ROYAL STATISTICAL SOCIETY
DATA | EVIDENCE | DECISIONS

STATISTICS AND DATA IN THE MATHS TO 18 PROPOSALS

4 October 2023

1. Overview

The Royal Statistical Society (RSS) is an organisation that advocates for the key role of statistics and data in society, on behalf of its membership. The RSS Vice President for Education and Statistical Literacy, Dr Sophie Carr, and the Education Policy Advisory Group (EPAG) seek to influence education policy to improve the quality of teaching, learning, and assessment of statistics and data.

The RSS is interested in the role of statistics and data education within the government's plan to ensure that every student studies some form of maths until the age of 18. The RSS has undertaken stakeholder discussions and consulted with experts, RSS Fellows and the wider public to further our understanding and formulate recommendations, which we will be sharing with the government's Maths to 18 Expert Advisory Group.

We focus here on the skills we believe every student should leave school with in order to successfully navigate daily life, rather than content necessary for more academic pursuits of maths, statistics, or data science. We consider statistics – the science of learning from data - and data literacy in terms of techniques and methods, but also in a broad sense, including the ability to think critically and interrogate data and claims in the world around us.

A key point is the importance of first considering the skills we value and want young people to have, before considering how this relates to the curriculum and assessment.

Another important point is that discussion in this area should not just focus on post-16 maths – it is crucial to also focus on pre-16 education. By the time students reach age 16 to 18 and are selecting their route for further studies or work, previous and possibly negative experiences of learning maths can influence choices and the ability to pick up necessary skills. Research by the University and Colleges Admissions Service (UCAS) indicates that some students begin to consider higher education choices as early as primary school, while for others, consideration too late can limit options. Education during childhood lays the foundation for everything that follows, and is a critical period for both developing preferences and learning. Investing in education in the early years has the potential to lead to great returns, and numeracy is linked to earning potential, employment prospects, and even health outcomes. This has implications for workforce productivity and government spending and savings. Efforts focussing on post-16 education without considering pre-16 education cannot be more than a partial solution or 'sticking plaster'. The aim is that improving pre-16 education can in turn improve post-16 education, with implications for student engagement, learning, and satisfaction, as well as teacher satisfaction and wellbeing.

We recognise that there is variation across age groups in how data and statistics are taught, with some primary schools demonstrating exemplary teaching, from which lessons could be learned. We focus here on secondary education as an area in which improvements could be made. We also recognise that school is not the only setting for maths until age 18 – 16 to 18 year-olds may take a range of other routes, including apprenticeships such as data technician or data analyst apprenticeships. We will be releasing a report in the coming weeks looking at non-degree pathways into data analysis careers, with a focus on apprenticeships. Of particular relevance to 'Maths to 18' is the misperception about what type of mathematical and statistical understanding is needed for people to have functional statistical literacy in the modern world – people need to know what tools they have available and how to use them; they do not need deep or detailed understanding of underlying theories.

We also recognise that the education system varies across the devolved nations and with regards to the different types of qualifications available to young people; we focus here predominately on England, as the host to the largest contingent of students across the UK.

Finally, we have addressed the question of the place of statistics and data within the Maths to 18 proposals by focussing on improving how mathematics, statistics, and data are taught, rather than consideration of larger-scale changes across subjects such as the introduction of an International Baccalaureate-style qualification or broader issues such as with teacher recruitment. We recognise that a sufficient supply of teachers is needed in order to teach maths, statistics, and data skills in the best way possible and to introduce more involved changes. We also believe that improving maths education should not be pushed aside and delayed; smaller, less time-intensive changes (such as the provision of ready-made easy-to-use resources to help teachers teach data skills, for example) can be implemented in the meantime.

Our ambition is for students to enjoy and engage with learning statistics and data science across all school years, realising the relevance of these subjects and viewing them as tools to understand the world around them. Students would appreciate the utility of the skills that studying these topics can equip them with, and therefore realise the benefit of studying them. Any post-16 curriculum aiming to provide young people with practical skills would need to feel relevant to students' lives, and to be accessible and engaging, with a visibly different focus to traditional academic mathematics. Students would leave school equipped with the skills necessary to interpret data, interrogate claims, handle figures needed for managing aspects of daily life (eg personal finances), and understand how coding and artificial intelligence contribute to the technologies they encounter daily.

2. Key points and recommendations

- The current **challenges** with the system include: students not leaving school with the skills they need to navigate daily life; students not enjoying and engaging with studying maths; maths having a negative reputation; well-established and long-standing issues around teacher recruitment and retention; and challenges around assessment – which does not reflect the practical nature of statistics, and can impede students and teachers being able to explore the areas of interest to them.

- Any Maths to 18 strategy should include focus on improving **pre-16 education**.

- It is important to first consider what **skills we value** (the statistical and data literacy skills that students leaving school need in order to navigate every-day life), before considering how to teach and assess them.

- To improve students' experiences of studying, motivation to engage with, and the reputation of maths, statistics, and data education, topics should be engaging and **relevant to real-world circumstances**. Providing the opportunity for students to explore **data sets** in an area of interest could be a good method to encourage students to engage with the subject. The curriculum should include the teaching of **data interpretation, modelling, and computing skills** from the early years of education. Mathematics education should **harness the power of computers,** to reflect maths as carried out in the real world, and to teach students how to use technology to help them to answer questions. Mathematics **taught in other subjects** could be acknowledged and built upon, in a joined-up manner, throughout the age range.

- Regarding the **qualifications on offer pre-16**, the GCSE system could be refreshed to increase engagement and learning of relevant skills for all students, while also allowing students to study more maths if they wish. One option could be to offer a **renovated Statistics/Data GCSE** alongside the (also renovated) Maths GCSE. Students could take **both GCSEs (= two GCSEs)**, or could take a **single combined GCSE option (= one**

GCSE), with core content covering both Maths and Statistics/Data. The core content would be relevant to daily life skills and would aim to increase engagement with the subject. The splitting of content via the categories of 'Statistics/Data' and 'Maths' versus eg 'Maths for life' and 'Maths for academic pursuit' may help to ensure that students are not put off taking the double GCSE option due to fear of too much or overly 'academic' maths. It could also help ensure that statistics and data are seen to be of equal status to maths. Further details on this recommendation are included below. An alternative option, if there were only scope to refresh one GCSE, would be to **include more statistics and data within the current Maths GCSE**, for all students to take.

- Post-16, take-up of **Core Maths** could be encouraged, as an initiative that allows students to continue learning maths relevant to daily life, with reports of high students enjoyment of the topic, but low take-up across schools.

- Aside from the well-established issues regarding **teacher recruitment, retention, welling, pay, and working circumstances**, any strategy to improve the delivery of maths must ensure that teachers are **invested and passionate** about the curriculum, and are brought on board with new initiatives. Easy-to-use **resources** (eg to allow students to explore data sets) could be **provided** as a feasible short-term step to allow teachers to teach enthusiastically and inspire students about areas of interest to them.

- Assessment must assess the skills we value. Statistics and data science are **practical subjects: projects and coursework** can allow students to demonstrate competence with the full statistical cycle (planning, collecting data, analysis, communication, consideration of implications and limitations), and allow better assessment of skills such as reasoning, problem-solving and critical analysis. This type of project work would additionally better equip students for the project-based nature of many jobs. **Continuous assessment** could remove some of the pressure of high-stake exams, and could allow students to log which skills and competencies they have. **Limitless resits of GCSE Maths** for students who have not passed will only demotivate students further; **an alternative qualification**, more appealing and relevant to daily life skills, should be introduced for students who have not passed after one resit.

- Efforts to improve the education of maths, statistics, and data science should also aim to **tackle inequalities**. This includes working to minimise the gender gap in take-up of these subjects; ensuring that the needs of the 'forgotten third', who require adequate maths, statistics and data skills to manage daily life, are met; ensuring that any new qualification pathways do not inadvertently disadvantage students (who may already be from disadvantaged backgrounds) by closing doors to future opportunities; and ensuring that embracing digital technologies in maths education does not widen the digital divide.

- **Engagement** with a wide range of stakeholders should be undertaken, to help ensure that the curriculum covers the skills needed for daily life and the future workforce; that teachers are invested in the curriculum; and that it is taught in a way that can inspire and engage young people.

Below, we set out further detail on the challenges we see with the current system, and potential solutions to overcome them.

3. Challenges with the current system

Skills gained

Many students are not leaving school with the ***skills they need to navigate everyday life.*** Requisite statistical literacy skills are changing over time with the increase of technology and AI. Citizens face a data deluge and need to be able to interpret data and critically evaluate health, climate, or political claims, as well as to manage their own finances. The applications of mathematical, statistical and data literacy are relevant to daily life, and range from financial skills eg calculating the cost of a mortgage or preparing a budget, to understanding exponential growth and risk of exposure during a pandemic, to understanding the mechanisms by which AI works and how to harness the power of computers and big data, to allowing people to be informed citizens, keeping themselves politically informed and allow understanding of the voting system. The RSS survey testing simple statistical skills (probability) among MPs, conducted in 2022, demonstrates that these skills are by no means universal.

A group especially underserved by the current system is the 'forgotten third' (pupils who obtained below a grade 4 in English and Maths at age 16). The current GCSE syllabus does not contain enough statistics and data relevant to daily skills for the majority, let alone the forgotten third.

Young people also need statistics and data literacy for a range of future career types and jobs, as well as admission to higher education programmes (especially those relating to preparation for professional practice such as medicine). Statistical skills and an understanding of data are needed for the majority of jobs, in order to inform human resources or policy decisions, understanding of variation and robustness in engineering and manufacturing, and knowledge of how to design or interpret research experiments in medicine and other sciences.

The student experience

Many students are ***not enjoying pre-16 maths*** as it is currently taught, and are not realising the full breadth of pertinent applications that studying maths, statistics, and data science can offer. Studying these topics can allow students to understand the world around them, exploring data and investigating questions on areas of interest to them, as well as providing them with relevant skills. But without clear examples of the relevance of studying these topics to daily life, students are not motivated to study them - why engage with learning a topic that does not appear to be useful?

Additionally, restrictive and outdated curriculums may not allow students to explore the topics that they may find most relevant and enjoyable. It is not just students who are put off by unstimulating curriculums - teachers who are not invested in the curriculum cannot teach with as much enthusiasm or provide inspiration to students.

Negative reputation

Maths and statistics have a ***negative reputation*** – it is acceptable to laugh about 'not being able to do maths' in a way that it is not acceptable to admit not being able to read. Students do not see studying maths as key to developing useful skills relevant to everyday life. We note that to change negative attitudes towards maths and statistics in the general population, a wider approach must be taken – focussing attention on students post-16 is already too late. Initiatives across the ages, including in younger children and adults, as well as sustained efforts to change cultural attitudes in major institutions (the civil service, the media) may help.

Teacher recruitment and retention

There are well known issues with the ***numbers, resourcing, training, pay, and wellbeing of maths teachers***. It can feel futile to consider new and promising curriculum or assessment initiatives when it is clear that they require teacher resources that are not currently feasible. Teachers not invested in the curriculum may not be able to teach enthusiastically. Teachers of other subjects (as part of efforts to embed maths in other subjects

or increase the number of teachers who can teach maths) may not feel comfortable teaching maths, and 'pure' maths teachers may not feel comfortable teaching statistics or data science.

Assessment

An ***overly strong focus on assessment*** can impede opportunities for teachers and students to explore areas of interest to them.

It can also be difficult for students to ***evidence their relevant skills*** – it is possible to pass a GSCE by skipping many statistics questions, and apprenticeship providers can feel the need to examine students on basic skills (measuring, telling the time) on entry, as they cannot tell the level of these specific skills from overall exam marks.

The manner of assessment can also restrict the types of skills tested, with exam-based assessment testing different skills to coursework or project-based assessment (skills that are inherent to statistics and data science).

4. How to get to where we want to be

Focussing attention solely on maths education at age 16 to 18 can only offer a partial solution to a long-standing problem. By age 16 to 18, students may already have had negative experiences of learning maths and have disengaged with the subject, impeding them from gaining the necessary skills to navigate life. Pre-16 education needs to be considered as a key part of the government's approach to delivering 'Maths to 18', focussing efforts on improving the student experience of learning. When considering post-16 education, the new curriculum must look and feel different to the current GCSE offer – it must be seen to be relevant to students' lives, be interesting and engaging, and accessible to students who are not confident in traditional school mathematics.

There is a culture of gearing education towards assessment. It can be difficult to see how the education system will change if assessment does not change first. However, it can be too easy to become trapped by the challenges of changing the existing curriculums and assessment practices if this is the initial focus. It is important to create a system of assessment that exemplifies core ideas, and rewards effective skills. Therefore, it is essential to first consider the skills that we value and think are critical for young people to leave school with, before considering what this means for the curriculum and assessment:

- Consider the ***skills*** we need to teach children so that they can navigate everyday life
- Consider the ***topics that children and young people are interested in*** and will engage with
- Translate this into ***coherent content,*** with links to other subjects in appropriate places
- Ensure ***engaging delivery,*** including adequate teacher resourcing and wellbeing
- Think about how to ***assess*** the skills we value.

Below, we use this framework to set out ideas on possible solutions to the challenges with the current system detailed above.

Necessary skills

Challenges*: students are* ***not leaving school with the skills they need to navigate everyday life, or for further study or work****; the current system is especially not serving the 'forgotten third' (pupils who obtained below grade 4 in English and math at age 16).*

Possible solutions: consider the skills we value and think are crucial to strive in the current climate, for example:

- **statistical literacy, critical thinking, and investigative skills** (a mental toolkit) to be able to interrogate the origins of data and why it was collected, to consider the suitability of the sample size and methods, and to critically evaluate claims seen in the media or online - organisations such as Full Fact are a source of contemporary, real-world examples of constructive critique that can support teaching
- **data and numeracy skills to be able to interpret and handle figures** needed for managing aspects of daily life eg personal finances, understanding the risk of a medical procedure or of getting a disease, or being an informed citizen
- an **understanding of data and coding** such that students can grasp the mechanisms by which coding and artificial intelligence contribute to the technologies they encounter, including machine learning algorithms such as k-nearest neighbours algorithm (KNN), random forests, and ChatGPT
- strategies to **understand large numbers** encountered in everyday life, eg by putting numbers in context and comparing them to known figures.

Considering aspects ***not well understood during the pandemic*** (eg exponential growth relating to new variants, false-positives, counterfactual reasoning, the value of randomising in studies) or areas not well understood in other common situations could be a starting point.

While this paper largely focusses on gaining the skills needed in day-to-day life, it is also important to ensure that maths education equips students wishing to continue with further education. An example of this is medical school, where the requirement for statistics on entry is often low, and some graduates have expressed a desire for a greater understanding of the statistics related to clinical practice.

Engaging topics

Challenges*: students are* ***not enjoying maths*** *as it is currently taught, and are not realising the full breadth of interesting applications that studying maths, statistics, and data science can offer or the key relevance of data in informing much decision-making; maths and statistics have a* ***negative reputation.***

Possible solutions: consider the topics that students find interesting, relevant, and capture their imagination, so that they engage, enjoy learning, and develop the necessary skills. For example, real-world data on gender inequality, migration, climate change, social media, sports, betting, market trends, Covid-19 and other health trends is easily accessible and may be of interest to students. Students should be introduced to real-world data, with all of its complex interactions, from the outset, not just at the final stages of education. Covering topics of interest can be a 'way in' to demonstrate the appeal, relevance and utility of data and statistical skills.

It would be useful to undertake substantive stakeholder engagement with students and teachers to investigate the topics students are interested in. This could help address any resistance to the idea of further study of maths.

Possible ways to incorporate topics of interest into education, or provide inspiration about these subjects, could include:

- **Exercises with data sets** – data sets on many topics of interest are freely available, and many are online and interactive. Exercises can be formulated, with questions to investigate, and students can have an opportunity to develop statistical and data literacy by interacting with real-world data of interest. Examples of sources with freely available datasets include the Common Online DataAnalysis Platform (CODAP), Our World in Data, the Organisation for Economic Co-operation and Development (OECD), the United Nations, and the World Bank. Other examples include the large data set included in Edexcel A Level Maths – similar data sets could also be covered pre-16.
- **Project work or coursework** – this is often an aspect most enjoyed by students, as students have the freedom to delve into a topic of their own choosing and to use their own initiative to plan and

complete the project. Coursework can also be key for children facing difficulties at school, eg long-term sickness and absences from lessons - coursework can provide an opportunity for these students to engage, enjoy learning, and complete a task at their own pace. More detail on incorporating coursework is included in the 'Assessment' section below.

- **Efforts to overcome the gender gap in coding/STEM subjects** and to spark girls' interest in coding, through positive role models and via topics of interest. This could involve applying concepts to topics of interest within the subjects of maths or statistics, or covering more aspects of coding or statistics in other subjects that may already be of interest, such as psychology. Girls who code has examples of coding activities for a range of abilities.
- **Inspiration about future opportunities** - exposure to the exciting and broad range of work that statisticians and data scientists undertake in business, industry, academia, the public sector, and government, could help provide inspiration and motivation to engage with these topics. Workshops, talks, or work experience with professionals could help with this. Teachers should also be aware of the importance of taking maths post-16 in terms of the doors it can open or close when providing advice about further education and future careers.

Curriculum content

Challenges**: students are **not enjoying maths** as it is currently taught, and are not realising the full breadth of interesting applications that studying maths, statistics, and data science can offer; maths education is not providing students with the **skills to navigate everyday life.

Possible solutions: rethink the curriculum based on what skills we want young people to have, working back in the curriculum from older to younger years accordingly.

Crucial areas to cover are data, modelling, and computation, and could include: exploration of data sets in areas of interest, including use of data sets to answer questions, solve challenges and make recommendations; basic data collection techniques (sampling, surveys, experimental design); basic data cleaning techniques; concepts such as effect size, spread, and central tendency, and statistical measures such as mean, median, mode, and range; data visualisation techniques, including the importance of disaggregating data; critical evaluation of statistical information including in graphs, charts, social media, and news reports - The Financial Times, New York Times, and The Economist offer expert guidance, and The New York Times offers relevant teaching resources on this; consideration of the implications – how data can be interpreted or presented in different ways to support certain agendas; understanding of probability and risk, including concepts such as 'false positives' discussed during the Covid-19 pandemic, and how to interpret the risk for a medical procedure; how modelling can be used to nowcast, forecast and predict the future, how good these models are, and instances in which they have provided good or bad predictions; use of critical thinking problem-solving skills; and computer programming, such as Python, Scratch, or commands to ChatGPT.

The curriculum should be updated to ***harness the power of computers and technology*** (computer-based maths) to reflect real-world maths and statistics. Mathematical education could focus on the human skills needed for critical thinking and problem-solving, rather than the skills that computers can already do (calculations, analysis of big data). Maths and statistics should aim to be enhanced by technology (as it is in real world, where computers are used to do calculations that humans can then interpret) rather than avoiding it. This would better prepare students for future careers or daily tasks, where they will be able to harness the potential of computers to help them achieve their aims.

There are many competing demands on the curriculum, and the mandate to cover too much content can limit teachers' ability to innovate and explore subjects in a way that may engage young people more. Real-world

examples that resonate with young people are far more likely to keep them engaged. This could include improving the real-world relevance of questions about eg coin-tossing or counters in bags, or refining the content taught on subjects eg algebra or geometry to ensure it is concise, relevant, and not repeated across the curriculum.

There is an argument that maths education pre-16, as it is post-16, could be separated into '***core maths' and a distinct more academic option***. There can often be challenges in introducing a new qualification, including slow take-up and costs. However, the existence of this option post-16 suggests that there may be appetite for such an option; many students enjoy core maths post-16 and wish they had met it earlier. Pre-16 core maths would focus on the aspects relevant for navigating life, and would include data science, statistics, modelling, and computer science as applied to relevant everyday scenarios. The aim is that this GCSE would replace the standard Maths GCSE, meaning that all students would be exposed to more statistics and data content with real-life applications. Students wishing to take more maths could take the further maths option, which would cover maths, statistics, data, and computing in more depth. This recommendation bears some similarity to the Mathematics in Education and Industry (MEI) recommendations to separate 'essential' maths from maths needed for A level study.

Another option could be to introduce a ***refreshed GCSE on statistics and data skills*****,** named something along the lines of 'Data Skills'. This GCSE would have a substantial component of project/coursework assessment as well as exam assessment. The standard Maths GCSE would also be refreshed, to ensure it sits alongside this new GCSE, and students could take ***both GCSEs if they wish.***

There would also be a ***single combined GCSE option, where students could take one GCSE that is composed of core content covering both statistics/data and maths.*** This core content would cover the statistical, data, and mathematical concepts relevant to everyday life skills. The aim is that this single combined GCSE would better equip students with the functional and relevant skills useful for a broad range of applications, and inspire them to enjoy maths, statistics, and data science, which would lead to increased engagement and willingness to study maths until the age of 18.

This option bears some resemblance to the GCSE science offer, where it is possible take double/combined science (two GCSEs) that covers the three single sciences of biology, chemistry, and physics (covering roughly two-thirds of each). In our scenario, the combined option (one GCSE) would be composed of roughly half maths and half statistics/data content. This option also bears some resemblance to the double-award GCSE in Maths and Numeracy being introduced in Wales, where students can take one GCSE composed of both aspects rather than having to choose between the two or take both.

The introduction of a combined maths and statistics/data GCSE would mean that a GCSE covering maths, statistics, and data would still compose one of the five compulsory core subjects in the national curriculum (two science, maths, and usually English Literature and Language). However if students wished to, they could take an extra mathematical sciences GCSE – so two GCSEs worth of maths, statistics, and data content. As the core content in the combined GCSE would cover both maths and statistics/data, we hope that this would lead to statistics and data being seen as equal in status to maths, and their importance being realised.

Separating content on 'maths' and 'data/statistics', versus eg 'core maths' and 'additional maths' or 'maths for daily skills' versus 'maths for academic pursuit' may mean that more students opt to take both GCSEs, viewing this option as allowing coverage of more content in different areas, rather than just 'more of the same' but at a higher level or for more academic purposes. Splitting the content in this way also allows recognition of the different disciplines, and how each is useful for different purposes. It may also spark interest for students who have had negative experiences with maths in the past, but find that they enjoy the related topics of data and statistics.

If there were only scope to refresh one GCSE, we would like to see more statistics and data included and recognised within the current Maths GCSE, for all students to learn more about each of these disciplines and see how they can equip them with useful skills relevant to daily life.

There is also an argument for embedding data, statistics, and maths **further into other subjects**, including geography, history, economics, psychology, and science (further details on teacher implications are in the section below). This interdisciplinary approach can help students realise the utility of these skills as related to a range of other topics. As a starting point, the elements of statistics and data literacy in these subjects could be recognised and acknowledged – it could even be possible for students to gain some sort of 'maths/statistics credits' to acknowledge they are studying maths, statistics, or data science in these topics. It could also be helpful to formally stipulate and assess maths, statistics, and data in other subjects, to ensure they are embedded in classroom teaching across the board. The maths taught in these other subjects should be better joined-up with maths and statistics courses, ensuring that the aspects needed for other areas are taught in maths class first (eg hypothesis testing for biology).

Inspiration for teaching statistics and data literacy can also be taken from other countries and teaching styles, including from self-directed learning styles such as Montessori Education (in which children learn by exploring their own interests), and from projects such as the International Data Science in Schools Project (IDSSP), which aims to transform how data science is taught in schools, ensuring that students leave school with an understanding of how to work with data and are inspired by data science. The IDSSP has aimed to create content that is both fun to learn and fun to teach, and can be used to supplement existing maths, statistics, computer science, courses, as well as to be included in other data-rich courses eg biology, geology, and economics.

Engaging delivery

Challenges*: there are well known issues with* ***recruitment, retention, and wellbeing of maths teachers;*** *teachers of* ***other subjects may not feel comfortable teaching maths****, and 'pure' maths teachers may not feel comfortable teaching statistics or data science; many students are* ***not enjoying maths*** *as it is currently taught – teachers who are not invested in the curriculum are less likely to be able to teach in an enthusiastic and inspiring manner.*

Possible solutions: challenges are well known around the need for increased funding and improvements in working circumstances for teachers, including increased numbers of teachers to remove pressure from existing teachers, increased salaries, and increased funding and time for teacher training. These issues are at the core of the problem, influencing the ability to introduce improvements in curriculum content, design, teaching, and assessment. Here we focus on additional elements that are necessary or useful to deliver an engaging curriculum that results in students gaining the skills they need:

- **Bringing maths and statistics teachers on board** – it is necessary to bring teachers on board with the topics to be taught on the curriculum; teachers could be involved in the creation of qualifications, or could take up extra training (Masters level or personal development time) to support teaching statistics, data, and problem-based learning. Teachers who are enthusiastic and passionate will be better able to inspire and distil the importance of these skills to students.
- **Bringing teachers in other subjects on board** – there is an argument for embedding data, statistics, and maths into other subjects. Teachers in some areas that are further from mathematics may feel less comfortable covering these topics, in which case further training on these topics, as well as on the importance of integrating these topics into other subjects, may be helpful. However, teachers in quantitative subjects may be accustomed to covering related topics already, and be content to teach subject-specific (or general) data, statistics, and maths.

- **Providing teaching resources**, for example using cloud-based software systems (applications stored and managed online, and available via internet connection, eg CODAP and other interactive online data platforms). Cloud-based systems proliferated during the Covid-19 pandemic, as a practical way to manage and share information without physical contact required. Freely available cloud-based systems can be used to analyse and visualise data, and utilising them in education could significantly reduce timelines to prepare educational materials, as well as reducing costs. Teachers will need simple interfaces to enable them to locate teaching resources by topic (eg inequality) and technique (eg correlation). The International Statistical Literacy Project provides an example. The RSS EPAG is currently undertaking work that links into this suggestion – the EPAG is sourcing real-world data generated by companies, and plans to turn this into a resource for teachers to help develop students' statistical and data literacy. The data, which will be shareable via a spreadsheet, will be adapted (at various levels of simplification) for different year groups to be able to develop appropriate skills.
- **Use of AI across learning**, including that in which students directly engage with learning online. Internet-based training (augmented with classroom discussion) can allow children to learn at their own pace and gain a sense of control over their learning. Online materials should be able to increase access to high-quality teaching materials, but care must be taken to ensure that a digital divide between more and less affluent schools or students does not exacerbate the divide in educational attainment, by ensuring equal access for all.
- **Interactive and engaging exercises** – students are more likely to understand, remember, and enjoy learning if engaging and interactive exercises are utilised to illustrate concepts. This could include anecdotes highlighting the relevance of topics, group discussion, and examples using physical everyday objects, as well as online interactive resources. Students learn in a range of different ways, and therefore a range of techniques and approaches to teaching topics can be helpful.

Assessment

Challenges: an ***overly strong focus on assessment*** *can impede opportunities for teachers and students to explore areas of interest to them; students* ***do not have evidence of specific skills.***

Possible solutions: it is important to 'assess what we value' rather than 'value what we assess' - assessment cannot be planned until we know what we value and therefore what we want to teach and evaluate. It is crucial to rethink assessment, as it is challenging for teaching to change while pressures from the current assessment system persist.

Statistics is a practical subject, which lends itself to a **practical assessment**. In the short-term, specific aspects could be incorporated into assessment to ensure that all schools teach them. For example, including a **particular technology environment** (eg Python or CODAP) in the assessment criteria. Freely available datasets, eg by the United Nations and others as detailed above, could be used for this purpose. This could elicit a large step forward in the education of data science and computer programming.

In the medium-term, **coursework** could be incorporated into assessment. This would allow for the assessment of practical statistical and data literacy skills, and is likely to better prepare students for future real-world projects, where independent thinking and project planning are key. Coursework can provide the opportunity for students to explore the full statistical cycle, including planning how to answer the question of interest, generating their own data, trouble-shooting for any issues, and drawing conclusions, in an area of interest to them. A current example of this is the A level Extended Project Qualification (EPQ), where students select a topic of their interest to research in depth. Teamwork and (oral) presentation of results are also skills required in the workplace, and which could be assessed as part of project work.

Care must of course be taken to tackle the issues of bias in teacher assessment and varying levels of parent or teacher support, which can favour more affluent schools or students with more educated or involved parents, and can heighten inequalities. However, coursework would be composing only a component of the end mark, not the entire grade; exams would still be taken. The propensity for coursework to favour or disfavour some students may be balanced with the propensity of exams to favour or disfavour other students (such as those who perform less well in high-pressure time-constrained environments).

Another concern is the increased pressure on teachers to spot plagiarism, the work of parents, or the use of large language models (LLMs) – especially following the widespread popularity of ChatGPT and other chatbots. It could be argued that if coursework is to prepare students for future real-world work, then the same real-world circumstances could apply – students could be permitted to use LLMs or other resources (and reference them) in their work, and the questions being assessed would focus on why students carried out the project in the way they did, how they decided which steps to take, and how they critically appraised any resources they used. Assessment could also ask questions that LLMs are not able to answer, for example to apply some learning to a personal context eg the home or school environment. AI and technology may also be able to assist teachers with marking in the future (eg of multiple-choice questions, of computer skills, or via computer assessments), which could release teachers' time and allow teachers to spend more time on other aspects of the role that they may find more pleasurable and fulfilling, such as preparing innovative and engaging lesson plans and activities.

In the longer term, a **comprehensive platform that includes tuition, examples, assessment, and evidence of completion** could be useful. Similar to the individual 'modules' within eg BBC Bitesize, such a system could allow **continuous assessment**, with the potential to lessen pressure from high-stakes exams. Students would be able to log which elements they have completed and build up a portfolio of skills. This would allow teachers to view which areas students may need support with, and afterwards, could also allow outside assessors/employers to be able to pinpoint which competencies students have. Appropriate search tools and coherent 'road maps' underpinning a variety of curriculum routes would be necessary.

5. Conclusion

In conclusion, it is important for the government's Maths to 18 strategy to focus on getting pre-16 education right. This could lead to improvements in education up to age 18 (and beyond). Education should begin with consideration of the skills we value most, followed by consideration of how we can incorporate the teaching of these skills into topics that students enjoy and will engage with, and finally how we can deliver this teaching and assess these skills appealingly and coherently.

Statistical and data literacy are crucial for navigating everyday life. Learning how to interrogate the world around them, explore data in areas of genuine interest, interpret and handle relevant figures and comprehend AI advances can provide exemplary 'hooks' to demonstrate the utility and appeal of data, statistical, and maths education to students.

This paper is informed by a roundtable discussion on 'statistics and data within the Maths to 18 proposals', chaired by Sophie Carr on behalf of RSS EPAG, and attended by Chris Budd, Darren Macey, Ellie Darlington, Ems Lord, Ernest Edifor, Jim Ridgway, Lynne McClure, Paul Glaister, and Stella Dudzic (May 2023), along with feedback from RSS members and interested statisticians and teachers.