Promoting Core Maths - background, evidence, plans, opportunities, and challenges

Paul Glaister

Department of Mathematics
PO Box 220, University of Reading
Whiteknights, Reading, RG6 6AX

Student: *'Why should I take Core Maths?'*
Parent: *'What advice should I give my son/daughter about taking Core Maths?'*
Head Teacher/College Principal: *'Why should we offer Core Maths?'*
Employer: *'What benefits will employees with Core Maths bring?'*
University Admissions Tutor: *'Should our entrance requirements include Core Maths, and why?'*

1. Introduction

In this article we discuss some of the issues relating to the promotion of Core Maths to students, parents, schools and colleges and their senior leadership teams, and also to employers and higher education (HE). As part of this we consider the educational landscape prior to the introduction of Core Maths and the various reports that have been published that led to the introduction of Core Maths.

We refer particularly to the needs of employers and HE, and highlight the main evidence and recommendations contained in these various reports, as we see this as a key component of any promotional activity to the primary stakeholders: students, parents, schools and colleges and their senior management, and hope to be able to address some of the questions above. We would hope that, having read this article, the benefits of Core Maths will be evident to any of the key stakeholders listed above, and that they will become more aware of steps that are being taken to establish collective ownership of Core Maths by all stakeholders.

2. Background to Core Maths

In 2010 the Nuffield report 'Is the UK an outlier? An international comparison of upper secondary mathematics education.' (Hodgen et al., 2010) gathered evidence from 24 different countries to make recommendations for consideration in the formation and implementation of policy. From the table in Figure 1 taken from the report it is clear that in England we have low participation rates in advanced mathematics post-16.

Students taking mathematics post-16

	Any mathematics	Advanced mathematics
Japan	All	High
Korea	All	High
Taiwan	All	High
Estonia	All	Medium
Finland	All	Medium
Germany	All	Medium
New Zealand	All	Medium
Sweden	All	Medium
Russia	All	Low
Czech Republic	All	-
France	Most	Medium
Massachusetts (USA)	Most	Medium
Ireland	Most	Low
British Columbia (Canada)	Most	-
Hungary	Most	-
Singapore	Many	High
New South Wales (Australia)	Many	Medium
Netherlands	Many	Low
Hong Kong	Some	Medium
Scotland	Some	Medium
Spain	Some	Low
England	Few	Low
Northern Ireland	Few	Low
Wales	Few	Low

Source: The Nuffield Foundation

Any mathematics	5-20%	20-50%	50-80%	80-95%	95-100%
Advanced mathematics	0-15%		15-30%		30-100%

Figure 1

The conclusion of the report was that potential models for post-16 mathematics should be researched and developed.

In 2011 Education Secretary of State Michael Gove said he '… would like to see the "vast majority" of pupils in England studying maths to the age of 18 within a decade.' (BBC News, 2011a). Gove's statement was based on advice in the 2011 Advisory Committee on Mathematics Education report (ACME, 2011): 'Mathematical Needs: Mathematics in the workplace and in Higher Education.', and which was reported by the BBC as 'Universities are having to dumb down the maths requirements on some of their courses in order to fill places, a report says.' (BBC News, 2011b).

The report's key findings included the following:

- The quantitative demands of almost all university courses are increasing; even subjects like history, which traditionally had involved no mathematics, now recognise the importance of statistics.
- We estimate that of those entering higher education in any year, some 330,000 would benefit from recent experience of studying some mathematics (including statistics) at a level beyond GCSE, but fewer than 125,000 have done so.
- Data on higher education acceptances suggest that some 180,000 of those accepted will encounter a significant amount of mathematics on their courses.
- An additional 150,000 students in the social sciences will also encounter some mathematics on their courses.
- The total demand figure for mathematically competent students is thus over 330,000 per year, but the supply is only 125,000.
- The recent increase in the numbers of those studying A-levels will not solve higher education's need for more mathematically competent students.
- For many students aspiring to higher education, a variety of mathematics courses beyond GCSE is needed.
- There are many courses, with entry requirements limited to Grade C at GCSE, which make significant mathematical demands on their students at some stage during the course.
- Students have been drilled to pass their school examinations and are unable to use their mathematics in the new contexts they are meeting at university.
- Within the social sciences there is concern about the marginalization of quantitative methods and the lack of understanding of the role of mathematically based arguments within social sciences disciplines.
- Many higher education students have experienced a two-year gap from their last encounter with mathematics.

The report's recommendations included the following:

- A wider curriculum and provision than exists at present should be developed in order to ensure that all young people are well placed to benefit from their studies in mathematics.
- The new post-16 courses should include statistics beyond the descriptive methods of GCSE to meet the needs of the large number of students who progress to a range of courses such as those in social and life sciences.
- The major elements in such new courses should include (statistics), problem-solving and working with mathematical models.
- The value of being able to communicate mathematics should be given more prominence as this is an essential skill in employment and in higher education.
- There should be an emphasis on building students' confidence and their ability to use mathematics in a range of familiar and unfamiliar contexts.

Two reports then suggested a way forward, culminating in the current Core Maths qualifications. The first was the 2012 ACME report: 'Post-16 Mathematics: A strategy for improving provision and participation. (ACME, 2012),

and the second the 2013 Nuffield report: 'Towards universal participation in post-16 mathematics: lessons from high-performing countries.' (Hodgen et al., 2013).

3. Development of Core Maths qualifications

In order to develop Core Maths qualifications the Government commissioned a report in 2013 (ACME, 2013) to establish the principles on which Core Maths should be based, and in July 2014 the DfE published the Technical Guidance (DfE, 2014) that Awarding Organisations had to follow in order for their proposals to be approved.

The technical guidance in particular states that:

> 'Core Maths qualifications should consolidate and build on students' mathematical understanding and develop further mathematical understanding and skills in the application of maths to authentic problems, thereby offering progression from GCSE mathematics. Qualifications should provide a sound basis for the mathematical demands that students will face at university and within employment across a broad range of academic, professional and technical fields.
>
> 'Core Maths courses should prepare students for the varied contexts they are likely to encounter in vocational and academic study and in future employment and life, for example, financial modelling and analysis of data trends. As such, Core Maths qualifications should foster the ability to think mathematically and to apply mathematical techniques to variety of unfamiliar situations, questions and issues with confidence. While Core Maths is likely to be particularly valuable for students progressing to higher education courses with a distinct mathematical or statistical element such as psychology, geography, business and management, such qualifications will also be valuable for any student aiming for a career in a professional, creative or technical field.
>
> 'Core Maths qualifications are distinct from A and AS level mathematics. The latter extend students' experience of mathematical techniques significantly, developing advanced analysis of mathematical problems and construction of related arguments and methods of proof. Thus they are oriented in particular towards students wanting to progress into higher level study with a significant mathematical focus as well as being valuable for broader fields of study and work.'

The three objectives of Core Maths in the Technical Guidance encapsulate the main purpose of the qualification:

Objective 1: Deepen competence in the selection and use of mathematical methods and techniques.

Guidance – we would expect students to be able to:

- Use a range of mathematical methods and techniques reflected in higher tier GCSE mathematics[5] to find solutions to mathematical and non-mathematical problems. This includes elements content for more highly attaining students highlighted in bold.
    - We expect techniques and methods to reflect a range of GCSE content areas, so these should be drawn from at least four of: Number; Algebra; Ratio, Proportion and rates of change; Geometry and measure; Probability; and Statistics.
    - This is not a broad 'recap' of GCSE content – the focus should be on a set of a carefully selected and challenging methods and techniques that make sense in the context of qualification purpose.
    - It is assumed that students will already have confidence and competence in the content presented in standard type within GCSE mathematics criteria. Students will make use of elements of this content when addressing problems within Core Maths but we do not expect these to be explicitly set out in qualification content.

- Understand a further set of more challenging mathematical concepts and techniques drawn from beyond GCSE which are relevant within technical, professional and/or academic contexts. A minimum of 20 per cent of overall assessment should be based on these, which can be drawn from A/AS level mathematics and/or other areas.
- Make decisions about which methods and techniques from GCSE mathematics and beyond are best used to understand and address specific problems; Use techniques correctly to generate answers and solutions and interpret and explain these in the context of the problem.

Objective 2: Develop confidence in representing and analysing authentic situations mathematically and in applying mathematics to address related questions and issues.

Guidance – we would expect students to be able to:

- Use a variety of mathematical and statistical approaches to represent and analyse relatively well-defined situations, including complex and unfamiliar situations. This includes identifying and understanding quantifiable information and related assumptions in that situation, using mathematical and statistical representations and techniques appropriately, and deriving new information to draw meaningful conclusions about the situation.
    - Situations and problems should be drawn from physical/technical/scientific and human/behavioural/social domains and reflect a range of contexts including professional and academic settings.
    - Mathematical methods and techniques should reflect those outlined under the first objective.

- Address authentic issues and questions by applying mathematical approaches with purpose to generate solutions, insights or answers. Evaluate the relevance of solutions in the context of the situation, establish how they could be used and communicate findings accurately and meaningfully.

Objective 3: Build skills in mathematical thinking, reasoning and communication.

Guidance – we would expect students to be able to:

- Generate and apply mathematical solutions to non-routine questions and problems: interpret new situations in terms of mathematical and quantitative characteristics; make judgements about strategies and methods to achieve a solution; take creative approaches where appropriate; and test and evaluate answers and conclusions.
    - Non-routine problems are those where specific methods and solutions are not immediately obvious because there may be limited, ambiguous or contradictory information; they require judgements or assumptions to be made and may not lead to a single or clear answer. Solving non-routine problems is likely to call on creative strategies, draw on broader knowledge and understanding, require more general discursive and problem-solving skills and demand reasoning about mathematical information and methods.
- Explain mathematical reasoning and conclusions to others and justify specific approaches taken to the problem. Interpret conclusions on the basis of mathematical understanding and explain limitations to answers and conclusions.
- Weighting of the objectives above in qualification assessment should reflect the purpose of Core Maths qualifications as set out in section 2.2. Both objectives 2 and 3 should each have greater weighting in content than objective 1.

4. Launch of Core Maths

Core Maths was launched in July 2014, accompanied by a keynote address by the Education Minister Liz Truss (Truss, 2014). In promoting Core Maths, it is described as:

- a new level 3 course for students in post-16 education and is aimed at students who have passed GCSE mathematics at grade C or above but who are not taking A Level mathematics;

which

- aims to help students retain, deepen and extend their mathematical skills and understanding through the use of meaningful and relevant problems, better preparing these young people for university, employment and life. Importantly, Core Maths has the same UCAS tariff as an AS-level.

5. Two further reports – the HE perspective

At the same time as the Technical Guidance was published the 2014 Nuffield report 'Mathematics after 16: the state of play, challenges and ways ahead.' (Hillman, 2014) gave a wholehearted welcome to Core Maths.

Immediately after the launch the Higher Education Academy (HEA) coincidentally published the 2014 report: 'Mathematical transitions: a report on the mathematical and statistical needs of students undertaking undergraduate studies in various disciplines.' (Hodgen et al., 2014).

The HEA report was a study of the following seven disciplines: Business and Management, Chemistry, Computing, Economics, Geography, Sociology and Psychology in higher education in the UK, and research was carried out to provide a strong evidence base to inform dialogue between the higher education and pre-university sectors on mathematical requirements.

The table in Figure 2 shows the proportion of UK students entering university with A-levels who have A-level in Mathematics, for various subjects.

	% with A level mathematics 2006	% with A level mathematics 2013
Chemistry	53	71
Economics	57	69
Biology	26	38
Geography	15	19
Business and Management	10	15
Psychology	9	13
Nursing	6	11
Sociology	2	4

Figure 2

The key findings of the HEA report include the following:

- All the disciplines in the Higher Education Academy STEM project require Mathematics and/or Statistics to some extent.
- 85,000 students are admitted into university each year to study the seven disciplines in the project.
- Other disciplines will have similar mathematical and statistical needs, including biological sciences, medicine and dentistry, architecture, building and planning, and various technology degrees.

- The number of students affected is of the order of 200,000 pa.
- The number of students entering the disciplines with an A or AS-level in Mathematics has increased in recent years but has probably reached a limit.
- The development of "Core Maths", a new pathway designed for students who achieve a grade C or better at GCSE, has the potential to bring about real improvements.
- Many students arrive at university with unrealistic expectations of the mathematical and statistical demands of their subjects.
- Lack of confidence and anxiety about Mathematics/Statistics are problems for many students.

The recommendations included the following:

- There should be clear signalling to the pre-university sector about the nature and extent of mathematical and statistical knowledge and skills needed in undergraduate degree programmes.
- As part of this signalling university tutors should consider recommending the benefits of continuing with mathematical/statistical study beyond the age of 16.
- They should be aware of the full range of post-16 Mathematics qualifications, in particular the new "Core Maths" qualification.
- Key stakeholders within the disciplines should actively engage with current and future developments of discipline A-levels as well as those in post-16 Mathematics qualifications, (e.g. "Core Maths").
- Core Maths provides an important strategic opportunity for higher education to influence the mathematical preparation of future students and the discipline reports unanimously recommend that key stakeholders should actively engage in these developments.

It is clear from the overwhelming evidence contained in the various reports outlined above that HE and employers should welcome Core Maths, and that as many students post-16 should be encouraged to take it if not taking AS-level or A-level mathematics. To promote Core Maths we need a consistent message that resonates with all stakeholders, and this will include taking key messages from these reports.

6. Launch of Core Maths qualifications

Following a rigorous process of establishing whether the six level 3 qualifications offered by five Awarding Organisations (already approved by Ofqual) met the conditions in the Core Maths Technical Guidance (DfE, 2014), and so could be titled 'Core Maths', the School Reform Minister Nick Gibb said (Gibb, 2014):

- 'New high-quality maths qualifications, which teach pupils how to use and apply maths in real situations, are designed to encourage thousands more pupils to continue studying maths beyond age 16.
- Strong maths skills are an essential part of our plan for education and are also vitally important to our economy.
- Only a fifth of pupils in England continue to study maths at any level after achieving a GCSE - the lowest of 24 developed countries.
- These new core maths qualifications will help address a 16 to 18 'maths gap' whereby students who achieve a good maths grade at GCSE currently drop the subject and start to lose their confidence and skills.
- Thanks to these new high-quality courses more pupils will be able to continue their study of maths, ensuring more young people leave education properly prepared for the demands of university, work and life in modern Britain.
- Pupils will learn how to apply maths to analyse situations, giving them the confidence they need to tackle problems in their adult lives.

7. Promotion of Core Maths to students, parent, schools, and colleges

Clearly there is a need to get endorsement of HE and employers for Core Maths, and this will assist in promoting Core Maths to students, parents, and senior managers in schools and colleges. We turn to this issue shortly. But before that we note that there are key players already within the Core Maths 'family' as part of the Core Maths Support Programme (CMSP), that have been, and will continue to act as ambassadors in the promotion of Core Maths, and these include the author, as well as: the CMSP central team; Regional advisers; Core Maths Leads community; Early Adopters community; Early Developers; the 34 Maths Hubs; NCETM; and, presumably, the five Awarding Organisations: AQA, City & Guilds, Eduqas, OCR/MEI, Pearson/Edexcel.

8. Engaging with Core Maths – HE

One significant group is HE – this is evident from the Mathematical Transitions report. HE stands to gain much from having students with a Core Maths background. A signalling from them about the value of Core Maths will make a significant impression on schools and colleges, and will lead to Core Maths being offered more widely. But as stated in the 2014 Nuffield report (Hillman, 2014):

> 'There is a chicken and egg situation here: higher education institutions won't make post-16 maths a required qualification or even provide a more subtle signal that it is necessary or desirable, because in a competitive market for students to do so would be to rule out large numbers of applicants. So there is still not sufficient incentive for students to choose maths qualifications, particularly in the context described earlier of constraints on the growth in numbers opting for the full A level and changes to the status of the AS level. With the introduction of Core Maths, there is potential to break this log jam.'

which highlights two particular issues. First, the 'chicken and egg' situation – schools and colleges will be reluctant to offer Core Maths unless HE are seen to 'welcome applicants with Core Maths', and HE will be less receptive saying this when there isn't widespread coverage - supply enabling demand and demand driving supply. Second, there is also the issue, even with widespread coverage in place, of the difference between 'selector' universities, typically in the Russell Group, where significant numbers of applicants have AS-level or A-level Mathematics, and 'recruiter' universities, where the latter run the risk in standing out from the rest (their competitors), and seeming to have more demanding entrance requirements. We believe that, steadily, or otherwise, these issues will be overcome.

In terms of feedback so far from HE, we surveyed the departments in one university offering courses in the following disciplines: systems engineering, economics, geography, biological sciences, pharmacy, chemistry, construction management and engineering, agriculture, food science, archaeology, and psychology, to determine what their requirements would be if their applicants had pursued a post-16 mathematics course. The response was rapid, uniform, and very much fitted in with the ethos of Core Maths. In terms of skills, their 'wish list' was as follows:

- know, understand and use existing GCSE material with confidence;
- solve problems in a variety of contexts;
- make logical and reasoned decisions;
- communicate;
- generalise;
- interpret;
- make deductions;
- use technology;
- modelling; and
- algebraic manipulation;

and in terms of 'topics', their 'wish list' was:

- fractions, ratios, percentages, and decimals;
- inequalities;
- graphs;
- algebra;
- probability;
- correlation;
- hypothesis testing; and
- summary statistics.

From archaeology, for example, the main messages were that:

- students are 'scared of maths';
- the course had an emphasis on primary, quantitative data - anything from metrics on a human skeleton to the dimensions of artefacts, to chemical isotopes and dating methods, to survey data
- there is a need to interpret visual data summaries;
- there is a need to understand basic descriptive statistics (e.g. mean, mode, median,
- percentages, ratios etc.)
- spreadsheet software competency was important, e.g. Excel.

The main issue that was reported was one of 'confidence' -'Many of our students can actually do it, but don't think they can.'

Everything set out in the Objectives in the Technical Guidance is highly relevant to the needs of these courses, and so Core Maths really does meet their needs, specifically by: 'deepening competence in the selection and use of mathematical methods and techniques'; 'developing confidence in representing and analysing authentic situations mathematically and in applying mathematics to address related questions and issues'; and 'building skills in mathematical thinking, reasoning and communication'.

So one may ask, 'how does HE cope now?' Two obvious remedies that are put in place are: mathematics and statistics support centres; and additional courses to re-teach GCSE and applying this in context. With entrants having followed Core Maths, and so better prepared for the demands of their course, there is clear scope for utilising these resources more effectively in supporting their students. The largest gain will be in improving graduate employability, a topic firmly at the top of every university's agenda. Either way, Core Maths is 'win-win' for HE. In addition, a unified message from HE, and those who employ their graduates, that recognises the value of Core Maths will be something we expect to see in the fullness of time.

9. Promoting Core Maths Senior Advisory Board (PCMSAB)

To provide leadership, develop strategies, and work with stakeholders, an advisory board has been established – the PCMSAB. This comprises: Dr Deirdre Hughes, Chair of National Careers Council (as Chair), members of the CMSP, as well as a number of key organisations who will be strategic partners in promotion activities - these include: Teach First, Confederation of British Industry, Association of School and College Leaders, Association of Colleges, Unison, Career Development Initiative, National Association of Head Teachers, Barclays Lifeskills, UK Engineering, National Union of Students, STEMNET, British Chambers of Commerce, National Institute of Adult Continuing Education, The Voice of Apprenticeships, Education and Employers Taskforce, Business in the Community, and three representatives from HE.

The aims of the PCMSAB are:

- to provide advice to CfBT[1]/DfE on the promotion of the CMSP in order to raise its profile, relevance and impact across England;
- to champion, challenge, clarify and collaborate in the promotion of the CMSP (and Core Maths) across England;
- to draw upon the latest developments designed to build confidence and capability in the mathematical skills of young people and adults;

with shared motivation and key issues:

- the need to build confidence, excite and motivate more individuals to continue with their Maths learning;
- the opportunity to connect the programme to career pathways, enterprise, employability and labour market opportunities;
- the challenge of how best to engage employers, teachers, parents and students in identifying the added-value benefits of the programme.

One key goal is to develop appropriate marketing materials that target the different stakeholder groups, but at the same time encompassing common, well-understood, key messages. These have to address both HE and employers, and include the whole cohort, i.e. any student with grade A*-C at GCSE.

The PCMSAB has set up working groups to develop strategies and lead engagement with their respective networks, with a view to gaining widespread endorsement of Core Maths. In time, case studies of students who have taken Core Maths will be invaluable, whether they have gone onto further study, employment, or an apprenticeship. – The PCMSAB has wide representation from employer organisations, and we are confident that employers will welcome Core Maths.

Work is in progress in engaging with Universities UK, the various university mission groups, UCAS, and the HE admissions community. This is a challenging area as universities and courses are large, autonomous organsiations, and there are many of them, offering vast numbers of courses in total. A working group will analyse data on university applications, admissions, current entrance requirements, mathematical demands and current mathematical support, to assist with the engagement with, and dissemination of, information to HE. Establishing an order of priority, in terms which courses and universities have the greatest need for Core Maths, is part of this analysis. The messages here will have to be carefully targeted to secure endorsement of HE from a wide range of universities and courses. A judicious choice of exemplar materials, particularly assessment tasks, will be important here.

The PCMSAB will also engage with relevant subject associations, learned societies, and STEM organisations.

10. Next steps and goal

The Core Maths Support Programme, its team, the various Core Maths networks of leads, adopters, and developers, and Senior Advisory Board, will continue to support existing and future schools offering Core Maths. We will continue to engage with employer organisations, and get widespread endorsement. We also wish to engage with as many universities and schools/departments in the target group, with the intention to encourage as many universities and courses to welcome applicants offering Core Maths (or AS/A-level Mathematics, of course, recognising that some will have taken the latter qualification).

[1] CfBT (Council for British Teachers, http://www.cfbt.com/) is delivering the Core Maths Support Programme.

We all appreciate that widespread endorsement by relevant university schools/departments is needed to motivate schools and colleges to offer it, pupils to take it, and their advisers to support them in doing so. But this will remain a 'chicken and egg' scenario, and progress will be slow, if each 'side' is waiting for movement on the other 'side' before acting. Universities will be aware that the number of students taking Core Maths is small at the moment compared with the potential cohort for whom Core Maths is an excellent pre-requisite for further study, so they will have to take a leap of faith in engaging with Core Maths and subsequently endorsing it; equally schools and colleges need to take a leap of faith in offering Core Maths in anticipation that it will receive widespread endorsement from HE and employers.

Importantly, everyone who interacts with Core Maths, whether in a major or minor way, should 'sign up' as an ambassador for Core Maths, and help 'bang the drum'!

Regardless of the audience, the message to take away is the same:

current needs - existing provision = Core Maths .

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