
Proceedings Paper:
Homer, M orcid.org/0000-0002-1161-5938, Mathieson, R orcid.org/0000-0002-6272-5088, Tasara, I orcid.org/0000-0002-1864-7609 et al. (1 more author) (2018) Increasing post-16 mathematics participation in England: the early implementation and impact of Core Maths. In: Golding, J, Bretscher, N, Crisan, C, Geraniou, E, Hodgen, J and Morgan, C, (eds.) Research Proceedings of BCME9. 9th British Congress of Mathematics Education, 03-06 Apr 2018, Warwick, UK. BSRLM , pp. 88-95.

Golding, J., Bretscher, N., Crisan, C., Geraniou, E., Hodgen J. and C. Morgan (Eds). (2018) Proceedings of the 9th British Congress on Mathematics Education (3-6 April 2018, University of Warwick, UK). Online at www.bsrlm.org.uk/tbc

Cover sheet for use in BSRLM Review for Proceedings of BCME 9

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Is this the first paper the named author has submitted for peer review? No

Please acknowledge here, as well as at the end of your paper, any funding received for the reported research: Nuffield Foundation grant EDU/42284

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Abstract: Core Maths, a relatively new and distinct post-16 qualification, has been developed to address a key UK government policy imperative – that of increasing post-compulsory mathematics participation in England from its low comparative position internationally. In the light of recent policy developments to increase uptake in post-compulsory maths, we discuss emerging findings from a large-scale three-year mixed-methods project on Core Maths, funded by The Nuffield Foundation. In particular, we use national data to investigate the wide range of other qualifications that Core Maths students are taking, but find little emergent evidence of any impact on attainment in these courses. We also present interview data from teachers and senior leaders demonstrating how Core Maths is being implemented in a wide variety of ways in schools and colleges.

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Increasing post-16 mathematics participation in England: the early implementation and impact of Core Maths

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Core Maths, a relatively new and distinct post-16 qualification, has been developed to address a key UK government policy imperative – that of increasing post-compulsory mathematics participation in England from its low comparative position internationally. In the light of recent policy developments to increase uptake in post-compulsory maths, we discuss emerging findings from a large-scale three-year mixed-methods project on Core Maths, funded by The Nuffield Foundation. In particular, we use national data to investigate the wide range of other qualifications that Core Maths students are taking, but find little emergent evidence of any early impact on attainment in these courses. We also present interview data from teachers and senior leaders demonstrating how Core Maths is being implemented in a wide variety of ways in schools and colleges.

Keywords: Post-16; Core Maths.

Introduction

This paper outlines early findings from a three-year longitudinal mixed-methods project funded by The Nuffield Foundation. We described the aims and background to the study more fully in a previous paper (Homer et al., 2017). In the current paper, we consider whether there is any early evidence of enhanced attainment in other subjects studied by students taking Core Maths, and outline some of the emerging qualitative findings from interviews with stakeholders (teachers, curriculum managers, and senior leaders) in a sample of 13 schools and colleges in England.

Post-16 mathematics education policy developments in England

Post-16 participation in mathematics in England (i.e. once compulsory study ends) is low, compared with our main international economic competitors (Hodgen et al., 2010). The UK government is committed to meeting an aspiration voiced in the recent review of post-16 mathematics (Smith, 2017) that in ten years' time all students will be studying some mathematics post-16 (Department for Education, 2018; HM Treasury, 2017). This can only be achieved through offering students an appropriate set of mathematical pathways. Core Maths is a new and distinct alternative to Advanced Level (A-level) Mathematics, the long-established academic mathematics pathway post-16. It is offered in various guises by the different awarding bodies in England (Homer et al., 2017), and was first taught in 2014 and first examined in 2016. It is designed primarily to support the mathematics in students' main programme of study, or at work and in everyday life (Core Maths Support Programme, 2016). The course is intended to be studied over two years, alongside A-levels or other Level 3 (i.e. advanced) qualifications, but with only half the number of hours devoted to it than a full A-level entails. Its focus is on applying already-learned mathematical knowledge and concepts in authentic contexts, and on developing confidence, competence and fluency (Department for Education, 2015); only 20% of the qualification is intended to be new

content. This makes it suitable for any students who pass their General Certificate of Secondary Education (GCSE) in Mathematics with at least a Grade 4 at the transition point to advanced study beyond the age of 16, making it a crucial addition to the portfolio of post-16 mathematics qualifications available in England. Core Maths has a high profile role to play if the government's education policy, and indeed wider economic policy (Lingard, 2011), aims are to be met.

Methodology

National data

Core Maths is intended to support other subjects that have elements of mathematical demand (Glaister, 2015). One major strand of our project, the analysis of data from the National Pupil Database, enables us to estimate the impact of studying Core Maths on students' attainment in other post-16 curriculum subjects. For the first cohort of Core Maths students (examined in 2016), we identified the five most popular subjects also being studied by these students. For each of these, we then carried out a modelling approach to compare attainment in these subjects between students who had and who had not studied Core Maths. We controlled for a range of potential fixed factors (gender, measures of socio-economic status, attainment at 16, ethnicity, and institution type) in a multi-level (clustering in school/college) random intercept only variance components model with the outcome variable A-level (or equivalent points) adjusted for qualification 'size'. Students entered for any other Level 3 mathematics qualifications were removed from the analysis. The key outcome of this modelling is an estimate of the Core Maths 'effect' on student attainment in each post-16 subject.

Interview data

Another key strand of the study seeks to answer a research question regarding what institutions are doing to maximise the success of Core Maths, and what barriers and challenges they are facing. This qualitative strand explores the views and experiences of staff and students within 13 English schools and colleges where Core Maths is currently being offered. Over 40 centres were initially identified, either through contact with Maths Hubs (regional maths education support networks in England) or directly via institutions' websites, as potential case studies. These were gradually approached to take part, bearing in mind a desire to ensure representation of the different types of post-16 setting which exist in England, until enough, and a reasonable spread of, institutions expressed an interest in participating.

The first round of fieldwork interviews took place in September/October 2017, to harness views at the start of the academic year, with follow-up visits taking place later in the project. Semi-structured interviews were conducted with teachers, students, and senior leaders responsible for institutional curriculum policy, focusing partly on relevant issues identified from the literature, but also allowing participants to talk freely about their experiences of and perspectives on Core Maths. Interviews with 15 Core Maths teachers, 12 Heads of Maths, and 11 senior leaders (defined as a Head of Faculty, Vice Principal, Headteacher or Principal) were transcribed and coded, and thematic analysis was carried out using inductive and deductive approaches.

Emerging findings

Core Maths and other subjects – national data

For the first cohort of students, Core Maths is combined with a very wide range of other subjects and qualification types. There is no predominant link with any other particular subject, albeit Table 1 shows that the majority of other courses taken by Core Maths students lean towards the scientific/quantitative as opposed to the arts/humanities.

Level 3 subject in 2016	Qualification type	N	% within Core Maths cohort
Engineering Studies	Advanced level vocational qualifications (BTEC Diplomas)	239	8.7
Applied Sciences		233	8.5
Computer Appreciation		213	7.8
Psychology	Advanced level academic qualifications (A-levels)	207	7.6
Biology		161	5.9

Table 1. The most popular subject/qualifications awarded to Core Maths students in 2016

Only a small percentage of the first Core Maths cohort took even the most popular subjects, and Table 1 also shows that Core Maths is taken alongside both academic and vocational courses.

Table 2 shows the total number of students awarded each of these five qualifications in 2016, and this is the sample size for each of the statistical models when estimating the impact of doing Core Maths on attainment (there was missing data for some co-variates which explains the lower Core Maths numbers compared to Table 1).

Post-16 subject examined in 2016	Total number of students awarded each subject	Number of students also awarded Core Maths	Core Maths students as percentage of total in each subject
Engineering Studies (BTEC)	7,655	206	2.69
Applied Sciences (BTEC)	15,019	196	1.31
Computer Appreciation (BTEC)	20,209	178	0.88
Psychology (A-level)	42,236	196	0.46
Biology (A-level)	21,660	148	0.68

Table 2. Sample sizes in comparative analyses

For the three BTEC subjects in Table 2, there is a positive but non-significant effect of doing Core Maths which is on average approximately 12% of an A-level grade (or equivalent). For the two A-level subjects, the Core Maths 'effect' is small but negative but again non-significant (13% of a grade worse for Core Maths compared to non-Core Maths students). To an extent, these non-significant findings are a result of the actual sample sizes within the Core Maths group being quite small (Table 2) so estimates have relatively large standard errors. It could also be the case that the actual effect on outcomes is hard to detect, since it is likely to be quite small – compare with, for example, Gill's (2017) work on the Extended Project Qualification, which found that the impact of doing that qualification was of the order of one A-level grade higher for a student taking four A-levels.

Results presented here should be treated with considerable caution. There was some missing prior attainment and demographic data, and the possibility of confounding variables that were not included in the analysis.

Perspectives on Core Maths in schools and colleges – interview data

This necessarily brief overview of the findings emerging most strongly from the qualitative data presents some of the themes which resonate (or not) with previous research or with stated policy intentions.

The need for more mathematics post-16

Participants echo the need acknowledged in the literature (British Academy, 2015; Department for Business, Energy and Industrial Strategy, 2017; Glaister, 2017; HM Treasury, 2017; Hodgen, Marks, & Pepper, 2013) for more students to be studying mathematics in some form post-16 for a range of reasons: to support other subjects, to assist with progression to and success in higher education or employment, and in order to become numerate citizens. Teachers and managers describe the benefits of Core Maths, as seen in this 11-18 school headteacher's comment that "it provided our students with an opportunity to continue maths, and maintain that subject within their profile, for the future, which we felt was a really strong thing to do".

Senior leaders express as much support for Core Maths as do mathematics teachers, provided that class sizes are sustainable and student outcomes are deemed satisfactory in the context of the institution.

Awareness of Core Maths

Participants describe strategies used to promote awareness of Core Maths among their colleagues. They report support from, for example, Psychology, Business Studies, and Science (particularly Biology) staff, but believe the potential benefits to students of taking Core Maths alongside such subjects need to be communicated more widely:

> "I think this year they're probably more aware than they ever have been, because of [Core Maths teacher] going into the morning sessions to sell it and going into the classrooms and things like that […] I think it's kind of gaining a bit more popularity and people are a bit more aware of it now, but I wouldn't be confident enough to say that everyone would know." FE College Curriculum Leader.

Little, if any, evidence is reported of awareness of Core Maths amongst students or their parents unless it is specifically mentioned to them by the post-16 institution hoping to recruit or retain those students:

> "…we have to explain what it is, because people don't know… the word is not out there massively. Everybody knows what A-levels are. Most people I think would know what BTECs are…it's not an awful lot of people who would be able to tell you what Core Maths is... until they get to the point where they're actually making their options." University Technical College Head of Maths.

Core Maths therefore seems to have relatively little currency as yet. Despite endorsements from universities on both the Core Maths Support Programme website (STEM Learning, 2017) and their own websites, there is a notable preference from some universities/HE courses for a particular GCSE Maths grade (e.g. some courses specify GCSE grade B, now a grade 6, in their admissions criteria), and will not take Core Maths in its place, despite Core Maths demonstrating progression beyond Level 2 (GCSE) and into Level 3. This is leading some centres to support a resit of GCSE Mathematics to improve a student's grade post-16, in preference to taking Core Maths:

> "…while students have picked it thinking it was, going to be a requirement, when they've looked at, as they've started to look at university requirements, they're more likely to say we want an A or B in GCSE...so some are thinking well would

> it have been better to resit the GCSE?… So I, I'm not sure there is a great awareness at university." Sixth Form College Vice Principal.

Positioning in the post-16 curriculum

Core Maths is also seen to have another problem related to awareness: it does not bear the more familiar title of 'A-level' or 'BTEC', but is a 'Level 3 Certificate'. As an AS-sized qualification (half the teaching time of an A-level, and only 40% of the value of an A-level in its contribution to university admission), it is an anomaly at a time when, our data suggests, the two-year linear model for three full A-levels (or equivalents) is becoming the norm, and the AS a thing of the past. This leaves centres struggling to work out how to integrate Core Maths into option blocks and timetabling:

> "…when we did four courses […] they were all ASes, and part of our problem was selling Core Maths as it wasn't an AS. And there was no second year studying it, which is the big problem with Core Maths in terms of selling it." Sixth Form College Head of Maths.

Current post-16 funding supports 600 guided learning hours (GLH) per year, which allows for three two-year A-level courses or the equivalent (180 GLH annually each), and 60 GLH for tutorial time, careers work and enrichment. Core Maths, at 180 GLH in total, is designed to be offered in addition to those three full courses over two years, and does not fit neatly within the funding formula. Managers justify the extra cost in terms of benefit. As one Head of Department explains, "[providing Core Maths is] bonkers from a funding point of view, but it's the right thing to do for the learner's progression […] we do balance the books, but there's the humane element of it as well".

Core Maths was designed to support students over the typical two-year post-16 study period (Department for Education, 2013), at 90 GLH per year. Whilst some institutions do run a two-year course, others run Core Maths over one year, which suits some institutions where it is not uncommon for students to leave after one year. It also frees students to focus on their main study programme in the second year:

> "we do it in Year 12 […] It seems to work better that way, so that they've got it out of the way, ready to go into Year 13." Studio School Assistant Principal.

On the other hand, a two-year course can better suit an institution which sees Core Maths as supporting other subjects, and where it fits with their timetabling if Core Maths has fewer teaching hours per week than an A-level/BTEC subject:

> "...as we were moving two or three years ago from modular A-levels to linear A-levels, we began to wonder how we might use a Core Maths qualification integrated into a larger programme of study. And so we sold Core Maths to them, that it would support their subject but also give them a freestanding qualification." Sixth Form College Vice Principal.

Core Maths can also be set up as an enrichment, which any student can opt into but which is additional to the (usually three) main subjects a student is taking:

> "I think it is quite a hard sell, 'cause you're asking the students to do something extra than what they actually need, to go to university. And even though it benefits them, I think they might think well I've got enough on my plate already, with three A-levels." 11-18 School Head of Maths.

> "Core Maths doesn't sit in the normal option blocks. It's as part of our additional enrichment and tutorial programme that we do so the students would study their three subjects, and Core Maths." 11-18 School Headteacher.

In some centres, Core Maths is offered at enrolment just as other subjects are, such as A-level History, with the same number of taught periods. However, Core Maths

has no second year into which students can progress. Students will then typically be directed towards an Extended Project Qualification (EPQ) in their second year:

> "…some of them would be doing something equivalent to two, Core Maths, and then they'd build up the extra UCAS points to make it equivalent to three with something like the EPQ as well." Studio School Head of Maths.

Progression is a common concern for centres attempting to position Core Maths within their mathematics provision. There are instances from our case study centres of students not studying Core Maths directly after GCSE in the first year post-16, but moving into Core Maths either from a GCSE retake in the first year post-16, or from a year studying AS Maths, where the student is not progressing into the second year of A-level. These possibilities have been seen to work well.

The most significant negative comment from centres not offering Core Maths is precisely the difficulty of incorporating it into the institution's curriculum offer. There is a particular sense of mismatch in institutions where the now-defunct AS/A-level Use of Mathematics qualification (see Noyes & Adkins, 2017; Noyes, Wake, & Drake, 2011) has previously been taken successfully by students. Respondents regard the removal of Use of Mathematics, and its replacement by something half its size, as an incomprehensible move on the part of the government:

> "…if they haven't done Use of Maths before, they think, yeah that's [Core Maths is] not a bad idea, but if you have done Use of Maths, you're just thinking, it's such an appalling substitute, for what was, and the students really liked it, you know, then the kids are committed…" Sixth Form College Head of Maths.

Issues of student 'choice'

The take-up of Core Maths by students is relatively low, even in institutions where support for Core Maths seems robust (Homer et al., 2017). Allowing students to choose Core Maths voluntarily is perhaps a fair approach to recruitment, but can be a risky strategy where student numbers are under scrutiny. Tying participation in Core Maths to particular study programmes seems to result in a bigger cohort, as more students are directed onto the course to support their studies in, for example, Applied Science (BTEC), or Psychology (A-level). This means some students find themselves obliged to take Core Maths, perhaps initially with some resentment, having thought they had given up mathematics after passing their GCSE. As part of our research, we are monitoring and will be reporting on the developing mathematical dispositions of Core Maths students.

There remains some concern in institutions about the long-term prospects of Core Maths, particularly bearing in mind the fate of Use of Mathematics. The future of Core Maths within an institution can depend on student numbers, and also on results, whether that be the outcomes of Core Maths itself, or the outcomes for students in other subjects, which participation in Core Maths is designed to support (Glaister, 2015; Homer et al., 2017; Smith, 2017):

> "…and as I say my massive concern is they'll drop Core Maths 'cause as well we're gonna become an academy [i.e. funded centrally, not locally] in February…so I don't know what that's gonna entail, in terms of, they might just say, right, you can forget Core Maths, because you've got a small number, you know, I really don't know what's gonna happen." 11-18 School Head of Maths.

Related reforms, CPD, and teacher supply

Amongst the staff interviewed, there is a feeling of weariness with reform (see Golding, 2017). With the arrival of Core Maths, there were the concurrent pressures of adapting

to the new Mathematics GCSE and A-level, so the amount of time and energy available for thinking about the delivery of Core Maths, and training for staff, has been variable, and in some cases minimal or non-existent. Our data show that choice of awarding body and specification has often been made on the simple basis of availability of resources, or even familiarity with the layout of the exam paper, and less often to a thorough comparison of available specifications. Engagement with local maths hubs, other teacher networks, or the Core Maths Support Programme prior to its demise, is also variable: some teachers in the study find this kind of networking and support invaluable, whereas others have developed their Core Maths provision independently.

There is a national concern over mathematics teacher shortages (Smith, 2017). However, in our case study centres, specialist mathematics teachers are delivering Core Maths, and are often enthusiastic, energetic and motivated about the new course:

> "…I think [joint Head of Maths] was quite keen to take it himself at one point, because he quite liked the sound of the set-up of the lessons and this idea of, well, here's a real world problem, what maths can we throw at it? And that's quite, there's something quite freeing about that." Studio School Head of Maths.

Frequently, Core Maths is deliberately allocated to teachers who formerly taught Use of Mathematics, or who came into teaching from other careers.

Concluding remarks

It could be argued that our case study centres represent a biased sub-section of school/college maths departments, since they value Core Maths enough to be running it in its early years, and agreed to take part in our research. It is also possible that findings from the first cohort of national data could differ from those of later cohorts, the first consisting of mainly enthusiastic 'Early Adopters' (Advisory Committee on Mathematics Education, 2014). Implementation of a new, innovative qualification is likely, in practice, to take time to mature. Hence, we will analyse national data from later cohorts to compare quantitative findings with those presented here. Future analysis will also focus on the longitudinal aspects of the study, monitoring any change in patterns of uptake and attitudes of students and other stakeholders. We will attempt to link the qualitative and quantitative aspects of the research as we gather more data, surveying a wider range of stakeholders, and bringing different theoretical perspectives to the analysis. Finally, our ongoing exploration of why institutions are choosing not to offer Core Maths will give us deeper insight into the challenges faced by this new qualification.

The data presented here generally indicate support for the wider policy imperative of ensuring more students study mathematics post-16. The two main challenges for centres are the logistics of positioning Core Maths within the curriculum framework and funding conditions now characterising the post-16 sector, and whether to target certain students or allow students to opt in. These questions are inextricably linked, and are themes that merit further investigation over the remainder of the project.

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