaching of statistics (2 out of 6 key teaching topics). These are labelled as - "Know." Guidance for teachers asks them to consider the following topics/skills development: investigating situations, representing situations, connecting situations, generalising findings and

		explaining and justifying findings. These are labelled as - “Do."
Progression through the educational levels of statistics: • The progression in the statistics curriculum within the UK is patchy, and unfortunately many young people feel underprepared and even surprised when they encounter statistics, especially at university. If the teaching of statistics was undertaken as a separate discipline, then there would be a great opportunity for a coherent curriculum for the subject to be nurtured and built upon throughout key stages of a young person’s development and educational journey. It would also enable the linking of statistics to other subjects (for example, the statistics within geography). This should start at the secondary level of education, being made compulsory from year 7 through to year 13. • A strong emphasis on the PPDAC cycle and statistical literacy should start at the primary school level and continue through to secondary level. As mentioned above, linking and embedding statistics across disciplines, at both the primary and secondary level, is crucial.	Beginning students (from 5 years of age) cannot be expected to make all of the linkages of the statistical problem-solving cycle. They require years of experience and training to develop more mature reasoning. Much like mathematics education, statistics education should be viewed as a developmental process. Emphasis on building the student’s statistical literacy skills.	Guidance is presented in a series of phases: • Phase 1 = years 0 to 3 • Phase 2 = years 4 to 6 • Phase 3 = years 7 to 8 • Phase 4 = years 9 to 10 • Phase 5 =years 11 to 13 Each phase covers the “Understand, Know and Do,” areas. Students are expected to build on foundational concepts in the statistical problem-solving cycle (NZ uses PPDAC – Problem, Plan, Data, Analysis and Conclusion/Communication). Statements are phrased as: I am deepening my understanding for – Understand, I can for – Do (i.e. I can pose investigative questions to explore a statistical problem), and I know how to for – Know. Statistics and Probability concepts are presented in year 0, and at each phase up to, and including phase 5.

Examples given to deliver statistical topics: • A greater variety of interesting and engaging topics and contexts need to be adopted in the teaching of statistics within the UK. This includes assessment and exam contexts, mostly produced by exam boards. • More time needs to be focused on the visualisation of data in the teaching of statistics, across all levels. Less time should be spent on manual calculations.	Many examples presented to reinforce the statistical problem-solving cycle (Formulate statistical investigative questions, collect/consider data, analyse the data, interpret the results). Examples given at A Level include bean plant growth, ladybird features (with data cards used that include pictures of ladybirds with different features) and music choice of classmates. Data visualisation techniques are also explored at elementary and middle school, with measures of central tendency explored at level B. Scatter plots and time series data are also considered at levels B and C. Examples given include Darwin's finches and their beak length. At level C, the statistical problem-solving cycle is used, and examples from levels A and B (Music choice of classmates and Darwin's Finches) to enable students to make links from earlier years of their study.	Examples from year 0 include: • Data is information about the world and comes in many forms. • People and the environment are not data, but data can tell us things about people, their lives, and their environment. • Summary investigative questions and the statistical enquiry cycle (PPDAC – Problem, Plan, Data, Analysis, Conclusion) are used to investigate a group. • Data visualisations are representations of all available values of one or more variables that reveal relationships or tell a story. I know how to: • explore summary investigative questions about everyday situations, using categorical data and discrete numerical (whole-number) data • use survey and data-collection questions • collect, record, and sort data or use secondary data sources • create and make statements about data visualisations • answer an investigative question by choosing statements from finding

		• identify relevant features in others' data visualisations. Examples are presented for each phase, however there are limited examples presented with reference to context. These are presented on the landing page for this curriculum area: click here for associated resources and further documents)
Assessment guidance: • A greater variety of interesting and engaging topics and contexts, underpinned by the PPDAC cycle and statistical literacy skills, need to be adopted in the assessment of statistics, across all levels, as well as exam contexts, mostly produced by exam boards. • More opportunities need to be made available for young people to engage with the production of statistical reports, that include quantitative reasoning skills, especially at the secondary level (year 10/11 upwards). AI assisted software and anti-plagiarism tools, such as Turnitin, can be explored, to assist in the prevention of plagiarism, to assist in the adoption of this form of assessment.	Links made to Common Core State Standards, in line with the US education national standards for the teaching of mathematics. Multiple choice questions and short answer style questions are presented. Questions focus on central tendency, measures of centre, variability for level A. Randomness, statistical problem solving cycle, and the mean as a balancing point for level B. Interpreting an interval and sample size effect on the margin of error, drawing conclusions about the relationship between two categorical variables, describing the relationship between two quantitative variables by interpreting a least-squares regression line, simulation and deciding if an observed statistic is unusual or plausible.	These are presented on the landing page for this curriculum area: click here for associated resources and further documents. They cover formative examples of assessment.

• Teachers need more support and training to teach statistics successfully. They also need help to find interesting and engaging contexts in the teaching and formative assessment of statistics, across all levels.		

References

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Other links are embedded and included within the main document.

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