# Centres for Excellence in Mathematics: Research trials focusing on specific teaching approaches

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The government in England aims to improve the teaching of mathematics up to level 2 in post-16 educational settings (colleges of Further Education and Sixth Form Centres) through twenty-one Centres for Excellence in Mathematics in England. One strand of the work of the Centres for Excellence is to participate in national trials which aim to research how, and how well, specific teaching approaches work. This paper introduces the research trials, outlining their design and considering the pilot implementation, which took place between October 2019 and March 2020. The paper provides some emerging findings and recommendations for a wider roll-out of the trials.

**Keywords: further education; GCSE re-sits; mathematics teaching; mastery; contextualisation; technology**

## Introduction and background

In England, young people (aged 16-18 years) in post-16 education who have not achieved a 'pass' (Grade 4) in mathematics are required to continue studying mathematics until they achieve this standard. Large numbers of them continue to study GCSE mathematics and then re-take the GCSE examination but their achievement rates are low, suggesting that new approaches need to be considered for these students, commonly known as GCSE re-sit students, to make better progress.

The Smith (2017) review of post 16 mathematics and the Mathematics in Further Education Colleges Project (Noyes, Dalby, & Lavis, 2018) both highlighted the need to support teachers to develop excellence in GCSE re-sit teaching in the FE sector. In response, in 2019 the government funded the Centres for Excellence in Mathematics (CfEM) programme, 'aimed at delivering a step change in maths teaching up to Level 2 in post-16 settings' (Education and Training Foundation: Centres for Excellence in Maths, n.d.). Twenty-one Further Education or Sixth Form Colleges, in all areas of England, were selected to take part in the programme. The Centres are expected to run a range of activities to improve the teaching and learning of mathematics, mainly targeting GCSE re-sit students with prior GCSE Grades 1, 2 or 3. One of the activities is to take part in research trials of mathematics lessons that foreground new teaching approaches within one of four themes (mastery, contextualisation, technology, and motivation and engagement).

The programme involves nine delivery partners, including the Education and Training Foundation (ETF) as the managing partner, Pearson to deliver resources and the University of Nottingham's Centre for Research in Mathematics Education to advise on, and evaluate, the research trials. Each centre is supported by one of three Regional Mathematics Leads (RMLs), employed by the ETF, with a key responsibility for overseeing the trials in the centres.

At the time of writing this paper, the research trials have completed a pilot year. However, because of the Covid-19 lockdown, some of the trials were cut slightly shorter than planned. This paper reports in more detail on the design and implementation of the pilot trials for the mastery, technology and contextualisation themes in which the University of Nottingham had a lead role. We include an account of the experiences of one of the Regional Mathematics Leads to compare with the perspective presented by the team from Nottingham.

The trial for motivation and engagement was designed and run by the Behavioural Insights Team, another of the nine delivery partners, and is not reported on here.

## The design of the research trials

### *Underpinnings*

Although the four broad thematic areas were stipulated by the DfE, the conceptualisation of these thematic areas was captured in briefing papers developed by and for the University of Nottingham team. These papers outline the key theoretical and analytical perspectives for each theme, hereby characterising teaching and learning practices in each theme in distinctive ways. For contextualisation, the Realistic Mathematics Education approach is prioritised, with lesson resources including carefully chosen contexts to support the progressive formalisation of models (Hough, Solomon, Dickinson, & Gough, 2017; van den Heuvel-Panhuizen, 2003). For mastery, lesson resources draw on NCETM conceptions of mastery pedagogy (2016, 2017), with particular emphasis on the use of varied representations, dialogic teaching, and rich tasks. The technology theme takes advantage of the ability of the computer to perform mathematical tasks (Drijvers et al., 2016; Hoyles, 2018), and provides students with dynamic access to mathematical ideas and structures. They experience mathematics in different ways, engaging in cycles of predicting, explaining and checking.

The designs of the four trials were underpinned by a set of key principles, which were developed within a 'hackathon' involving a number of the delivery partners and CfEM centre leads, conceived and run by Pearson during March 2019. Each hackathon was informed by the relevant briefing document. These key principles for the three strands led by the University of Nottingham defined and differentiated the pedagogic approach for each thematic area in the trial lesson design process. For contextualisation, for example, the key principles were:

Work in the area of maths and context should focus on:

- Careful selection of contexts that best highlight the relationship between mathematical structure and context
- Ensuring students spend more time exploring how context and mathematics are interrelated
- Ensuring students engage in a range of different ways of working on mathematics in context including those that involve peer collaboration.

Each trial was underpinned by a logic model, developed following a series of 'theory of change' workshops hosted by the University of Nottingham in April 2019. One logic model (contextualisation) is given here (Figure 1). The logic models for the mastery and technology themes differ only in the details of the mediating mechanisms.

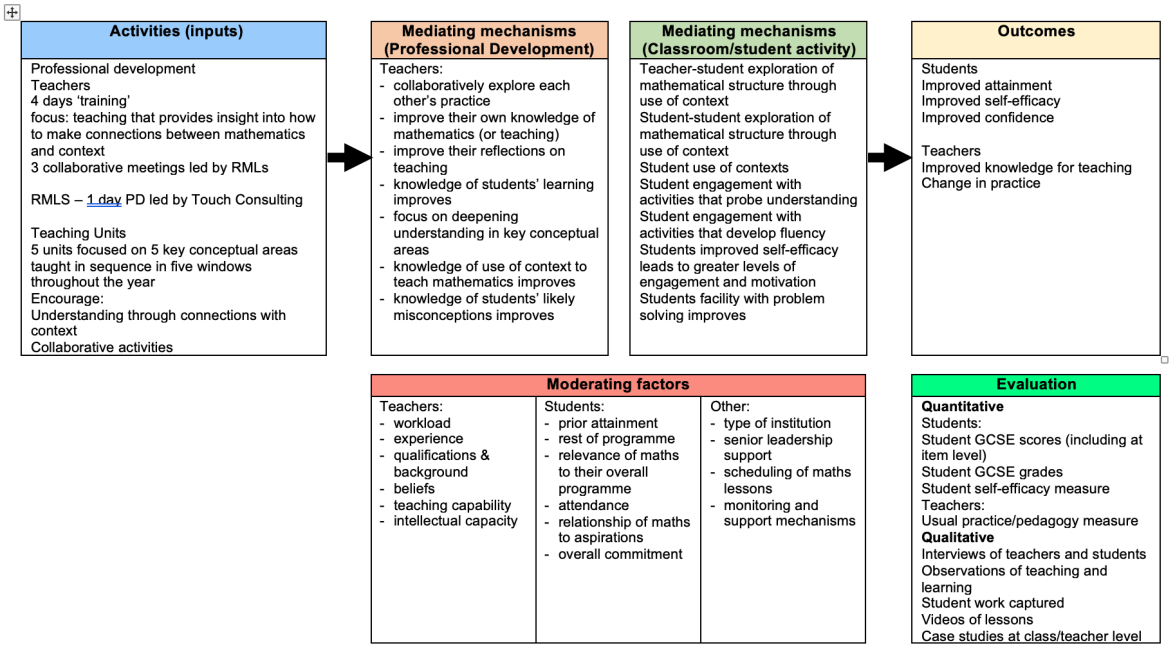


Figure 1: logic model for contextualisation trial

The logic models include activities and mediating mechanisms. The activities involve trial teachers across each of these three themes teaching five lesson units focused on five key conceptual areas, with an emphasis on mathematical structure. The five key conceptual areas, determined by the University of Nottingham team and informed by a) an analysis of GCSE examination results b) research literature and c) discussions with the RMLs, were 1. Number (factors, multiples and primes), 2. Multiplicative reasoning, 3. Fractions, decimals and percentages, 4. Basic algebra and 5. Measure (area and volume).

Five 'teaching windows'(Figure 2), between October 2019 and April 2020, were identified, during which teachers were expected to teach the five lessons. To support teachers to teach the lessons with fidelity to the key principles of each theme, teachers were required to attend local 'cluster meetings' led by the RMLs during each teaching window. The cluster meetings adopted an iterative lesson study approach, with each meeting including a lesson observation of a trial teacher teaching the current trial lesson, accompanied by pre- and post-lesson discussions of observed student learning and other teachers sharing their own experiences of delivering the same lesson. These discussions were guided by research questions (e.g. How do students talk about the relationship between the original scenario, the bar models, and the algebraic expression/equation?) that highlighted particular key principles for each lesson. Each cluster also included an opportunity for teachers to work collaboratively to explore the next lesson to be taught.

## The pilot trial: what happened?

Fifty-nine teachers, forming 11 cluster groups, and approximately 1800 students took part in the three trials. Most teachers taught four of the trial lessons to all their GCSE re-sit classes, some taught five and some only taught three before the colleges were closed because of the Covid-19 lockdown. All cluster groups, apart from one, met four times face to face and once online. The other one met three times face to face and twice online.

The University of Nottingham collected both quantitative and qualitative data to evaluate impact on students' GCSE re-sit results and the implementation process of the trial lessons and professional development support via cluster meetings. Although challenges remain around further GCSE data collection for this academic year, a significant amount of data has been collected to facilitate implementation process evaluation. Baseline surveys for both teachers and students assessed perspectives on mathematics teaching and learning and self-efficacy respectively. Although it was the intention that they should also complete surveys after the trial to map any changes in behaviours and attitudes, we do not yet know how many of them will complete these post-intervention surveys. Six colleges, two in each theme, were selected as case studies of the implementation of a trial in a college, and data in the form of teacher interviews, lesson observations, cluster meeting observations and RML interviews were collected in each window. Other data included interviews with the CfEM leads and curriculum managers at each case study college to gauge wider impact and contextual barriers.

It is too early to provide a detailed analysis of the data so here we present our emerging findings and observations, mainly in relation to the trial lessons teachers were asked to teach and the professional development provided for teachers.

### *The lessons*

The lesson units were designed by Pearson, with significant input from the University of Nottingham. The lesson design process began in June 2019 for lessons to be taught between November 2019 and March 2020. Each unit consisted of a lesson plan, which explained in detail what the teacher should do and, importantly, why. For example, the commentary explained how the steps of the lesson were aligned with the key principles of the theme. There was also a PowerPoint for the teachers to use and any worksheets or other resources the students or teachers might need (e.g. apps used in the technology theme). The lessons were not trialled by teachers.

Designing fifteen trial lessons in six months is difficult and balancing the competing requirements of lessons was challenging. For example, the lesson plans were very long because they included information for teachers to explain how the student activities were aligned with the theme (e.g. contextualisation). However, teachers reported that they did not have time to read such long lesson plans. From the perspective of the researchers at the University of Nottingham, based on our observations of lessons and interviews with teachers, some activities in some of the lessons worked very well but overall they require significant review.

In terms of teaching the lessons, for most teachers the pedagogic approach in the lessons differed from their business-as-usual approach. Some viewed this as an opportunity for learning and welcomed the time and space to try something new, while for others this created frustration as they felt that the lessons distracted from their core purpose of preparing their students for examinations.

There was significant variation across the case studies in how teachers taught the lessons within the intended thematic approach explained in the lesson plan. Some teachers stuck rigorously to the lesson plans making only minimal adjustments to lesson resources (e.g. adjusting a worksheet to fit onto a single page). Other teachers made much bigger changes to lesson resources, appearing to be paying only lip-service to the intended approach. To some extent, the degree to which teachers changed the lessons may have been related to issues of ownership, with many teachers identifying a lack of ownership as problematic. This may have affected both their

understanding of the intended pedagogic approach and their capacity and willingness to teach using the specific approach as intended.

However, across all the case study trials, teachers identified learning instances around transformed teaching approaches, with some teachers transferring approaches from the trial lessons into their business-as-usual practices. For example, one of the teachers in the mastery trial reported that she had begun to use different representations more often in her classes.

From the perspective of the RMLs, the lessons challenged some teachers' dominant practice of drilling students for the examination. The RMLs recognised that the lessons were designed to allow opportunities for students to develop their conceptual understanding through active participation but pointed out that, for this to occur, teachers needed to be willing to review their pedagogy and the role of the three Regional Maths Leads was to facilitate this.

The RMLs observed that there was some confusion in the participating teachers' minds about what the lesson interventions would achieve. It seems that by the end of the process, some teachers were disappointed that the lessons did not provide any quick solutions to the complex problem of teaching GCSE re-sit mathematics, while other teachers recognised that the lessons provided examples of an altered pedagogy. They added that some teachers did not appreciate that the five lessons provided examples of a specific pedagogical approach, appearing rather to think that the lesson itself could, or should, influence student outcomes. The RMLs suggest that managing the expectations of the teachers participating in the trials is important in any pre-trial professional development and they recommend that more attention is paid to this in future rounds of trials.

### *Professional development for teachers*

In most cluster meetings, one of the teachers at the host college taught the lessons for that 'window' and the other teachers and the RML observed. There followed a post-lesson discussion, framed by a set of research questions provided by the team at the University of Nottingham, during which all teachers could share their own experience of teaching the lesson. To end, the lesson for the next window was introduced by the RML and cluster meeting logs were completed by all participants.

The researchers at the University of Nottingham observed that the cluster meetings did not always follow this format, largely due to timetabling constraints: sometimes the lesson could only be taught later in the day, so the next lesson was introduced first. Further, although it had been intended that teachers should teach the lesson for each window before the cluster meeting, it seems that many teachers postponed their own teaching of the lesson until after they had seen in taught (some teachers even referred to this as 'modelling').

As might be expected, there was a wide variety in the extent and quality of the post-lesson discussions, and the researchers' observations suggested that in some groups little attention was paid to the research questions and the discussion was somewhat superficial. However, the RML perspective suggests that in-depth discussions about mathematical concepts and opportunities to develop new strategies to reduce the need for rote memorisation of algorithms or formulae, were viewed as extremely valuable by the teachers. Overall, it appears that there is widespread agreement that the cluster meetings provided valuable professional development and learning for teachers, and they particularly valued the opportunity to work

collaboratively with colleagues from other colleges to investigate and discuss mathematics teaching and learning.

## Reflections and next steps

This paper has provided an overview, from the perspectives of the research team at the University of Nottingham and the RMLs, of the pilot trials. As indicated, the trials were met with mixed reactions. The biggest challenges were in achieving the design aims for the lesson units and managing the expectations of the trial teachers. Lessons have been learned and will inform the next rounds of the trials.

The lesson units will be reviewed by panels of teachers, led by one of the RMLs, and a set of recommendations will be produced and shared with Pearson. More attention will be paid to preparing the teachers for the trials so that they understand better what the trials aim to achieve.

It is envisaged that further rounds of trials (probably from September 2021) will involve a larger cohort of teachers and cluster meetings will be run by lead teachers who will be selected from the teachers who took part in the pilot trials. The University of Nottingham and one of the other delivery partners (Touch Consulting) will run professional development for the lead teachers to prepare them for the role.

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