Education Endowment Foundation

Direct Instruction in Key Stage 3 Connecting Maths Concepts

Evaluation Report

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Contents

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Executive summary

The project

The Direct Instruction in Key Stage 3—Connecting Maths Concepts pilot aimed to explore the promise and feasibility of implementing the Connecting Maths Concepts (CMC) programme to support Key Stage 3 (KS3) students with low prior attainment in mathematics. Developed in the United States as a comprehensive mathematics programme for primary-aged students, the programme consists of sequenced, scripted lessons and assessments designed to provide specific, systematic, and structured instruction in fundamental concepts in mathematics. It is based on the Direct Instruction (DI) model of teaching and key elements include whole-class mastery, error correction, choral responding, feedback, assessment, and the use of a motivation system.

In this pilot study, the CMC programme was implemented in eight secondary schools in the Midlands region of England. A total of 189 students across Years 7, 8, and 9, took part in the programme between September and December 2019. Schools implemented 15 weeks of the CMC programme to groups of up to 14 students per year group. Students completed a placement test to match their level of attainment with the appropriate CMC programme level and received CMC as a replacement to usual mathematics lessons three to five times a week. Lessons were designed to be 70 minutes, comprising 50 minutes of whole-class instruction and 20 minutes of independent working.

Teachers and learning support practitioners received two days of training, ongoing coaching, and CMC course materials to deliver the CMC programme (subsequently referred to as 'DI instructors'). Programme training and implementation were supported by the U.S.-based National Institute for Direct Instruction (NIFDI)—a prominent Direct Instruction support provider in the U.S.—and a local delivery team, coordinated by Midland Academies Trust (MAT).

The evaluation sought to explore whether the approach, which has been evaluated and field-tested in the U.S., showed evidence of acceptability and promise, feasibility and scalability, and readiness for trial in the specific context of English secondary schools and the targeting of students identified as low attaining in mathematics. A mathematics attainment outcome measure for use in future trials was also piloted. The National Foundation for Educational Research (NFER) conducted the evaluation using a mixed-methods approach. This involved a survey of student attitudes to mathematics before and after the programme, group interviews with students, and interviews with DI instructors, NIFDI, and MAT staff.

Figure 1: Summary of pilot findings

Research question	Finding
Is there evidence of acceptability and promise?	There is preliminary evidence that the CMC programme increased students' confidence in their mathematics understanding and ability, particularly in Year 7. However, the perceived effectiveness of the programme elements was mixed. Evidence also suggested some signs of potentially adverse impacts on students' behaviour in mathematics lessons, although behaviour challenges were perceived to have abated over the course of the pilot. The lack of alignment to the mainstream KS3 curriculum content and lack of differentiation to students' varying needs was also a concern for supporting students' mathematics learning.
Is the approach feasible and scalable?	The CMC programme is feasible to deliver, however the specified lesson duration and timetabling, group size, and student selection process presented logistical challenges that suggest a risk to delivery at scale.
Which mathematics attainment outcome measure is most suitable for future trials?	Hodder Education's Progress in Understanding Mathematics (PUMA) Year 6 spring and summer papers were tested for use in a future potential trial. These were too challenging for the target group of students and a measure that better matches student attainment will need to be identified for future trials.
Is the approach ready to be evaluated in a trial?	In its current form, the CMC programme is not ready for trial as a replacement mathematics programme for KS3 students with low prior mathematics attainment. Yet, modifying the programme to address the issues encountered in the pilot is not feasible as this would undermine the integrity of the programme.

Additional findings

This pilot sought to explore the application of the CMC programme in the specific context of English secondary schools, targeting KS3 students who had low prior attainment in mathematics. The evaluation findings present a mixed picture of successes and drawbacks when the programme is delivered in this context.

Preliminary findings suggest some evidence of promise. The CMC programme positively impacted students' confidence in their mathematics understanding and ability. Over half of surveyed students also reported that the programme helped them do better at mathematics. However, there was no change in students' self-reported mathematics motivation and, in some cases, students' perceptions of their own behaviour in mathematics lessons deteriorated over time and they became less likely to agree that they behaved well in mathematics lessons. Given the programme's design for primary-age students, as might be expected, further analysis of the pilot data indicated that students in Year 7 were more positive about the CMC programme overall. When considered alongside data from DI instructor and student interviews, this suggests the programme may be best targeted at the lower age and attainment range of KS3 or upper primary age. Evidence of promise is therefore mixed, however, the analysis is limited by a small sample, short timeframe, and the absence of a control group.

Perceptions of the acceptability and effectiveness of the CMC approach were also somewhat mixed. Interviewed senior leaders, DI instructors, and students valued elements of the programme such as the sequenced structure, the way mathematics concepts were explained, and the focus on mastery, assessment, and feedback. However, qualitative evidence also revealed low-level behaviour issues related to perceptions of insufficient challenge, too much repetition, and choral responding. The lack of differentiation to meet students' varying needs and lack of alignment to the KS3 curriculum content was also a concern when supporting students to catch up and return to mainstream mathematics education. However, there were indications from interviews with DI instructors and students that engagement with CMC was increasing–and behaviour issues abating—as the programme progressed.

The evaluation found that it was feasible to deliver the programme in schools. Programme materials, resources, and support from NIFDI and MAT were regarded as being high quality, effective, and the support was reported to be of appropriate depth and frequency, with indications that this could be replicated at scale. However, schools encountered some challenges in meeting the programme requirements, including timetabling, and staffing the programme according to the placement test, class size, lesson duration, and frequency criteria. The pilot also recruited fewer schools and students than originally planned, which may suggest some challenges to the scalability of the programme.

Pilot schools reported a need for mathematics programmes to support KS3 students with low prior attainment in mathematics. Although this is a small and self-selecting sample of schools, this may indicate a broader need in other schools. However, some forms of adjustment would be required before the CMC programme is ready for trial. The evaluation evidence indicates the need to review the implementation approach—including the target students and whether the programme replaces the main curriculum or is supplementary to it—and some of the programme's content, including extension materials for faster learners. Given the mixed findings, alternative next steps should be considered such as targeting upper primary-age and Year 7 students, delivering an alternative DI-based programme (such as Corrective Mathematics) as a supplementary intervention in addition to the main curriculum for KS3 students, or employing a different intervention that combines the effective features of the CMC programme with alignment to the mathematics curriculum and pedagogical culture in England.

Introduction

This report presents the findings from a pilot evaluation which tested the promise, feasibility, and readiness for trial of the Direct Instruction Connecting Maths Concepts programme in Key Stage 3. As part of the pilot, the CMC programme was taught in schools in the Midlands region to groups of Year 7, 8, and 9 students identified as low attaining in mathematics. Students received CMC in groups of up to 14 students per year group as a replacement for usual mathematics lessons during the whole of the autumn term 2019. The CMC programme was implemented in schools with the support of the U.S.-based National Institute for Direct Instruction (NIFDI)—a prominent Direct Instruction support provider in the U.S.—and a local delivery team based in the Midlands and coordinated by the Midland Academies Trust (MAT). The support team comprised a programme manager and three trained DI coaches. The evaluation was conducted by the National Foundation for Educational Research (NFER) between May 2019 and February 2020.

Intervention

Developed in the United States by Dr Siegfried Engelmann and colleagues from the University of Oregon, CMC is a comprehensive mathematics programme of sequenced scripted lessons and assessments designed to provide highly explicit, systematic, and structured instruction covering a wide range of content related to fundamental concepts in mathematics. It is based on the DI model for teaching, which emphasises clearly defined, consistent, and prescribed teaching tasks. The lessons in the CMC programme are sequenced to help students make connections between important mathematics concepts, procedures, and knowledge. The programme structure is designed to enable students to master key concepts, introduced over several lessons, with opportunities to practise and review their understanding through independent work and mastery tests (Engelmann *et al*., 2013). The CMC programme can be delivered by any trained DI instructors, including mathematics class teachers as well as teaching and learning support assistants; no prior qualifications are required.

The programme has six levels from A (lowest) to F (highest). In the U.S., the CMC programme is typically used as a whole-school core-instruction programme for teaching mathematics to primary-age students. Each level of the programme is designed to meet the curriculum standards (Common Core State Standards) required for a particular age group (Engelmann *et al*., 2013). Students are 'placed' onto a relevant level of the programme based on a series of initial 'placement tests', beginning with Level A, and there is scope for movement between groups covering different levels of the programme to accommodate different rates of student learning (Engelmann *et al*., 2013).

In the pilot, students were first given the Level D placement test as this was selected as the most appropriate level for the target students in the pilot, followed by either the Level C or Level E test depending on the number of errors made on the initial test. The Level E test was slightly adapted for the pilot as items about money using U.S. terminology were removed. The placement tests for Levels C and D require that students who have not completed previous levels of CMC only take part one of a two-part test. For the Level E test, both parts are administered. Depending on the number of errors made in the test/s, the students were placed in one of three categories: assessed as requiring Level C of the programme, assessed as requiring Level D of the programme, or assessed as being too proficient for Level D. For the pilot, only students who were assessed as requiring Level D of the programme were eligible to take part. The placement test is administered in the same format as the CMC lessons themselves, with scripted instructions to facilitate standardised administration, and use of signals to cue students' responses. The tests are short (taking approximately five to 20 minutes each to administer) and cover recognising one- to three-digit numbers, a timed section on addition and subtraction, and column addition and subtraction. The Level E test also covered multiplication, division, fractions, and word problems.

In consultation between the local delivery team and NIFDI, Levels C and D of the programme were initially identified as the most appropriate levels for the target group of students in this study—KS3 students in Years 7, 8, and 9 with low prior attainment in mathematics. Following initial placement testing, the decision was made to run the CMC programme Level D for all intervention groups as this maximised the number of students involved as only small numbers of students were assessed as requiring Level C. Also, in consultation between the local delivery team and NIFDI, the decision was made to limit the size of CMC groups to a maximum of 14 students in the pilot given that the target students had low prior attainment in mathematics. Previous applications of CMC in the U.S. have involved instructional groups of varying sizes (for example, small groups of four to six pre-school age children and larger class sizes of 20 or more students).

The Level D CMC programme includes 130 lessons in total. At the end of every ten lessons, students complete a mastery test. At the end of 70 and 130 lessons, students complete a cumulative test. Pilot schools aimed to implement part of the CMC Level D programme over a 15-week period (between 40 and 60 lessons from September to December 2019). Therefore, it was planned that students in the pilot would experience several mastery tests but would not reach the point in the programme of the first cumulative test. Each lesson was designed to include 50 minutes of structured work and an additional 20 minutes for student independent work (a total recommended lesson time of one hour and ten minutes). The programme guide recommends that CMC lessons are delivered over five sessions per week, however, it was recognised by the MAT delivery team that this might not be achievable for pilot schools that had fewer scheduled mathematics lessons per week. Hence, pilot schools were expected to deliver three to four lessons of CMC per week for participating students as a replacement for normal timetabled mathematics lessons.

The CMC programme includes five pedagogical features that are regarded by the developers as essential elements of effective delivery (Engelmann *et al.*, 2013) which are detailed below:

- Paper-based placement tests;
- Instructor materials—teacher's guide for how to teach CMC, presentation books with all the lessons, mastery tests and cumulative tests, Answer Key,[1] and Board Displays CD;[2]
- Student materials for all students—workbooks for each lesson, a textbook, and a student assessment book containing mastery tests and cumulative tests and remedies worksheets; and
- Downloadable materials provided online via ConnectED (an online portal) such as maths fact worksheets and access to other CMC online content.

Connecting Maths Concepts textbooks, instructor materials, and student materials are published by McGraw-Hill Education.[3] Pilot schools were provided with all programme resources and no additional materials were required. Schools had the option to use a visualiser (real-time image capture devices for displaying an object on a screen) to present the materials.

The first 60 lessons of the Level D CMC programme include sequenced lessons covering the following topics: addition and subtraction, multiplication and division, place value, inequality, mental maths, equations, money, measurement, estimation, geometry, fractions, maps, and time.

The CMC programme includes five pedagogical features that are regarded by the developers as essential elements of effective delivery (Engelmann *et al.*, 2013):

- Feedback—there is a strong emphasis throughout the programme on the instructor providing immediate feedback to students both verbally within lessons and in communicating written results of mastery tests once marked.[4] The DI instructor records mastery test scores to monitor progress and the need for error corrections. Feedback consists of two components: error corrections (discussed below) and confirmation of correct answers. Positive feedback is given for correct responses (see motivation section below).
- Error corrections—if one or more students make a mistake, instructors are required to correct the mistake immediately for all students in the group to ensure that misconceptions are not adopted and allowed to embed and that the correct understanding is practised. Remedies for a comprehensive range of common student

[1] The Answer Key provides the answers to all of the problems, activities, and tests in the programme. It is used by instructors to assist in checking student class and independent work and for marking tests. The Answer Key also specifies the remedy exercises for each test (that is, subsequent exercises that students need to complete to address any errors in their work) and provides a group summary of test performance.

[2] The Board Displays CD contains all of the displays that instructors are required to present during CMC lessons. The displays can be used with a projector, television, or interactive whiteboard. Instructors navigate through the displays in coordination with the lesson material.

[3] https://www.mheducation.com/prek-12/program/connecting-math-concepts-comprehensive-edition-2012/MKTSP-UUF07M0.html?page=1&sortby=title&order=asc&bu=seg

[4] Previous evaluations of the CMC programme (for example, McKenzie *et al*., 2004; Wellington, 1994; Arthur and Stockard, 2014) indicated that students found immediate feedback motivational and beneficial in securing their understanding and informing where they might need to concentrate particular attention.

misconceptions are provided in the programme, specifying to instructors which lessons and exercises should be revisited if students have made errors on the mastery tests.

- Motivation system—instructors are required to use a system for motivating students who are complying with the programme and meeting expectations. This includes awarding points for positive behaviours in lessons. The CMC training for instructors outlines what the system should involve to ensure feedback that reinforces positive behaviours and motivates students to apply themselves, although instructors can define the specific details and rules of such a system depending on their preferred teaching style and the needs of their students.

- Choral responding—during group instruction in lessons, the instructor asks students to answer questions as a group in response to an instructor signal. This is considered to be more efficient than asking students for individual responses as the instructor can gather information on the whole group's understanding of concepts at the same time and then respond to misconceptions of one or more individual students. Instructors decide on a signal to use as a cue to the students that they require a choral response (such as a hand drop or clap). Specific signals are used for different situations. For instance, if the students are engaged in workbook activities, an instructor might use an audible signal rather than a visual signal as the students are looking down at their own work.

- Independent work—each lesson includes structured activities for the whole group for approximately 50 minutes and 20 minutes of additional independent work. The programme stresses the importance that this work is done independently rather than collaboratively with other students. It is therefore recommended as preferable that this activity takes place during school hours and under the instructor's supervision and monitoring to provide additional reminders and prompts if required (particularly if any errors are noticed). As part of this activity, the instructor supports the group to mark their own work and correct their errors. The instructor records independent work scores to monitor progress and the need for error corrections.

Pilot schools were supported by NIFDI and MAT to implement the CMC programme with KS3 students. The CMC programme is one of many DI programmes that the U.S.-based National Institute for Direct Instruction (NIFDI) provide support and training to schools to implement.

The U.S.-based NIFDI team trained school-staff on:

- how to administer the placement tests to place students in Level D of the CMC programme:[5] placement test training was provided via two online remote twilight sessions, each lasting one and a half hours; and
- how to deliver the CMC programme at Level D: CMC programme training involved a two-day face-to-face workshop at a local training venue in the Midlands for school staff elected to deliver the CMC Level D programme (that is, DI instructors).

During implementation of the CMC programme, trained DI instructors in pilot schools were provided with the following support:

- regular on-site school visits: the original plan was for each school to receive three on-site visits at the start, midpoint, and end of the term of implementation; in practice, each school was visited more frequently than this to help provide additional support for implementation (discussed further in the section presenting findings on Research Question 2f, page 48); during the first two weeks of implementation, all pilot schools were visited by a NIFDI coach and an assigned coach from the local MAT coaching team; this was followed by weekly or fortnightly visits during implementation from an assigned MAT coach, and near the end of the term, there was a final visit from the assigned MAT coach who was accompanied by the NIFDI coach;
- email and telephone support from an assigned MAT coach from the local delivery team;
- written feedback from MAT coaches (based on observations) via a Technical Assistance Form (TAF),[6] which was reviewed and quality-assured by NIFDI on the fidelity and effectiveness of implementation of the CMC programme and suggestions for enhancements; and

[5] The pilot was initially planned to include delivering CMC at Levels C and D according to how students were placed and, therefore, initial placement test training covered both placement tests. The placement test results subsequently revealed low numbers of students placing into Level C and hence the decision was taken to only offer the intervention at Level D.
[6] Technical Assistance Forms (TAFs) are standardised forms used by NIFDI in supporting schools to implement DI approaches. They are used to record information during observations of trainee DI instructors on aspects of the programme that were implemented well and identify areas for development.

- monitoring of programme delivery (including analysis of programme monitoring data and, if required, review of videoed CMC lessons by NIFDI and MAT): as part of the pilot, participating schools were required to submit weekly in-programme data to be examined by MAT and NIFDI which was used to determine the need for further support to ensure programme fidelity; this included lesson progress charts and student test summary forms (including recorded mastery test and independent work scores).

CMC is a highly manualised intervention that must be delivered with fidelity to the lesson script and sequencing and must include the features that have been identified as being crucial to effective delivery. However, there are some aspects of the programme and implementation that permit degrees of tailoring, including bespoke coaching support for DI instructors and scope to repeat lessons if students make a high proportion of errors. In addition, schools had the flexibility to timetable the intervention delivery as appropriate to their normal lesson slots and staffing availability. However, pilot schools were advised that, if it was not possible to schedule lessons for one hour and ten minutes as recommended, they should deliver the programme content continuously across lessons, including the scheduled content and independent work (for example, deliver 50 minutes of structured content in one lesson and the accompanying 20 minutes of independent work in the first part of the following timetabled lesson). Indeed, this is compatible with the guidance provided in the CMC Level D teacher's guide explaining how the programme should be delivered (Engelmann *et al.*, 2013).

Background evidence

The attainment gap between disadvantaged and non-disadvantaged students starts in the early years and increases as students' progress. Recent evidence (DfE, 2018a and Ofsted, 2015) suggests the gap at Key Stage 2 has closed slightly but remains stubbornly persistent at KS4. KS3 marks an important transition from primary to secondary school and evidence suggests that gains made by students in KS2 are not embedded and developed at KS3 (Ofsted, 2015). In terms of maths attainment, this trend is exacerbated by a lack of high-quality maths programmes and a shortage of specialist maths teachers for the KS3 age range (DfE, 2018b; Allen and Sims, 2018).

The Direct Instruction (DI) approach has been widely used in the U.S. for many years and has shown evidence through meta-analysis, reviews, and randomised controlled trials for effects in general (Engelmann, 2014; Stockard *et al.*, 2018) and, in particular, on maths attainment for students in the KS1 and KS2 age-range (Hodgen *et al.*, 2018; Stockard, 2010; Skarr, 2013; Vreeland *et al*., 1994; Crawford and Snider, 2000; Jitendra *et al*., 1994) as well as KS3 and KS4 (Hodgen *et al.*, 2018; Flores and Kaylor, 2007; Przychodzin *et al.,* 2004; Parsons *et al*., 2004; Kitz and Thorpe, 1995; Hasselbring *et al*., 1987), and students struggling with maths concepts, with low prior attainment in maths, and learning difficulties (Hodgen *et al.*, 2018; Gersten *et al.*, 2009; Dennis *et al*., 2016; Flores and Kaylor, 2007; Przychodzin *et al.,* 2004; Parsons *et al*., 2004; Kitz and Thorpe, 1995). The DI approach thus has the potential to support students to maintain a more consistent trajectory of progress in maths.

DI emphasises clearly specified, scripted lessons designed around small learning increments and clearly defined and prescribed teaching tasks delivered at a fast pace. It is based on the theory that clear instructions can greatly improve and accelerate learning by eliminating misunderstandings. There are several principles underpinning the DI approach thought to be central to its effectiveness. With DI, the learning is led by the instructor who directly and explicitly introduces concepts and strategies. This is distinctive to more enquiry-based and student-led teaching and learning approaches. The DI theory suggests that its approach ensures that learning is more efficient as knowledge is acquired more directly and more quickly, as opposed to the implicit learning that may take place through a process of trial and error that may be more likely in student-led practice (Przychodzin *et al*., 2004). The DI classroom maximises the time dedicated to direct instruction from the teacher, with additional opportunities for students to work independently once they are familiar and confident with the strategies the teacher has introduced in detail.

DI is particularly distinctive in that it follows a complete structured curriculum programme, where concepts are introduced in a step-by-step sequence to help students to master key mathematical concepts before moving on to other related concepts. Proponents of DI argue this facilitates manageable and secure increments in students' learning that build on a strong foundation of understanding (Stockard *et al*., 2018). This is considered particularly beneficial in the teaching of maths where certain knowledge must be mastered as a prerequisite for more complex knowledge (for example, addition and multiplication). Mastery learning is, therefore, a key feature of the DI classroom and is regularly assessed to inform subsequent teaching.

A further distinctive feature of DI is that it emphasises the importance of consistent, clear, and unambiguous teaching. This is based on the understanding that concepts can be confused and misunderstood by small variations in the way they are explained and exemplified. Hence, DI programmes follow a clear script and use consistent examples and strategies that have been demonstrated to be effective. One of the potential benefits of the codified and scripted nature of the lessons is that DI lessons can be taught by both specialist and non-specialist maths teachers. Much of the teacher-student interaction is also specified in DI programmes, with students taught to respond in a particular way and in unison as a class ('choral responding') on the teacher's visual and auditory cue.

DI programmes offer a distinctive approach to teaching maths to those more commonly adopted in England. While teaching of KS3 maths in England also tends to emphasise direct and explicit introduction of concepts and strategies and, in this sense, shares a focus on teacher-led instruction, in DI programmes the degree of teacher direction is particularly accentuated. Hodgen *et al.* (2018) raise a concern about the transferability of DI programmes—designed in the U.S.—to the English context where such highly directed approaches may have less validity among teachers. Teaching of KS3 maths in England typically does not involve scripted lessons and cued choral responding from students; these elements are particularly characteristic of the DI approach and mark a substantial difference to existing practices. In addition, typical maths teaching in England involves more use of students working independently in pairs and groups whereas DI focuses more on students working on their own on highly structured practise activities interspersed with whole group responding. Hodgen *et al*. (2018) indicate that explicit instructional approaches, such as DI, are likely to need balancing with other maths teaching approaches in the English context (including implicit teaching and student-led working).

Connecting Maths Concepts is an evidence-informed, comprehensive maths programme based on the DI model for teaching. It incorporates several of the features recommended by the EEF (2017) guidance for KS2 and KS3 maths teaching such as using assessment to build on students' existing knowledge and understanding, teaching strategies for solving problems, addressing misconceptions, and emphasising connections between concepts and procedures.

Most sources of literature discussing CMC draw heavily on the theoretical and empirical underpinning of the DI approach. Evidence for CMC specifically focuses on its use with primary-age students, for which it was designed. CMC has been implemented for many years in the U.S. and several small-scale studies that randomly assigned students to intervention and control groups, as well as larger observational studies with comparison groups of students receiving other maths programmes, have indicated its impact on students' maths attainment outcomes and led to numerous instances of it being used as a whole-school approach to teaching maths at primary age (McKenzie *et al*., 2004; Wellington, 1994; Arthur and Stockard, 2014; Przychodzin *et al*., 2004; Crawford and Snider, 2000; Tarver and Jung, 1995; Snider and Crawford, 1996). The evidence for CMC specifically focuses on its impact on students' maths attainment (and less so on the feasibility of the approach). One example is the small-scale study by Wellington (1994), which compared students studying CMC with comparison groups. CMC was implemented in eight schools; in these, CMC was taught to one first grade and one fourth grade class (equivalent to Year 2 and Year 5 in England, respectively) along with two comparison classes in each grade taught in the usual way. Students' maths attainment was examined using a pre- and post-test. No significant differences were detected for the first-grade groups but statistically significant differences (at the < 0.05 level) in favour of the CMC groups were identified for the fourth grade classes.

This pilot offered the opportunity to evaluate the CMC programme, as a particular model of DI, in the English context, and with secondary-age students identified as low attaining in maths. The pilot sought to establish proof of promise for a wider trial of CMC at KS3. Figure below presents a logic model for the CMC programme that was devised between NIFDI, MAT, and the evaluation team during an initial IDEA (Intervention Delivery and Evaluation Analysis) workshop to underpin the pilot evaluation study. It sets out the key features of the programme and the short- and long-term outcomes that are anticipated to result from this model of teaching. It was beyond the scope of this short pilot study to investigate the 'longer-term impacts' outlined in the logic model, despite these being identified as intended consequences of all other aspects of the model. The logic model sets out the intended plan for implementation and is reviewed in light of the pilot findings in the section below addressing Research Question 1f (page 40).

Figure 2: Connecting Maths Concepts—logic model.

Rationale, evidence and aims

Connecting Maths Concepts (CMC) is based on the Direct Instruction (DI) model for teaching, which emphasises clearly-specified, scripted lessons designed around small learning increments. While there is evidence of the effectiveness of DI in the U.S. (Hodgen *et al.*, 2018), there is less evidence of the impact of CMC specifically. The CMC pilot aims to demonstrate that a DI programme in mathematics can be used in place of normal mathematics provision at Key Stage 3 and provide participating lower-attaining students with a firm foundation in fundamental operations and mathematics reasoning.

Project inputs and activities

Expert training on CMC from National Institute for Direct Instruction (NIFDI):

- training for teachers to administer placement tests (2 x 1.5 hour twilight sessions)
- training for teachers to deliver CMC programme D (face-to-face, two full days).

CMC delivery materials

- Level D resources including placement tests, Teacher's Guide, and workbooks for all students.

Local delivery and implementation support:

- senior leader from the Midland Academies Trust (MAT) to provide strategic oversight
- lead local coach to direct the activities of the coaching team and liaise with NIFDI coaches
- two local coaches to form the local coaching team under the direction of the lead local coach
- onsite coaching support for schools provided by NIFDI coaches, plus offsite feedback based on analysis of videoed CMC sessions
- NIFDI coaches support local coaching team
- minimum of three coaching visits to schools (initial, midpoint, and end-point).

DI classroom features

- Connects critical mathematics concepts to build understanding
- Delivered exactly as scripted with limited adaptation
- Maximises teacher instructional time
- Lessons of one hour and 10 minutes with 50 minutes instruction and 20 minutes independent working
- Clear and consistent routines and procedures
- Positive motivational system
- Mastery of content, reinforce content, and repetition
- Choral responding and individual turns
- Fast pace
- Independent working
- Instant feedback

Outputs

- Teachers trained in delivering CMC and placement tests
- Preselected Year 7, 8, and 9 students placed into appropriate level of CMC programme, based on placement tests
- CMC is delivered to groups of up to 14 students
- Participating students undertake 40–60 CMC lessons over the course of the autumn term 2019.

Shorter-term outcomes

Students:

- increased maths confidence, enjoyment and motivation, knowledge, understanding, and progress (e.g. fewer errors)
- improved attendance in maths lessons
- improved behaviour in maths lessons.

Teachers/schools:

- increased understanding of DI as a teaching method
- increased confidence in using DI with lower-attaining students
- increased effectiveness in using DI
- increased interest in further usage of DI.

Longer-term impacts

Students:

- increased maths attainment at KS3 (as compared to a comparison group)

Teachers/schools:

- DI seen as a viable/preferable alternative to other maths teaching approaches for lower attaining students
- DI embedded within maths and other subjects
- Elements of DI methodology used within wider practice.

Contextual issues Characteristics of participating teachers, students and schools.

Research questions

The evaluation sought to address the research questions detailed below.

1. Is there evidence of acceptability and promise?

a) Do schools feel that there is a need for the intervention? What particular needs does it address?

b) What are staff perceptions of the effectiveness of the intervention?

c) Is there preliminary evidence that the intervention has impacted on students':[7]

   i) confidence in maths?

   ii) enjoyment of maths?

   iii) motivation in maths?

   iv) progress in maths?

   v) behaviour in maths?[8]

d) Are there any differences in emerging student outcomes (see (c) above) by gender or year group?

e) Do there appear to be any unintended consequences or negative consequences associated with the intervention (for example, on teacher workload, on students' enjoyment of, and motivation in, maths, or on non-intervention students in schools)?

f) Is there evidence to support the logic model? Are any adjustments to the logic model required?

2. Is the approach feasible and scalable?

a) Has there been sufficient demand from schools for the pilot? What is the likely demand/appetite for a full trial?

b) What recruitment methods have been used? Have they been effective? What is the key learning for recruiting for a full trial?

c) Is the intervention feasible to deliver in schools (for example, in terms of staffing, facilities, timetabling)? Would adjustments be needed for a full trial?

d) Has the placement test been delivered as intended (fidelity)? Has the intervention reached its intended student target group? Would adjustments be needed for a full trial?

e) Has the staff training been effective in preparing staff to deliver the intervention? How effective was the placement training? How effective was the delivery training? Would adjustments be needed for a full trial?

f) What materials and support have been provided to staff? How effective have they been in supporting staff to deliver the intervention? Have there been any issues with the quality and timeliness of support provided, given that programme staff are based in the U.S.? Would adjustments be needed for a full trial? To what extent has the capacity and expertise of the England-based team been built to run training and provide support should the intervention go to trial?

g) Has the suite of lessons been delivered as intended (fidelity)? Have any adaptations been made? Who has delivered the lessons? Could any improvements be made?

h) Have staff been fully engaged in the intervention? Have there been any barriers to engagement (for example, workload, time, expertise)? How, if at all, have these been overcome? Have any types of staff (for example, specialists, non-specialists, teaching assistants) been more engaged in the programme than others?

i) Have students been fully engaged in the intervention? Have there been any barriers to engagement (for example, prior knowledge, support needs)? How, if at all, have these been overcome?

[7] The evaluation also sought to explore students' attitudes to school more generally in order to contextualise students' attitudes to mathematics. Hence, the student survey included a question on students' general attitudes to school and responses are described in the findings section.

[8] This sub-question was added following the development of the logic model with MAT and NIFDI, when it was suggested that improvement in students' behaviour in maths lessons was an aspirational short-term outcome of the programme.

j) If staff had not delivered the intervention, what maths lessons would they have delivered instead (including topics and teaching approaches)? What is the normal approach/business as usual? How does CMC compare to other programmes and approaches teachers have used with this target group of students?[9]

k) What are the staff and other marginal costs for schools to deliver the intervention?

3. Which maths attainment outcome measure is most suitable for future trial?

a) Which PUMA assessment has the best distribution profile for students that received the intervention at Level D?

4. Is the approach ready to be evaluated in a trial?

a) Is the intervention ready and suitable for a full trial? Do any changes need to be made to the intervention theory, recruitment processes, placement test, training, content and delivery mode, provision of support to staff, intervention materials, or project management?

b) Can a sufficient number of schools be recruited to a trial?

c) Are there any key contextual factors that appear to facilitate or impede successful implementation (for example, related to programme management; school or staff characteristics or circumstances)?

d) Is the intervention likely to be affordable for schools?

e) If the intervention is ready for a full trial, how should this be administered (for example, selection of student target group and numbers, schools and localities targeted, measurement of primary and secondary outcomes, evaluation tools, and monitoring processes)?

Ethical review and data protection

The pilot evaluation was conducted in accordance with NFER's Code of Practice, which sets out guiding principles relating to ethics, data protection, data security, and caring for research participants. The research complied with NFER's Code of Practice and did not present any particular ethical challenges or sensitivities requiring referral to the NFER Code of Practice Committee. NFER is registered with the Information Commissioner's Office for all research activities and only undertakes activities of an ethical nature.

The legal basis for processing personal data for this pilot evaluation was GDPR Article 6 (1) (f), which states that 'processing is necessary for the purposes of the legitimate interests pursued by the controller(s) or by a third party except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of the personal data'. The NFER's and Midland Academies Trust's legitimate interests for processing personal data for this project were to evaluate and deliver (respectively) the CMC programme, which has the potential to benefit students' maths learning. NFER and MAT were joint Data Controllers for the project. They jointly decided on the means and purposes of processing personal data in order to effectively deliver and evaluate the programme. NIFDI was a data processor and processed teacher data in order to provide training and support for the implementation of the intervention. No special category data was processed as part of this pilot evaluation.

Each school that agreed to participate in the study was asked to complete a memorandum of understanding (MoU), which set out the programme and evaluation requirements and required a senior leader (headteacher) and key contact in each school to read and sign in order to join the programme (see Appendix A).

Schools that signed up to the pilot were provided with an information sheet which provided further details about the pilot evaluation (see Appendix B). Schools that signed up to the pilot were asked to circulate a privacy notice for parents/carers of participating students (see Appendix C) and a privacy notice for teachers and delivery staff (see Appendix D), which each provided details about the data that would be collected about students and teachers as part of the study and the legal basis for doing so. The parents of participating students were given the opportunity to withdraw their child/children's data from data processing as part of the evaluation if they had objections (see Appendix E). Schools were asked to remove data about any students whose parents had opted them out of participating in the evaluation data collection prior to any data being shared with the evaluators. This allowed students to take part in the intervention but

[9] This research sub-question was originally part of research question 1b in the evaluation plan. In practice, the research instruments focused on asking participants for their views on CMC in comparison to business as usual practices and, hence, the findings reporting these responses are included in the report in relation to research question 2j.

not the evaluation data collection if they were not inclined to. In addition, opt-in consent was obtained before DI instructors, school senior leaders or heads of maths, MAT and NIFDI staff, or students were invited to participate in interviews as part of evaluation activities. Prior to interviews commencing, the evaluation researchers explained the purpose of the interviews and assured research participants of the anonymity and confidentiality of their views.

Data sharing between NIFDI, MAT, and the evaluators was in strict adherence with the privacy notices, which were drafted collaboratively by these organisations, and were underpinned by a data-sharing agreement (which included procedures for the secure transfer of data). Due to the location of NIFDI in the U.S. being outside of the European Economic Area (EEA), no personally identifiable student data was shared with NIFDI. As part of the programme delivery, DI instructors had the option to video their delivery of CMC lessons in order to receive feedback from NIFDI and MAT coaches. MAT sought opt-in consent from participating DI instructors to share videoed and other personal data for the purposes of providing programme support (as outlined in the privacy notice for teachers and delivery staff, see Appendix D) with NIFDI in the U.S. (see Appendix F). Finally, where DI instructors wished to take up the element of support that offered feedback from NIFDI on videoed lesson instruction, MAT asked the DI instructors to distribute a form to the parents of students in their DI classes to request their consent for their children to be videoed (see Appendix G).

All data gathered during the study was held in accordance with the General Data Protection Regulation (GDPR, 2018) and was treated in the strictest confidence by the NFER, MAT, and NIFDI. Only anonymised findings were shared with the EEF and are included in this report.

Project team

Implementation of the CMC programme in pilot schools was coordinated by Midland Academies Trust as the grantee organisation and local delivery team in collaboration with NIFDI as the programme implementation support team.

Midland Academies Trust is an English academy chain, based in the Midlands, with an understanding of the local context and good links with local schools. The local delivery team was led by a senior leader from MAT who provided strategic oversight of the pilot and managed the programme. A lead coach (also a qualified teacher) managed the day-to-day programme implementation, quality assured the delivery, liaised with NIFDI, and provided coaching support to pilot schools. The lead coach had gained experience of using DI over several years of self-study and had been involved in supporting and coaching other schools to introduce DI alongside directing a DI training hub in England. A further two local coaches, who had some prior experience of using DI with students, completed the local coaching team and were responsible for providing ongoing coaching support to pilot schools implementing CMC. The local delivery team had some prior experience in implementing DI approaches, and the CMC programme specifically, in their schools. At the start of the pilot, and ongoing throughout the pilot, NIFDI staff provided training to the local coaching team to ensure increasing expertise of DI practices was embedded and to hone the team's coaching skills. The three local coaches attended a five-day Coaching Institute training programme in summer 2019 that took place at the National Direct Instruction Conference in Eugene, Oregon and was delivered by NIFDI. The training was intended to demonstrate and develop the role of a coach, coaching relationships, and feedback practices. MAT was responsible for recruiting pilot schools, providing ongoing coaching support to DI instructors in pilot schools, and gathering programme monitoring data.

NIFDI is a prominent support provider of DI programmes, based in the U.S., providing programme information and resources, training, and implementation support to educational institutions to maximise student achievement through DI. NIFDI was founded by Siegfried Engelmann, Professor of Education at the University of Oregon and creator of DI, to provide a comprehensive training and support programme to schools. NIFDI provided coaching support to the local delivery team and delivered all programme training to school staff.

NFER is an independent educational research charity; it conducted the evaluation of this pilot study. NFER worked closely with MAT and NIFDI to agree a detailed description of the intervention and conduct independent evaluation data-collection activities and analysis, the findings of which are included in this report.

Table 1 below provides a summary of the key personnel involved in the study and their responsibilities.

Table 1: Summary of project team

Name	Role	Institution	Responsibilities
Robin Shakespeare	Delivery team	MAT	MAT senior leader, responsible for strategic oversight of the implementation of the CMC programme.
Chloe Sanders	Delivery team	St Martin's Catholic Academy	MAT lead coach, responsible for managing the CMC programme implementation on a day-to-day basis and quality assurance. MAT coach who supported DI instructors in three pilot schools.
Kimberley Flynn	Delivery team	MAT	MAT coach who supported DI instructors in two pilot schools.
Jayne Bradshaw	Delivery team	MAT	MAT coach who supported DI instructors in three pilot schools.
Kurt Engelmann	Delivery team	NIFDI	NIFDI senior leader, responsible for oversight of NIFDI training and coaching support to the local delivery team.
Rochelle Davisson	Delivery team	NIFDI	NIFDI Coordinator of Training, responsible for arranging NIFDI training sessions to DI instructors and the local delivery team.
Tamara Bressi	Delivery team	NIFDI	NIFDI Coach, responsible for providing training and onsite coaching support for DI instructors and the local delivery team as well as offsite data analysis and problem-solving.
Suzanne Straw	Evaluation team	NFER	Project Director, responsible for leading the NFER evaluation team and for quality assuring evaluation delivery.
Jennie Harland	Evaluation team	NFER	Project Leader, responsible for overseeing the day-to-day running of the evaluation.
Kathryn Hurd	Evaluation team	NFER	Head of Survey Operations, responsible for overseeing the administration of the survey and endpoint assessment.
Lorna Jones	Evaluation team	NFER	Mathematics assessment expert, responsible for administration, marking, and analysis of the endpoint assessments.
Afrah Dirie	Evaluation team	NFER	Project statistician, responsible for conducting quantitative analysis of the survey and endpoint assessment.

Methods

Recruitment

Recruitment of schools to the intervention

Midland Academies Trust (MAT) was responsible for the recruitment of 12 schools to participate in the pilot intervention. Schools were recruited from the Midlands region of England in close proximity to the delivery team, which is based in Nuneaton. Schools were recruited between April and June 2019 through an existing network of the Midland Knowledge Schools Hub and other local school partnerships, including teaching school networks, the Thomas Aquinas Catholic Multi-Academy Trust, and local educational authorities.

All secondary schools/academies in the area were eligible to participate. However, schools were required to have limited prior use of Direct Instruction and a sufficient number of students who had not achieved the expected standard for maths at KS2 to be able to convene and staff viably sized intervention groups of up to 14 students. It was expected that all pilot schools would deliver the intervention to a group of students in Years 7 and 8, but they also had the option to deliver the programme to Year 9 students if there was sufficient need, applying the same criteria, and it was viable to timetable and staff the groups. Schools also had the option to run an additional Year 7 or 8 group if either were oversubscribed.

Schools were provided with information about the CMC programme pilot and, if they wished to participate, asked to sign a memorandum of understanding that outlined the requirements of the pilot intervention and the evaluation (see Appendix A). Schools were asked to release teachers or other participating staff to attend programme training and to timetable CMC classes to replace normal maths lessons for the entire autumn term 2019, with a maximum of 14 students[10] per year group in Years 7 and 8, and optionally in Year 9 (Table 2, page 18, presents further information about the achieved student groups).

Findings about the effectiveness of recruitment and the demand for the programme are discussed in sections on Research Question 2a (page 42) and 2b (page 43).

Selection of staff for the intervention

Each school was asked to nominate staff to deliver CMC to students. This could involve one member of staff if the school decided that a single member of staff would deliver the programme to all intervention groups, or more staff if different members of staff delivered the intervention to different year groups. There was a requirement that all staff who were to deliver the intervention and administer the placement test must have received the relevant programme and placement test training. Schools could decide which staff member/s would receive the training to become DI instructors delivering the programme in school. This could include maths specialist teachers, non-specialist maths teachers, the special educational needs coordinator or teacher (SENCO/SEN), teaching assistants (TAs), or higher-level teaching assistants (HLTAs) (Table 11, page 30 provides characteristics of DI instructors who delivered the intervention). Schools could also select a different member of staff to administer the placement tests (for example, an exams officer) to those delivering the intervention itself as long as they received the placement test training.

Selection of students for the intervention

The pilot study targeted groups of students in Years 7, 8, and 9 who had a scaled score of below 100 in their KS2 maths SATs (below age-related expectations). This initial group of students were given the CMC programme placement tests to assess their level of attainment in order to select the appropriate level of the CMC programme. If there were more than 14 students in each year group who placed at Level D, the following students were prioritised for participation in the pilot:

- first, students with an Education and Health Care Plan (EHCP), special educational need, or SEND statement;
- second, students scoring below the national average KS2 maths scaled score of 95; and

[10] The CMC programme does not prescribe any minimum number of students per class and it was up to the schools to decide the minimum number of students per class based on the feasibility of delivering the intervention in their settings.

- third, students scoring below the expected standard for KS2 maths (a scaled score of below 100) who had significant concessions (for example, extra time, reader, scribe).

Placement testing for Year 8 and Year 9 students took place in July 2019 (when the students were in Year 7 and Year 8 respectively) so that intervention delivery could start promptly in the autumn term. Placement testing for Year 7 students took place in September 2019 at the start of the autumn term and Level D materials were pre-ordered ready for delivery from September 2019 for those Year 7 students assigned to the Level D programme. It was not possible to conduct the placement testing with Year 7 students any earlier as prior to this these students were in primary schools and not yet attending the participating secondary schools.

Achieved intervention sample

The original intention (set out in the evaluation protocol) was to pilot CMC in 12 schools. In practice, a total of eight schools were successfully recruited and took part. Findings about the effectiveness of recruitment and the demand for the programme are discussed in sections on Research Question 2a (page 42) and 2b (page 43). A total of ten DI instructors were trained and delivered the CMC programme to students in their respective schools.

In practice, one of the eight participating schools implemented the programme as an intervention in addition to normal maths lessons rather than as a replacement as the pilot intended. The school signed-up to the pilot late and did not have time to staff and timetable the programme as a replacement. This school was still fully involved in the pilot, including all programme and evaluation activities.

It was originally anticipated that the pilot would involve up to 504 students (up to 14 students per group in Years 7, 8, and 9 in each of 12 schools). At the start of programme implementation, participating schools provided the evaluators with a list of students in their schools who were receiving the CMC programme. This totalled 189 students. This number was considerably lower than expected as only eight schools took part, most schools provided intervention classes in only two of the year groups, and, on average, intervention classes were smaller than the maximum of 14 students. Table 2 below provides a breakdown of the number of schools and students participating in the pilot study.

Table 2: Number of schools and students participating in the pilot

	Intervention groups			
	Year 7	Year 8	Year 9	Total
School 1	✓	-	✓	8
School 2	-	✓	✓	
School 3	✓	-	-	
School 4	✓	✓	-	
School 5	✓	✓	-	
School 6	✓	✓	✓	
School 7	✓	✓	-	
School 8	✓	✓	✓	
Total no. of intervention groups	7	6	4	17
Total no. of intervention students	92	63	34	189
Average no. of students per intervention group (range of group sizes)*	13 (8–16)	11 (6–13)	9 (1–15)	-

* As explained in the findings section below, occasionally group sizes were larger than the recommended 14 by one or two students.

Retention to the intervention

All eight pilot schools and 17 intervention groups remained engaged in the pilot and experienced the CMC programme throughout the autumn term 2019 as planned. There was no attrition of schools or intervention groups, and very little evidence of attrition of students from the programme. However, the evaluators were informed of isolated occasions of changes in intervention participants over the term—for instance, a student joining or leaving the intervention group. To avoid over-burdening schools, and because this appeared to be a small number of cases, schools were not asked to provide an updated list of participants at the end of the intervention (any new students were still invited to participate in evaluation activities at the end of the pilot and spare copies of data collection instruments were provided).

Recruitment to the evaluation and evaluation sampling

All schools were informed about the external evaluation activities when they signed up to participate in the pilot programme and were provided with an evaluation information sheet, privacy notices for parents of students and for staff, and an evaluation withdrawal form (see Appendices B, C, D and E respectively).

The pilot evaluation aimed to involve consultation and data collection with all pilot schools. All schools were asked to provide lists of students participating in the intervention in each year group. All students were asked to complete surveys about their attitudes to maths at baseline and endpoint, as well as PUMA maths assessments at the end of the pilot. Fidelity data (for example, CMC lesson attendance) was requested from all pilot schools. All DI instructors in all pilot schools were invited to take part in an evaluation interview towards the end of the pilot.

The evaluation also involved face-to-face visits in four selected schools at the start and end of the pilot. Criteria for identifying schools to visit was based on consultation with MAT and NIFDI to select schools that provided some variation in contexts, such as progress with implementation, number and role of staff members delivering the intervention, and class size. Initial visits also coincided with MAT and NIFDI coaching visits to enable observation of how the coaching support was provided to DI instructors. Selection of schools to visit at the end of the pilot was also informed by the wish to re-visit two schools originally visited plus two additional schools to provide case-study insights in a breadth of school contexts as well as minimise burden on individual schools, and also took into consideration opportunities for observing DI lessons and speaking to students from different year groups. DI instructors were responsible for selecting students to participate in group interviews with the evaluators but were invited to select students to reflect variation of experiences and engagement with the CMC programme.

Data collection

The pilot evaluation employed a mixed-methods qualitative and quantitative approach to gather process and early impact data, as well as test out a range of instruments for use in a potential future trial. Data collection methods are described in turn in the following sections, alongside the achieved samples of responses.

IDEA workshop with Midland Academies Trust and the National Institute for Direct Instruction

In spring 2019, at the start of the pilot, NFER attended two set-up meetings and then held an IDEA (Intervention Delivery and Evaluation Analysis) workshop with MAT and NIFDI to complete the TIDieR (Template for Intervention Description and Replication) framework, review the intervention materials, and support the development of, and discuss and agree, the logic model (see Figure 3 above). This enabled clarification of the intervention's aims, the target student group, sampling strategy, proposed content, and delivery mechanisms, and intended outcomes of the pilot. The aims, research questions, methods, and timescales for the pilot were also agreed upon and were specified in an evaluation plan.[11]

Interviews with project managers, developers, coaches, and trainers

Semi-structured telephone interviews were conducted with representatives from NIFDI and Midland Academies Trust at the start (October 2019) and end of the pilot (December/January 2019). The evaluation plan set out the intention to interview two MAT and two NIFDI representatives at baseline and endpoint. The interviews explored the programme content and delivery approach, engagement of schools and DI instructors and demand for the programme, success of recruitment to the pilot and the feasibility of recruitment for a future trial, training approaches, what had worked well, and any delivery challenges.

In addition to the interviews, the evaluation team were invited to attend several delivery review meetings (three) between MAT and NIFDI colleagues over the course of the pilot. These included reviews of placement testing outcomes, the programme training, and implementation of the programme in schools. These meetings provided a useful additional opportunity for the evaluation team to keep abreast of progress in implementation and to be aware of aspects of delivery that were working well or were challenging, and which could be followed up in formal evaluation interviews. The evaluation team also conducted brief interviews with MAT and NIFDI colleagues following the programme training and observed coaching sessions in pilot schools. These discussions provided another useful opportunity for the evaluation team to explore the developers' and delivery teams' immediate responses to the programme training and coaching

[11] https://educationendowmentfoundation.org.uk/public/files/Projects/Evaluation_Protocols/CMC_Evaluation_Plan_FINAL.pdf

support, and to debrief following coaching observations in schools. The themes raised in these meetings and debriefing sessions were subsequently explored in formal interviews and served to substantiate the researchers' understanding of the programme delivery rather than provide the sole basis for any findings reported.

Table 3 displays the achieved interview sample with key members of the NIFDI and MAT teams that informed the analysis and findings in this report.

Table 3: Achieved sample—interviews with developers and delivery team

	Baseline interviews	Endpoint interviews	Informal feedback
Developers	✓ (2) NIFDI senior leader; trainer	✓ (1)* NIFDI trainer	✓
Delivery team	✓ (2) MAT strategic lead; lead coach	✓ (4) MAT strategic lead; lead coach; coaches	✓

* Only one member of the developer team was interviewed at endpoint (NIFDI trainer). The other members of the developer's team felt they had sufficient opportunity to contribute their views to the evaluation via baseline interviews and the review meetings between the developers and the local delivery team that the evaluation team had attended.

Observation of training

The evaluation team attended and observed the remote training sessions on placement testing in summer 2019 to gain an understanding of the assessment, its content, and outcomes, how it is administered, participants' informal feedback and queries, and the thresholds for student selection to each level of the programme intervention. An observation schedule was used to structure the data collection on these themes. During the observation, the researcher recorded the sequence of events, noting the delivery mode and content, as well as participants' engagement, questions, and responses. After the observation, the researcher summarised their notes in relation to whether the core fidelity features of the placement test process were clearly conveyed, participants' responses to the placement test process and practicalities of using it, as well as how prepared they appeared to be for implementation.

In August 2019, a member of the evaluation team observed the two-day face-to-face training event which focused on programme delivery. This provided understanding of delivery expectations and an opportunity to capture initial feedback from participants and to interview the trainer. An observation schedule was used to structure the data collection. The full observation schedule is provided in Appendix I. The schedule follows the same format as for the placement test training observation, gathering information about the coverage of core fidelity features of the programme and participants' responses and indications of their preparedness for implementation.

Observation of coaching

In September 2019, the evaluation team also observed, in four of the pilot schools, the coaching provided by MAT and NIFDI to support implementation of the programme. The aims of the observations were to understand in detail how the coaching support was provided to schools, including the modes, content-focus, and extent of the support. An observation schedule was used to structure the data collection on these themes and followed the same format as the training observation schedules described above. The observations also included a member of the evaluation team observing the coaching debrief after the lesson between each of the four DI instructors, their MAT coach, and the NIFDI trainer. Brief conversations with staff delivering CMC and senior leaders were also completed where time allowed.

Observation of programme delivery

In addition, towards the end of the programme in November 2019, four schools were visited as part of the case studies (see section 'school case studies and telephone interviews', page 25). The aim of the visits was to observe the delivery of the CMC programme in the classroom. This involved re-visiting two schools that had been visited earlier to observe the initial coaching support, and two schools were newly visited (therefore, overall, six of the eight pilot schools were visited by the evaluators). Schools were selected in consultation with MAT/NIFDI with the aim of having variation in contexts, such as progress with implementation, number and role of staff delivering the intervention, and class sizes. Each visit included observation of a CMC lesson to at least one intervention class from Years 7, 8, and 9. Structured observation schedules were used to standardise data collection on aspects of programme delivery, including:

- whether the intervention appeared to be delivered as intended and evidence of core fidelity features (for example, use of the programme script, resources, pedagogical features such as choral responding, and student independent work);
- student engagement and responses; and
- aspects that appeared to be working well or were challenging.

The observations also included gathering feedback from staff and students, where this was possible, via a small number of informal direct questions to individuals either during or after the sessions (for instance, the DI instructor invited the researcher to circulate the classroom and speak briefly with students).

Table 4 below shows the achieved sample of observations of training, coaching, and delivery of CMC in schools that informed the analysis and findings in this report.

Table 4: Achieved sample: observations of training, coaching, and programme delivery

Placement tests training	CMC programme training	Coaching support	CMC programme delivery
✓ (1)	✓ (1)	✓ (4 schools)	✓ (4 schools[12]) (observations of 6 DI classes covering Year groups 7, 8 and 9)

Baseline and endpoint student survey

A bespoke survey was designed to capture students' attitudes to, and experiences of, maths in school at baseline and endpoint. The survey can be found in Appendix J. All participating students were asked to complete the online survey prior to the start of programme delivery in September 2019 and again in the final weeks of term in December 2019. The original evaluation design assumed that Year 8 and Year 9 intervention students would be identified in June 2019 (when they were in Year 7 and Year 8 respectively) and therefore they could complete the baseline survey in the summer term and start the intervention promptly in September 2019. In practice, there was insufficient time in the summer term for this after the students had been selected following the placement testing. As a result, all three-year groups of students were asked to complete the survey in September 2019. Schools were asked not to start delivering CMC until students had completed the baseline survey and all eight schools completed surveys within the first couple of weeks of September.

The survey included 12 questions at baseline and three additional questions at endpoint. This included four questions to obtain details of respondents' characteristics (such as year group and gender) and the remaining questions each included several individual items such as statements to explore various aspects of students' attitudes to maths. It was designed to take approximately ten minutes to complete.

The survey was partly based on tried and tested questions from existing surveys, and it explored constructs that could be evaluated as secondary outcomes in a future trial. The survey was designed by experienced researchers with contribution from the evaluation team's maths expert. It explored students' experiences of DI classroom features and changes in attitudes to maths associated with the short-term student outcomes outlined in the CMC logic model. Some question items were drawn from student surveys on maths attitudes that the evaluation team had successfully administered previously. In addition, the team drew on relevant questions in the TIMSS 2015 (Trends in International Mathematics and Science Study) student questionnaire, including questions on students' attitudes towards learning maths.

The student survey comprised 40 individual question items in total exploring the following aspects of students' attitudes to maths:

- confidence in maths generally (four items);
- confidence in maths topics (nine items);

[12] Of the four schools where the evaluators observed CMC programme delivery, two schools were re-observed following initial observations of coaching support and two schools were newly observed. Hence, during the whole evaluation, observations were conducted in six different schools in total.

- maths motivation (five items); experience of maths lessons (seven items);
- experiences of maths teaching (five items);
- behaviour in maths lessons (four items); and
- perceptions of the relevance of maths (three items).

It also explored students' attitudes to school in general (three items). As part of the analysis, the survey items were clustered into factors that measured consistent constructs and these closely reflected the question areas in the student survey (for further detail on the factors and the individual survey items they comprised, see Appendix H). The endpoint survey also included a small number of additional questions asking students directly about their views of the CMC programme, including:

- whether they liked or disliked the approach and some of its key aspects (five items); and
- whether or not it helped them to learn maths (three items).

The surveys were reviewed by the EEF, MAT, and NIFDI colleagues prior to administration with students. Students were asked to indicate their responses to various statements about learning maths on Likert-style rating scales that included either four or five response options (for example, 'disagree a lot', 'disagree a little', 'neither agree nor disagree', 'agree a little', 'agree a lot'). This enabled analysis to explore whether students' responses changed between baseline and endpoint.

Schools were asked to organise access to an ICT suite or sufficient individual devices such as tablets to enable all students in the intervention groups to complete the survey online in a single session. In practice, DI instructors occasionally found it challenging to organise online access to the survey for Year 7 students at the beginning of term when they had not yet been assigned computer access. Consequently, printable paper-based versions of the surveys were produced with exactly the same questions which were distributed to schools and, once completed by students, returned to the evaluators via secure courier. Of the 184 student baseline survey responses received, 156 were completed online and 28 completed via paper surveys. At endpoint, all 147 survey responses received were completed online.

Table 5 displays the achieved student survey sample that informed the analysis and findings in this report. Some issues were encountered with response rates to the survey at endpoint: no endpoint surveys were completed for one of the DI intervention groups as the DI instructor did not respond to the request and response rates across groups were generally lower as individual students were absent from classes due to illness and end-of-term activities. The sample of students whose individual responses could be matched at baseline and endpoint for the purpose of analysis was 128. This was lower than the overall number of responses at baseline and endpoint as students who answered less than one-third of the survey questions were removed from the analysis.

Table 5: Achieved sample—baseline and endpoint student survey

	Dispatched to (N)	Responses received (N)	Response rate (%)	Matched response rate (N)
Baseline survey (September 2019)	189	184	97	-
Endpoint survey (December 2019)	189	147	78	128

Fidelity and dosage monitoring

The original evaluation design planned for a fidelity log that would be completed by DI instructors during the pilot to capture data on:

- the lesson number and topic(s) covered of the CMC programme;
- duration of each lesson;
- individual student attendance (to explore variation in students' exposure to the intervention); and
- whether the lessons were delivered as prescribed or adapted.

The aims of the log were to assess whether the intervention was delivered as planned (with fidelity) and to provide data on the numbers of students participating to indicate the level of exposure (dosage) to the intervention.

During the development of the fidelity log and in consultation with Midland Academies Trust and NIFDI colleagues, it became evident that much of the fidelity data required was being collected as part of the internal programme monitoring. As part of programme implementation, DI instructors in pilot schools were asked to provide data to MAT and NIFDI to enable them to monitor delivery of the programme, and inform and tailor their support. Data was collected via a suite of existing monitoring forms that are used by NIFDI in supporting schools in the U.S. to implement DI programmes. These monitoring forms collected the following information:

- lesson number of CMC delivered—recorded on a 'Lesson Progress Chart', which included the details of the number of CMC sessions delivered each week and if any sessions were missed, as well as the CMC lesson in the series delivered in each session of that week; CMC covers topics in a set sequence so the lesson achieved indicates the topics covered;
- duration of lessons—a timetable of the length of maths lessons and the days of the week they were scheduled to take place;
- Independent Work Summary Charts—which recorded, for each student, the number of errors on independent work completed during the lesson, and if students were absent for the lesson; and
- Mastery Test Scores—which recorded, for each student, the score for each section of the test and the overall score.

In order to reduce data collection burden on schools, it was decided that the evaluation should utilise these existing sources of data to measure programme fidelity and dosage rather than ask schools to complete an additional evaluation fidelity log. This programme monitoring data was shared (in anonymised form) with the evaluation team. In addition, it was agreed with MAT that the most efficient way to collect individual student attendance data was at the end of the pilot via schools' normal lesson register systems (for example, School Information Management Systems, SIMS, which is used in most English schools). Coaches supported the DI instructors to securely transfer lesson attendance reports for maths to the evaluation team. Lesson attendance data was received for DI groups for five of the eight pilot schools.

However, this approach resulted in a degree of compromise in the type of fidelity and dosage data collected compared to that originally planned:

- the internal programme monitoring sources had limited data on adaptations in implementing the programme and the originally envisaged fidelity log was designed to ask DI instructors about this explicitly; and
- the internal programme monitoring data being collected by MAT and NIFDI did not include data on individual student attendance at each maths lesson, which the evaluation had hoped to collect.

Although an alternative approach was identified to collect student attendance data directly from schools based on their lesson registers on SIMS, the delivery team raised concerns about the validity of this student attendance data for the purpose of measuring dosage. This was due to a concern that registered attendance at a maths lesson did not necessarily mean that CMC had been delivered in that lesson. For instance, lessons may have been delivered by a cover teacher if the DI instructor was absent, or curriculum delivery may have been suspended in place of enrichment activities. The Lesson Progress Charts recorded the number of sessions delivered each week and dates of delivery of each session. However, it was not possible to analyse which students attended each CMC lesson as student attendance data did not include the date of lessons but rather the proportion of maths lessons attended by each student.

The fidelity monitoring and dosage data informing the findings of this report are, therefore, primarily based on evidence collated by MAT and NIFDI as part of the internal programme monitoring. The attendance data offers only limited insights but is used in the findings as a general indication of intervention dosage based on the average proportion of maths lessons that students attended during the term of the pilot.

Views on fidelity to the programme were substantiated during evaluation interviews with DI instructors, delivery team staff, coaches, and developers, plus through observations of delivery. Furthermore, the student maths attitude survey also asked students a series of questions about their experiences of maths lessons and maths teaching designed to explore their perceptions of whether they experienced the features of a DI classroom that we might expect (for example, whole-class teaching and practising learning until everyone understands).

In addition, schools were asked to provide the results of the placement testing to the evaluation team to enable evaluation of fidelity to placement-testing guidance and student selection to receive the intervention. This was received

for most schools, covering most of the CMC groups and students, but was not received for around a quarter of students from either schools directly, or indirectly via MAT.

Table 6 displays the achieved sample of fidelity data that informed the analysis and findings in this report.

Table 6: Achieved sample—monitoring and fidelity data

Timetabled duration of CMC lessons	CMC lesson in the series reached by end of pilot	Completion of mastery tests	Student attendance at CMC lessons*	Placement testing results	Total N students receiving CMC
✓ (8 schools)	✓ (8 schools)	✓ (8 schools)	✓ (5 schools; 89 students)	✓ (141 students)	189

***** As outlined in the above text, this data may not necessarily capture attendance at CMC lessons but rather attendance at mathematics lessons more generally. In addition, this data may not capture where CMC lessons were not delivered because DI instructors were out of school or normal lessons were suspended for activities such as whole-school events.

Student endpoint assessment

The evaluation included trialling a number of maths assessments with students who were receiving CMC, with the aim of informing the selection of a suitable assessment to use in a potential future efficacy trial to measure impacts of the programme on student maths attainment.

Hodder Education's Progress in Understanding Mathematics (PUMA) Key Stage 2 assessments were selected to pilot in this study due to their published validity and effectiveness as psychometric measures, correlation with KS2 National Curriculum test results, as well as the relative brevity of the test and ease of administration for teachers. The PUMA suite consists of three standardised tests per year across Key Stage 2; one test per term increasing in difficulty across the three terms. This assessment also enabled the piloting of more than one test from the series with comparability of results across tests due to the use of consistent content and style.

The CMC Level D programme is considered by the MAT team, who have used the programme in their own schools, to be roughly equivalent in standard to age eight to nine, Year 4 in England. The evaluation team selected from six PUMA tests that target students between the autumn term of Year 5 to the summer term of Year 6. This decision was based on the assumption that tests intended for the student's school year would be too difficult for them and that testing at the intervention's estimated start-point target age would be too easy.

The range of assessments was reviewed in consultation with the MAT team to assess the suitability of the tests for the Level D CMC students. The number of tests selected for trialling was also informed by the number of students receiving the intervention to ensure sufficient numbers of students could take each test to allow for meaningful interpretation of the results. Based on this, two tests were selected: PUMA Year 6 spring and Year 6 summer papers. The selected tests were administered randomly across the students in the eight pilot schools in December 2019 towards the end of the term of CMC.[13] The random allocation of tests was completed by an NFER statistician using the R statistical software programme and test papers were pre-populated with the student's name and provided to schools. The paper-based tests were then administered in schools by DI instructors with the support of MAT coaches, and standardised guidance drawn from the PUMA assessment teacher guide, along with instructions for organising and returning the tests. Test papers were securely transferred to schools and then returned to NFER once completed. The tests were marked by trained NFER markers under the supervision of the evaluation team's maths assessment lead. Schools were provided with feedback on the assessments based on the overall sample across all eight pilot schools, including the overall mean score on each test. Table 7 displays the achieved student endpoint assessment sample that informed the analysis and findings of this report.

[13] Random administration meant that each pilot school had some students who were asked to complete the spring paper and some who were asked to complete the summer paper.

Table 7: Achieved sample—student endpoint assessment

PUMA Year 6 spring	PUMA Year 6 summer	Total N students taking assessments	Total N students receiving CMC
N = 83	N = 77	N = 160	N = 189

School case studies and telephone interviews

Case-study visits were conducted to four of the eight pilot schools towards the end of the pilot. Case-study schools were selected to provide some variation in characteristics (for example, in terms of school size, proportion of students eligible for free school meals, Progress 8 performance) and delivery of the intervention. This was based on discussion with NIFDI and MAT coaches about progress with implementation and implementation contexts, such as size of intervention groups and role of staff delivering. Two case-study schools were re-visited following initial visits as part of observations of coaching and early delivery (see above, 'observations of programme delivery'); two schools were newly visited. In addition, telephone interviews were conducted with at least one DI instructor from the four other (not visited) pilot schools. This meant that interviews were conducted with at least one DI instructor from each of the eight participating schools.

Case-study interviews involved in-depth semi-structured interviews with a head of maths or senior leader, a DI instructor, and up to three groups of between four and six students participating in the programme. The interviews with staff explored their views on the programme aims, content, and delivery, student selection, the feasibility, ease, and challenges of programme implementation, level of fidelity and any adaptations, dosage and reach, perceptions of impact and student progress, and financial and in-kind costs incurred. Group interviews with students explored their attitudes towards maths and their views on the programme content and its impact on them. During each of the four case-study visits, observations of programme delivery to a Year 7, 8, or 9 class were conducted (as outlined above: 'observation of programme delivery'). Table 8 displays the achieved sample of school case-study and telephone interviews that informed the analysis and findings of this report.

Table 8: Achieved sample—school case-study and telephone interviews

Interviews with DI instructors	Interviews with heads of maths/senior leaders	Interviews with CMC students	Observations of CMC programme delivery
✓ (8)	✓ (4)	✓ (8 groups; total 29 students from 3 x Years 7 groups, 3 x Year 8 groups, and 2 x Year 9 groups)	✓ (4 schools) (observations of 6 DI classes covering Year groups 7, 8 and 9)

Data analysis

A statistical analysis plan (see Appendix K) was devised at project set-up stage to guide the analysis of the student maths attitude survey and PUMA maths assessments. This was reviewed and agreed with the EEF, MAT, and NIFDI as an annex to the evaluation plan.

Analysis of student maths attitude survey

Analysis of the student maths attitude surveys involved comparison of the matched sample of responses between baseline and endpoint to explore the extent of any change over time in individual students' views. The survey asked students to rate their responses, usually on five-point scales, for example, the extent to which they agreed or disagreed with a range of statements about their experiences of maths. The same questions were used at the start (baseline) and end of the intervention pilot period (endpoint). All statements were positively worded except one where the scale was reversed for the purposes of analysis. In all of the survey analysis, the responses of students who answered less than a third of the questions in the survey were removed from the analysis (N = 24).

Factor analysis was conducted on baseline survey responses and resulted in five factors that grouped together survey questions measuring similar constructs (see Appendix H for further details). For each of these factors, a 'score' was created based on the sum of students' responses on the question rating scales. In the analysis, 0 equates to 'neither agree nor disagree', a positive score equates to the agree/confidence options, and a negative score equates to the disagree/not confident options. In the findings sections below, the results of this analysis present the mean scores for

each factor at baseline and endpoint. We tested the level of significance of differences between students' mean responses to the survey at baseline and endpoint for each factor using paired t-tests to derive a p-value—a statistically significant p-value of 0.05 or less indicates that the probability of any difference occurring by chance is lower than 5%.

Items that did not load into factors or were not appropriate for factor analysis as they measured distinctive constructs (22 items in total) were analysed, and are reported in the findings below, as individual items. Analysis of these responses involved running a McNemar's test (chi-squared test for paired data) to compare students' responses at baseline and endpoint.[14] The analysis of these single items compared any change in responses over time by analysing the proportion of students whose individual views either stayed the same at both time points on the response rating scales (for example, an individual student rated that they were 'confident' at baseline and again that they were 'confident' at endpoint), or changed over time (for example, rated that they were 'not confident' at baseline, but 'confident' at endpoint).

Analysis of student maths attitude surveys was also conducted to explore the influence of a range of covariates on any changes in student attitudes to maths over time. Selected covariates included gender, year group, and treatment dosage, the latter categorised into three groups based on the number of the CMC lesson in the series reached by the end of the pilot: 'low' was defined as 14–17 lessons of CMC, 'medium' as 18–24 lessons, and 'high' as 25–30 lessons.[15] Factor scores at endpoint were the dependent variables in separate multilevel models containing two levels (school and student) with gender, year group, treatment dosage, and the baseline factor score as covariates in each model.

Questions that were asked only in the endpoint student survey were analysed using the statistical technique analysis of variance (ANOVA) to compare the means of students' responses depending on their gender, year group, and treatment dosage. The basic frequencies of these questions were also produced to reveal the patterns of students' responses.

There are limitations to the reliability of the quantitative analysis of the study as the sample was small. In addition, any changes in students' maths attitudes cannot be confidently attributed to the programme given the absence of the counterfactual (comparison to business as usual) and the inability to control for the range of influences on students' engagement and progress. Furthermore, due to small numbers of cases for some response options or within subgroup categories in some of the analysis, response options were combined (for example, 'very' and 'quite' confident). This meant it was more difficult to detect a shift in responses over time. For instance, it was possible that students became more or less positive over time but stayed within the same overall response category. Finally, a further limitation is that the baseline and endpoint surveys were only three months apart and therefore there may not have been sufficient time for a change in attitudes to manifest.

Analysis of student endpoint maths assessment

The analysis of the endpoint assessments included the distribution of raw scores from each test. The expected distribution profile for an assessment that effectively measures the target cohort is a 'normal' distribution of scores and would resemble a bell shape—with the majority of cases centred symmetrically around the middle value (the mean) of the scale with reducing numbers of cases in the extremities and no skewing to either end of the scale. The analysis of the endpoint assessments also included investigating the relationship between the placement test and endpoint measure to explore the suitability of the test as a baseline measure in a potential future trial. The analysis involved carrying out a multilevel regression model with two levels (school and student), the endpoint assessment score as the dependent variable, and the placement test score as a covariate. This was to explore if the placement test was a suitable prior attainment measure for the end-point assessment. If the placement test score had a significant effect on the endpoint assessment score, this would indicate that the placement test and endpoint assessment were comparable measures.

[14] This analysis was not detailed in the statistical analysis plan as it was not known at that stage which items would be compiled to create factor measures.

[15] Originally, it was envisaged that schools would deliver approximately 60 hours of CMC over the autumn term and reach CMC lessons in the range 40 to 60. The evaluation plan sets out the intended categorisation to measure any variation in the programme dosage: 'none' is defined as 0 hours, 'low' as 1–30 hours, 'medium' as 31–40 hours, and 'high' as 41 hours or more. However, during the analysis it was subsequently decided that a more accurate measure of students' exposure to the CMC programme would be the number of CMC lessons in the series they had received. This was because the number of hours of CMC was an estimate based on the length and number of timetabled mathematics sessions per week and did not necessarily reflect the number of CMC lessons students actually received. Furthermore, CMC lessons can be repeated, which means reduced exposure to the different lessons in the sequence and this would not be captured by a measure based on the number of hours of lessons. At the end of the pilot, schools submitted to MAT the CMC lesson number in the series they had reached.

Analysis of qualitative data

All interviews were recorded (following participants' verbal agreement) and written-up into templates based on the interview schedules, which were designed to explore the research questions. Analysis of qualitative data, including all interviews and observations, involved coding the data thematically (summarising the content of responses into conceptual categories) according to a framework of themes both emerging from the data and structured by the logic model and research questions. This enabled the summarised and coded segments of data to be mapped onto a matrix of evidence, structured on the research questions, and distinguished by respondent groups and school cases for further analysis. For each research question area, codes of responses and evidence were then analysed:

- across cases—to explore the range of responses across the pilot schools and prevalence of views and experiences;
- within cases—to explore the context for specific views and experiences (for instance, intervention group sizes, the role of staff delivering the intervention) and to triangulate views within each case; and
- between different respondent groups (delivery staff, school leaders, DI instructors, and students)—to explore the extent of convergence or divergence of their views in relation to specific areas of questioning.

Triangulating quantitative and qualitative analysis

All of the quantitative and qualitative analysis was then triangulated, drawing the evidence from all of the data sources together, to provide a comprehensive assessment of the effectiveness and perceived current and potential future impact of the CMC programme with KS3 students who are low-attaining in maths. We did this by identifying and mapping the research questions to the data collection methods that provided evidence on each question. A summary of how the different data collection strands were used to address each of the research questions is provided in Table 9.

Table 9: How data collections methods address different research questions

Data collection method	Research question	Indicator
Baseline and endpoint student attitude survey	1c, 1d, 1e, 1f	Change in students' self-reported attitudes, confidence, and knowledge.
	2i	Student perceptions of CMC maths lessons compared to normal maths lessons.
Observation of training (placement testing and CMC programme delivery training), coaching, and intervention delivery	2e	Participants engaged in the training and appear to understand the theory and requirements to enable them to deliver the placement tests and intervention.
	4a	Implications for a trial training model.
	1f, 2g	CMC lessons are delivered as scripted and for the recommended time. Key features of DI pedagogy are present in lessons (e.g. motivational system, feedback, choral response, and independent working).
	2h, 2i	Signs that staff and students are engaged in the lessons (e.g. the DI instructor is confident with the script, students appear to understand the content, and students can move forward with the content at a similar pace).
	2f	DI instructors engaged in the coaching and constructive feedback is provided by the coach.
Interviews with project managers, developers, coaches, trainers	2a–2h	High levels of school interest in the intervention reported, effective recruitment strategies, minimal challenges in implementation, staff engaged in the training and understand the programme theory and delivery requirements, placement testing and intervention implemented as intended.
	4a–4e	Challenges and issues with the intervention can be addressed; capacity of the delivery team built.
Fidelity monitoring	1f, 2g, 2i, 2h	Evidence intervention delivered as intended and most students attend each lesson.
Student endpoint assessment	3a, 4e	Effective measurement of maths attainment for the student target group.
School case-study and telephone interviews	1a, 1b, 2i, 2j	Staff perceive intervention as addressing need, staff and students have positive perceptions of the intervention and it compares

Data collection method	Research question	Indicator
		favourably to other maths lessons, students engaged by the intervention.
	1c, 1d, 1e, 1f, 4e	Staff and student perceptions of positive student outcomes; which students benefit most/least; no unintended/negative outcomes; identify beneficial features of the intervention approach and attribute to outcomes.
	2a, 2b, 4b	Staff would recommend the intervention to other schools and their reasons for engagement have been fulfilled .
	2c, 2h, 4a, 4c	Staff perceive only minor and surmountable challenges to implementation.
	2d, 2g	Staff report delivery and student selection as intended.
	2e, 2f	Staff report training, materials, and support as being effective (e.g. perceive the training as being high quality and materials enabled them to understand the intervention thoroughly and deliver the intervention as intended, coaching support is perceived as being timely and useful).
	2k, 4d	Staff identify affordable costs of the intervention.

Timeline

A timeline of activities related to the evaluation and intervention delivery is provided in Table 10.

Table 10: Timeline

Date	Programme delivery activity	Evaluation activity
April–May 2019	Project set-up meetings	Project set-up meetings; IDEA workshop; development of logic model and TIDieR framework
June 2019	Recruitment of schools (signed MoUs) Placement test training (remote, 2 x 1.5-hour sessions)	Observation of placement test training
July 2019	Additional 'mop-up' placement test training Schools administered placement tests (Years 8 and 9) Training for local delivery team coaches (coaching institute)	
August 2019	Two-day training workshop for DI instructors on delivering the intervention	Observation of programme training and interviews with trainers
September 2019	Schools administered placement tests (Year 7) Student selection and lists provided (Years 7, 8, and 9) Programme delivery starts Coaching visits to schools	Student selection and lists provided (Years 7, 8, and 9) Administered online baseline student maths attitudes survey Observations of initial coaching visits to schools
October 2019	Coaching visits to schools	Interviews with programme managers, developers, and trainers
November 2019	Coaching visits to schools	Case-study and telephone interviews with schools
December 2019	Coaching visits to schools Endpoint assessment administered Collation of monitoring information (MI) data Pilot ends	Case-study and telephone interviews with schools Endpoint student attitude survey administered Endpoint assessment administered Interviews with programme managers, developers, trainers, coaches

		Collation of monitoring information (MI) data
January 2020		Analysis
February 2020		Presentation of findings to the EEF, MAT, and NIFDI

Findings

Participants

Eight schools were involved in the pilot and a total of ten DI instructors delivered the CMC programme in schools to 17 groups of KS3 students—a total of 189 students. This was considerably fewer than the original target of 12 schools and up to 504 students. Reasons for this are explored in the following findings sections relating to recruitment and demand for the programme. However, there was no attrition of schools and very little attrition of students during the pilot study.[16] Table 11 displays the characteristics of the DI instructors and schools involved in the pilot and shows that there was some variation in terms of the schools represented in the study, particularly in terms of school attainment (reflected by Progress 8 scores) and levels of deprivation (indicated by the proportions of students eligible for free school meals (FSM)). This demonstrates that the pilot was undertaken in diverse contexts and included different types of schools.

Table 11: Selected characteristics of participating DI instructors and schools

DI instructor's role in school	N
Mathematics teacher	7
Learning support practitioner, assistant, or teaching assistant	3
Total	10
School type	N
Academy converter	6
Academy sponsor-led	2
Total	8
School age range	N
11–18 / 11–19	7
4–18 (all through)	1
Progress 8 score (2019)	N
Well above average	1
Above average	1
Average	3
Below average	-
Well below average	2
No data available	1
Total	8
% of students eligible for FSM	
0–10%	2
11–20%	2
21–30%	3
30–40%	1
Total	8
School Ofsted rating	
Outstanding	1
Good	6
Requires improvement	1
Total	8
School size (no. of students)	
Under 1000	1
1001 to 1200	3
1201 to 1400	2
1401 to 1600	1
1601 to 1800	1
Total	8

Source: NFER interviews with DI instructors 2019; Government Get Information About Schools website: https://get-information-schools.service.gov.uk/

[16] The pilot evaluation did not involve re-collecting student intervention lists at the end of the study. We estimate—based on a combination of sources of information, including interviews, internal programme monitoring data, survey, and endpoint assessment response rates—that in the region of six or fewer students ceased to receive CMC during the intervention period (for example, they were moved to another instruction group or left the school).

Acceptability and evidence of promise

This section assesses the strength of the evaluation evidence for the intervention's theory of change (ToC). The pilot sought to evaluate the application of the CMC programme in the specific context of English secondary schools with KS3 students who were low attaining in maths. The pilot evaluation was underpinned by a logic model that outlined the inputs, activities, and programme components and the short- and long-term outcomes and impacts that were expected to be achieved as a result of these (Figure). Hence, the logic model provides a summary of the underlying theory for how the programme components are expected to lead to specified outcomes and impacts and is reviewed in this report in a similar way to a ToC.

The findings of this section are presented against each of the key research questions exploring the acceptability and evidence of promise of the programme. This included:

- the perceived need for the intervention;
- the effectiveness of the approach;
- the perceived outcomes and unintended consequences or negative impacts; and
- the extent to which there was evidence to support the pilot logic model.

Q1a: Is there a need for the intervention?

The evaluation evidence suggests that pilot schools initially perceived the CMC programme as having the potential to address an identified need for suitable maths provision to support low-attaining students. In addition, they were enthusiastic to try the approach, despite only modest prior knowledge of DI. Some caution is required in extrapolating implications from these findings about the need for the intervention in schools more generally given the small and self-selecting sample of schools in the pilot.

Mathematics department heads, senior leaders, and DI instructors identified that the main need for the DI intervention was to address a gap in effective maths provision for students in low-attaining groups. They suggested that the target students had fundamental gaps in their basic maths knowledge from KS2 and were not ready to access the mainstream KS3 maths curriculum. Pilot schools reported a need for provision to help address these gaps and support students to catch-up with their peers. Some schools had tried alternative 'interventions' for this group with limited success; other schools had a bespoke curriculum in place in an attempt to bridge the gap. The DI approach appealed because of the focus on developing strong foundations in basic numeracy skills. Some interviewees also felt the approach could help to support students with SEN and speech and language difficulties, who can fall into low-attaining groups.

The DI approach appealed to interviewees in pilot schools because of the pre-existing evidence of its effectiveness. Some heads of department, senior leaders, and DI instructors noted their awareness of this prior evidence. This included examples of DI being used with success in other schools and in other subjects in their own school and knowledge of the evidence base from the use of the approach in the U.S. Heads of department, senior leaders, and DI instructors also explained that the DI approach appealed because it aligned with other evidence-based approaches, such as mastery and emphasis on recall to support retention of knowledge.

Potential DI instructors were usually approached by senior staff in their schools and asked to take part. DI instructors were either maths teachers or learning support practitioners such as teaching assistants. DI instructors were typically identified to implement CMC because of their maths subject knowledge, their experience of supporting low-attaining students, their openness and enthusiasm for trying new approaches, or because they were the designated teacher for the selected students. They typically had little prior knowledge of DI, although they all reported being interested and enthusiastic to learn a new approach. Only one DI instructor instigated involvement in the pilot themselves.

Q1b: What are staff perceptions of the effectiveness of the intervention?

Overall, the views of school staff regarding the effectiveness of the programme were mixed.[17] They highlighted both effective and less effective (or challenging) aspects of the programme in broadly equal measure. Indeed, all eight interviewed DI instructors, and some senior leaders interviewed, each identified a mixture of views about the

[17] School staff interviewees included interviewed senior leaders and heads of maths (N = 4) and DI instructors (N = 8).

programme—each identifying both positive and negative aspects. Table 12 displays these intervention aspects grouped into those that were more often considered effective by some or most interviewees, those that were more often considered less effective by some or most interviewees, and aspects where views were more varied across, and indeed within, interviewees' comments.

Table 12: Staff perceptions of the effectiveness of the programme

Effective aspects	Aspects with mixed views	Less effective aspects
Assessment and feedback Mastery Structure of the programme Motivation system Explanations of concepts	Choral responding Materials Placement	Lack of differentiation Content Extent of prescription Programme monitoring requirements

Aspects of the programme perceived to be the most effective

Assessment and feedback
Over half of school interviewees reported valuing the mastery tests and independent work for monitoring student progress and motivating students to reduce errors and improve their accuracy and efficiency.

Mastery
More than half of school interviewees mentioned that they liked the emphasis in the CMC programme on repeating and recapping concepts, correcting errors, and recalling with increasing accuracy and efficiency until students had mastered concepts and developed solid understandings before they moved on to new content.

Structure of the programme
Just under half of DI instructors commended aspects of the CMC programme structure including its gradual introduction, sequencing and interweaving of topics and focus on increasing the level of challenge, and reducing the amount of scaffolding and support from the instructor. This structure was valued for helping to develop the confidence of students who found maths challenging. One DI instructor explained: 'The structure and the scaffolds really lends itself to teaching lower ability or lower prior-attaining students.'

Motivation system
Half of DI instructors reported that the clear behaviour expectations in CMC and the student and teacher points game worked effectively in managing behaviour and encouraging student participation. Some interviewees noted the additional benefits of linking the student/teacher points game with the school's rewards and sanctions policy (for example, merit system).

Explanations of concepts
Just under half of DI instructors noted the effectiveness of the explanations of concepts in CMC which were very clear, simple, and accessible for learners who found maths challenging and offered alternative explanations to those traditionally used which might have been ineffective in the past. Examples included place value and 'big number and small number' for additions and subtractions.

Aspects of the programme with mixed views

Choral responding
Choral responding was valued by around half of school interviewees as an efficient means of quickly gauging student understanding and of actively engaging all students in answering questions. Around half of interviewees had an opposing view and reported frustration at the emphasis on students having to respond in unison, which at times prevented the lesson from moving forward when students did not fully participate (this also relates to the issue explored in the section below on 'extent of prescription', page 34). Several DI instructors noted that they had more success with this approach when combined with individual turns as a means of students responding, and indeed the CMC programme training encouraged DI instructors to follow choral responses with individual turns.

Materials
Most school interviewees regarded the CMC resources as being of high quality and accessible. It was helpful for students to have their own copies of workbooks and see how answers should be set out correctly. One DI instructor said: 'I think it's beautifully resourced.' DI instructors also reported the advantage of having pre-written lesson materials; this saved time preparing and ensuring the quality of resources. However, some issues were identified with the CMC

materials including the U.S. terminology (for example, monetary references) and insufficient extension materials and homework resources.

Placement
Three interviewees noted that the placement test had effectively placed students in the programme and provided them with an appropriate level of challenge. However, several other school staff commented that there was insufficient challenge for students in the CMC programme, even for those who placed at Level D. This led to concern about parental complaints about the simplicity of work such as single-digit addition and subtraction. Occasionally, DI instructors commented on the ability range of the students who placed in the CMC group and questioned the scope of the placement test for diagnosing student ability levels, advocating the need for additional teacher assessment and professional judgement. Further information about the placement testing process is provided in the section addressing Research Question 2d (page 44).

Aspects of the programme perceived to be less effective or challenging

Lack of differentiation
This was a recurrent issue raised by all DI instructors as a substantial challenge in implementing the programme. Because of the whole-class teaching approach and the emphasis on error corrections and repetition until all students understood and responded as expected, DI instructors found the learning was restricted to the pace of the slowest learners in the group, and in timed activities this was particularly noted. There were indications that students who finished independent work quickly had to wait for up to several minutes with nothing to do until all students had completed the work. In some cases this may have been an issue of fidelity to the programme as the CMC Level D teacher's guide suggests that instructors should stop independent work to mark it with the group when the middle performing students have completed the work rather than wait for the lowest-performing students (Engelmann *et al*., 2013). School staff noted that this was different to usual teaching practices in which teachers provided extension activities for the more able and faster students. Interviewees commented that, even among students who placed at Level D, there was still a considerable range of abilities and rates at which students could process the content. These DI instructors explained this issue:

> '*If there's a student who understands it, there's not really room for them to move ahead. They have to wait for everybody else to understand it*.'

> '*I feel like the CMC course is focusing mainly on the bottom end*.'

To address this issue, at least five DI instructors reported using extension activities and resources either within class or as homework (or both). Some DI instructors reported creating their own such resources and others used CMC 'maths fact worksheets'[18] as extension activities, although there was some mixed understanding as to whether it was compliant with the programme to allow students to complete these independently in class and as homework, and some concerns about the questions being too easy. The message from DI instructors was clearly that, in order to more effectively meet the needs and abilities of different students in their groups, they would value greater use of extension resources within the programme to offer students more opportunities to practise learning, to stretch higher-attaining students, and provide additional tasks that students could complete independently of teacher direction both within class and at home.

Content
The content of the CMC programme was also a concern for around half of the school staff consulted, particularly the heads of maths and senior leader interviewees. This included two related issues. Firstly, a perception that the programme included too much repetition and insufficient new content. Secondly, a concern that the content did not align with the maths topics that needed to be covered as part of the KS3 National Curriculum and to prepare students for the journey on to the KS4 GCSE curriculum. One head of maths/senior leader suggested students on the CMC programme had missed a 'massive chunk' of the required curriculum. Because of this difference in content and the way maths concepts are explained in CMC, some staff questioned whether students' learning from CMC would be transferable and applicable when the students returned to their normal maths programmes of study. To counter this, one school had re-written the KS3 maths schemes of work to cover the content that had been missed during the pilot. The misalignment

[18] Maths Fact Worksheets are worksheets linked to the programme of lessons for each level of CMC. They can be used in addition to the scripted lesson activities at the instructor's discretion. They are designed for use in the classroom to recap maths concepts already introduced in the series. The instructor supervises completion of the worksheets within a specified time limit and then talks the students through marking and correcting their work (McGraw-Hill Companies Inc. (2012) *Connecting Math Concepts: Comprehensive Edition – Level C Math Fact Worksheets*. Columbus: McGraw-Hill Education).

of content was particularly pertinent for Years 8 and 9; there was closer alignment of CMC content with the Year 7 curriculum, which was one reason why some interviewees suggested that the programme was most suitable to this latter year group. Interestingly, in one pilot school, the normal programme of maths for low prior attaining students focused on core number skills and this provided a better alignment with CMC.

Extent of prescription

More than half of interviewed school staff reported that the extent of prescription in the CMC programme was challenging. This particularly related to the choral responding aspect as well as error corrections and the specific way students needed to respond, which could be confusing (for example, students were required to say the problem initially without the answer but wanted to give the answer straight away). Where students gave the answer in the wrong format but had understood the maths, DI instructors had to repeat the question, which created instances of frustration and low-level behavioural issues among students.

Interviewees also suggested that the highly explicit and prescriptive nature of CMC could mean that students struggled to apply the learning from the programme to other contexts where the problem was not presented in the same format. Some DI instructors implied that the programme was more effective for them when they used a more balanced and varied combination of choral responding and individual turns, used their discretion about when the students had understood and were ready to move on, and incorporated some broader discussion of maths concepts to enhance understanding and application.

Programme monitoring requirements

Most DI instructors found the level of programme monitoring onerous. They valued the purpose of the programme assessments for tracking student progress, providing formative insights, and informing student feedback, however, they suggested the recording of marks and monitoring of lesson progress increased their workload, was confusing and inefficient, and not always purposeful in aiding their delivery (although several acknowledged the additional purpose of monitoring required as part of piloting the programme). Marking students' independent work and mastery test answers, and recording these in the respective charts, is a feature of the CMC programme as the assessments are designed to inform subsequent teaching (for example, elements of the programme may need to be repeated if students have made errors). However, submitting this information to MAT or NIFDI, along with details of lesson progress and scheduling, was an additional programme monitoring requirement as part of the piloting of the programme and provision of implementation support.

Q1c: Is there preliminary evidence that the intervention has impacted on students?

This section explores the perceptions of school staff and students of the perceived impact of CMC on students. Data is drawn from survey responses and interviews. It covers impacts on students':

- confidence in maths understanding and ability;
- maths motivation and enjoyment;
- maths progress; and
- behaviour in maths lessons.

Students' confidence in maths understanding and ability

The analysis of survey responses indicated that students rated their confidence in maths understanding and ability significantly higher at the end of a term of CMC than at the beginning ($t = 6.27$, $p \leq 0.05$). More students agreed 'a little' or 'a lot' with the statements that make up this factor at endpoint than they did at baseline. Table 13 displays these results.

Table 13: Student survey—impact on students' confidence in maths understanding and ability

Factor	Survey items	Mean factor score BL* (standard deviation)	Mean factor score EP** (standard deviation)	T-value	P-value (0.05)
Confidence in maths understanding and ability	I am confident at maths; I understand most of the work in maths; I learn things quickly in maths; I am doing well in maths; I feel good when I can do difficult maths problems	1.34 (4.98)	3.83 (4.88)	6.27	<0.05

Source: NFER baseline and endpoint survey of students, September–December 2019; N = 128.
* Baseline. ** Endpoint.

The surveys also asked students about their confidence in their understanding of nine maths topics. Students were significantly more confident in their understanding of the topics of addition and counting at endpoint than they were at baseline. While there were also small improvements in some of the other maths topic areas, there were no significant changes over time for any of the other seven maths topics (Table 14).

The analysis of these single items compared any change in responses over time by analysing the proportion of students whose individual views either stayed the same at both time points on the response rating scales (columns two and three in Table 14) or changed over time (columns four and five). As noted, the analysis is limited by the small sample size as response options had to be collapsed, meaning it is more difficult to detect any shift in responses over time.

Table 14: Student survey—impact on students' confidence in understanding maths topics

How confident are you in your understanding of the following maths topics…?	% confident at BL and EP	% not confident at BL and EP	% confident BL, not confident EP	% not confident BL, confident EP	N	Statistically significant change (p≤0.05)
Fractions	26	47	10	17	126	0.23
Measurement	52	18	14	15	125	1
Equations	30	34	17	19	120	0.761
Addition	82	4	2	12	125	<0.05
Subtraction	83	2	7	7	121	1
Counting	81	3	1	15	125	<0.05
Money	67	11	7	15	127	0.090
Multiplication	71	10	7	11	125	0.405
Division	43	27	13	16	123	0.618

Source: NFER baseline and endpoint survey of students, September–December 2019. Percentages may not sum to 100 due to rounding. BL = baseline, EP = endpoint.

Further questions, asked only in the endpoint survey, also revealed modest positive impacts of the CMC programme on students' understanding and confidence in maths. Table 15 shows that around half of students thought that the programme had helped them understand maths better and become more confident at maths. However, these positive indications are balanced by a similar proportion of students indicating that the programme helped in these ways only 'a little' or 'not at all'. Furthermore, it is difficult to contextualise these responses in the absence of a comparison group to collect the views of students who did not receive the CMC programme. The following section regarding Research Question 1d (page 38) explores some of the variables that may account for the difference in the extent to which students found the CMC programme helpful.

Table 15: Student survey—impact on students' maths understanding and confidence

Has the new maths programme you used this term…	Not at all / a little % (N)	Quite a lot / a lot % (N)	N
…helped you understand maths better?	51 (72)	49 (68)	140
…made you more confident at maths?	44 (62)	56 (78)	140

Source: NFER endpoint survey of students, December 2019. Percentages may not sum to 100 due to rounding.

In interviews with school staff and students themselves, there were also accounts of positive impacts of the CMC programme on students' maths confidence and understanding. All DI instructors and senior leaders interviewed reported improvements for at least some students' confidence since starting CMC. They noticed students were coping better with the work in maths, were more capable of volunteering answers to questions, and more readily recalled and connected different maths concepts. DI instructors also explained that students understood maths concepts better due to the clear explanations, repetition, and structure of the CMC programme, which gradually builds related concepts. Several interviewees described such impacts:

> *'Compared to, for example, my bottom set [Year] 7s last year, there is definitely more confidence, and there are fewer people who come in at the start of the lesson saying "I can't do maths"' [DI instructor].*
>
> *'I think it is very well geared to allowing the students to achieve which is lovely because I love to see them when they have got everything right and they have got 100 per cent' [DI instructor].*
>
> *'I think that high level of over teaching helps to consolidate' [head of maths/senior leader].*

Some students themselves also identified having more confidence in maths and better understanding since starting CMC, as these students explained:

> *'…confidence to shout it out gets me more confident, but I'll be even more confident in six months' [Year 7 student].*
>
> *'You say it out loud and you hear other people saying it, it just gets stuck in your head' [Year 9 student].*

Students' maths motivation and enjoyment

The surveys explored students' views about their motivation for, interest in, and enjoyment of maths, as well as questions about how relevant they perceived maths to be for daily life and getting a job in the future. The survey also included a question about general attitudes to school to provide context for students' views about learning maths more specifically. These items were combined to create the factor measures 'maths motivation', 'relevance of maths', and 'school motivation'.

As can be seen in Table 16, there were no significant differences in students' survey responses at baseline compared to endpoint for either of the factors 'maths motivation' or 'relevance of maths', which suggests that, after a term of CMC, students' motivation for maths and their perceptions of the relevance of maths were unchanged. Direct impact on students' perceptions of the relevance of maths was not anticipated in the pilot logic model though is a relevant attitude to explore as it could be related to students' maths motivation, and it is interesting to note a slight deterioration in students' attitudes between baseline and endpoint, although not significantly so.

Students' attitudes to school in general declined significantly between baseline and endpoint ($t = -3.03$, $p \leq 0.05$) as can be seen in Table 16 in relation to the factor measure 'school motivation'. This trend of reducing engagement after primary school and as age increases is highly typical and widely reported in other literature. This general trend of declining motivation towards school creates a challenging context to improve motivation towards specific subjects and may account, at least in part, for students' static motivation towards maths over the course of the pilot.

Table 16: Student survey—impact on students' maths motivation

Factor	Survey items	Mean factor score BL (standard deviation)	Mean factor score EP (standard deviation)	T-value	P-value (0.05)
Mathematics motivation	I enjoy learning maths; I want to do well at maths; I find maths interesting; I like coming to school when I have a maths lesson.	2.97 (3.87)	2.95 (3.86)	-0.04	0.97
Relevance of maths	I think learning maths will help me in my daily life; I need to learn maths because	2.68 (2.62)	2.28 (3.00)	-1.56	0.12

	it will be useful for getting a job; I would like to do a job that involves maths.				
School motivation	I like school; I am keen to do well at school; I am interested in what I learn at school.	3.19 (2.85)	2.46 (3.19)	-3.03	<0.05

Source: NFER baseline and endpoint survey of students, September–December 2019; N = 128.

Qualitative evidence from interviewees regarding the impact of the programme on student maths motivation was mixed. Two-thirds of school staff suggested that some students were displaying signs of enjoying the CMC programme and were more motivated in CMC lessons compared to normal maths lessons, particularly because of the level of participation required and the clear expectations of the lesson. One head of maths/senior leader explained the positive impact on students' maths motivation:

> '*The students are a lot more engaged. They know where they are going with the lesson and they are comfortable to try, even if it is a mistake, they are very, very comfortable to put their hand up. The kids are a lot more focused.*'

Conversely, half of interviewed DI instructors reported some issues with student motivation (discussed further in the sub-section on Research Question 2i in relation to student engagement).

Students' perceived maths progress

There is tentative evidence to indicate modest positive impacts of the CMC programme on students' progress in maths. Firstly, in response to a question asked only to students in the endpoint survey, over half of students thought the programme helped them do better at maths (Table 17). However, this finding is tempered by two-fifths of students who responded that the programme had only helped a little or not at all.

Table 17: Student survey—impact on students' maths progress

Has the new maths programme you used this term…	Not at all / a little % (N)	Quite a lot / a lot % (N)	N
…helped you do better at maths?	41 (57)	59 (83)	140

Source: NFER endpoint survey of students, December 2019. Percentages may not sum to 100 due to rounding.

School staff interviewees also reported that the CMC programme helped students to make progress in mastering the basic numeracy skills of addition, subtraction, and multiplication. A particularly noted aspect of progress was in the students' increasing efficiency and automacy in solving maths problems. This was noted to have the potential to reduce the processing and metacognitive demands required of students when they were faced with more challenging maths problems in the future. One DI instructor explained this impact:

> '*Some of my Year 8 students who I've known and worked with in small groups before who are weak and one of them is autistic, I can see and I'm very impressed with just how much it is automatic to them now, that things they struggled with before, they can just do. So, I can see it working*.'

Some students also reported benefits of the CMC programme on their sense of progress in maths learning, as a comment from this Year 8 student exemplified:

> '*I think I am doing very good because when I get my results, when I mark all the questions and see the total score that I got I can say that is an improvement, that is progress.*'

One-third of school staff interviewees felt that there had been insufficient time during the pilot to monitor the impacts of the programme, particularly on students' progress, so they were reticent to comment.

Student behaviour in maths lessons

As can be seen from Table 18, there was no statistically significant difference in students' views of class behaviour in maths lessons at baseline compared to endpoint. However, the survey also asked students about their perceptions of their *own* behaviour in maths lessons and the analysis indicated that some students' views changed in a negative direction over time (these findings are discussed in relation to Research Question 1e below). While these findings present a somewhat inconsistent message, when coupled with qualitative insights from DI instructors and students, they do raise some concerns about potential behaviour issues in response to CMC.

Table 18: Student survey—impact on students' maths class behaviour

Factor	Survey items	Mean factor score BL (standard deviation)	Mean factor score EP (standard deviation)	T-value	P-value (0.05)
Class behaviour in maths lessons	My maths teacher makes sure all students are concentrating in lessons; students listen to what the teacher says in maths lessons; there is often noise and disruption in maths lessons.[19]	1.52 (2.42)	1.18 (2.3)	-1.23	0.22

Source: NFER baseline and endpoint survey of students, September–December 2019; N = 128.

Half of the DI instructors experienced challenges with students' behaviour in maths lessons during implementation of CMC, including resistance to participate in choral responding and minor disruption (explored more fully in subsections on Research Questions 2c and 2i, pages 43 and 50 respectively). However, feedback from school staff interviewees, reports from NIFDI and MAT coaches, and evidence from monitoring information (including that sessions continued to be delivered in all schools with progression through the series of CMC lessons recorded as well as independent work and mastery tests completed) indicated that these challenges were generally surmounted. Over the course of the pilot, DI instructors reported feeling more confident in delivering the CMC programme and the NIFDI trainer and MAT coaches provided strategies to help instructors to address student behaviour issues. These included altering the classroom layout and seating plan and greater use of the motivation system.

Q1d: Are there any differences in emerging student outcomes by gender or year group?

Analysis indicated that students' survey responses varied according to their year group and, to some extent, the number of CMC lessons in the series they had experienced (as an indication of dosage).[20] However, we found no differences in students' survey responses by gender.

This subgroup analysis explored the covariates year group,[21] gender,[22] and CMC dosage[23] on the dependent variables:

- five survey factor scores at endpoint—confidence in maths understanding and ability, maths motivation, relevance of maths, class behaviour in maths lessons, and school motivation; and
- endpoint only questions—whether students liked or disliked the approach and some of its key aspects and whether or not it helped them to learn maths.

For the analysis of factors, this involved multilevel models to explore the influence of the three covariates on any changes in students' attitudes to maths over time as measured by the five factors. For the analysis of endpoint only questions, the analysis involved a chi-squared test for the gender variable and a Goodman-Kruskal gamma statistic for the year group and treatment dosage variables (as these are ordinal data).

The multilevel model analysis of survey factor scores indicated that, whilst holding all other covariates in the model constant, Year 8 students' confidence in their maths understanding and ability at endpoint was significantly lower than Year 7 students, with an effect size of -0.40 (-0.75, -0.06). Although Year 9 students' confidence was also lower than

[19] As this item was negatively worded, responses were reversed so that a positive response to this item became a negative score in the analysis.
[20] Dosage was categorised into three groups: 'low', 14–17 lessons of CMC; 'medium', 18–24 lessons; and 'high', 25–30 lessons.
[21] Year 7: N = 50; Year 8: N = 38; Year 9: N = 29.
[22] Female: N = 56; male: N = 61.
[23] Low: N = 41; medium: N = 36; high: N = 40.

Year 7 students' at endpoint, the difference was not significant. Furthermore, the multilevel model analysis indicated that, whilst holding all other covariates in the model constant, Year 8 students' maths motivation at endpoint was significantly lower than Year 7 students, with an effect size of -0.50 (-0.96, -0.05). Again, although Year 9 students' maths motivation was also lower than Year 7 students' at endpoint, the difference was not significant. Lastly, Year 8 and Year 9 students were significantly more likely to be negative about class behaviour in maths lessons at endpoint than Year 7 students: Year 8 effect size -0.42 (-0.81, -0.05) and Year 9 effect size -0.56 (-1.06, -0.09). The full results of this multilevel model analysis are displayed in Appendix L.

The analysis of endpoint only questions also indicated variation in students' attitudes by year group. Year 7 students were significantly more likely than their peers in Years 8 and 9 to respond that the CMC programme had helped them to understand maths better ($x^2 = 7.03$, $p \leq 0.05$). Year 7 students were more likely to respond positively about this, whereas Year 8 and Year 9 students were much more divided in their views and more likely to be negative. This pattern was also noticed in relation to questions about whether the programme helped students do better at maths and be more confident in maths—although the differences were not sufficiently stark as to reach the level of statistical significance.

These are interesting findings and add weight to the qualitative evidence that the CMC programme may be better suited to Year 7 students. However, the findings should be interpreted with caution as students tend to have declining attitudes to learning as they get older.

The analysis also indicated that, whilst holding all other covariates in the model constant, in terms of programme dosage, students who had reached a 'high' number of CMC lessons were significantly more likely to become more positive between baseline and endpoint about class behaviour in maths lessons, with an effect size of 1.12 (0.66, 1.68), than students who received low dosage. Although the attitudes of students who received a medium number of CMC lessons also became slightly more positive at endpoint compared to students who received a lower number of CMC lessons, this difference was not significant. This could suggest that as students progress through the CMC programme class behaviour can improve, a finding that also aligns with the qualitative evidence that issues with student behaviour reduced over the course of the pilot.

There was some suggestion from interviewed school staff that younger, lower-prior-attaining students (that is, the lower-attaining placed students) and students with English as an Additional Language (EAL) benefited most from CMC. This related to the content (focus on basic numeracy skills, which aligned most closely with the curriculum for younger students), repetition, the explicit instruction, clarity of explanations and simple language, and some aspects of the format, such as choral responding.

Q1e: Do there appear to be any unintended or negative consequences associated with the intervention?

The analysis of students' survey responses found that some students' attitudes to their own behaviour in maths lessons changed significantly in a negative direction between baseline and endpoint. As shown in Table 19, the analysis of this single-item survey question indicated that although the majority of students were positive about their behaviour in maths lessons at both time points, a fifth of students (19%) who agreed that they behaved well in maths lessons at baseline subsequently disagreed with this statement at endpoint. This is a concerning finding and may reflect some of the issues reported qualitatively by DI instructors and students about behaviour and engagement in CMC lessons (explored more fully in subsections on Research Questions 2c and 2i, page 43 and 50 respectively). A further possible explanation is that the behavioural expectations set out in the CMC programme and reinforced by the motivation system—predominantly, for students to respond in unison at the DI instructor's signal—may have influenced students' perceptions of their behaviour if they were not always compliant with these particular expectations.

Table 19: Student survey—impact on students' behaviour in maths lessons

How much do you agree or disagree with these statements about behaviour in your maths lessons?	% agreed at BL and EP	% disagreed at BL and EP	% agreed BL, disagreed EP	% disagreed BL, agreed EP	N	Statistically significant change (p≤0.05)
I behave well in maths lessons	66	7	19	8	127	<0.05

Source: NFER baseline and endpoint survey of students, September–December 2019. Percentages may not sum to 100 due to rounding.

The analysis of students' survey responses found no other evidence of negative consequences of CMC on the outcomes measured.

Occasionally, school staff and student interviewees identified negative impacts of CMC on engagement, enjoyment, and progress. Primarily, this related to a perception that the Level D programme was too easy and repetitive, with limited scope for differentiation and therefore it was not sufficiently engaging and challenging. In a couple of cases, this issue appeared to be exacerbated by having a mixture of placement levels in the group. However, this was also thought to be an issue for some students who were correctly placed at Level D. As one DI instructor explained:

> '*My concern is that I have students at the top end who are being held back. Yes, I know they're consolidating their knowledge, but my concern is that at the top end they're being held back by the bottom end*.'

Students were a little more likely than staff to report no or negative impacts. This was because students felt the programme was too easy and repetitive. As these students described:

> *'We already know this type of stuff. I did this in Year 4, 5, and 6. Then there's other year groups that are doing harder stuff. They talk about it and it just makes me think, "I want to do harder stuff. I don't want to keep doing adding, subtracting in Year 9"' (Year 9 student).*
>
> *'I do that work easily and it is not hard so I don't really feel like I am learning much because I already know [it]' (Year 8 student).*
>
> *'I feel like I have double-backed on myself because at one point I am feeling like I am improving because I am getting all the answers right but when I actually think about it logically it is like I am not doing good because it is work that I have been doing a long time ago. It doesn't really help me, it is like I've just taken five steps forward and ten back' (Year 8 student).*

Interestingly, some DI instructors suggested that students might not have been aware of the progress they were making because of the limited volume of new content per lesson, the incremental structure of the programme, and the emphasis on mastery and proficiency—and this could account for the different perceptions of DI instructors and students.

Finally, in one case, a head of maths/senior leader reported an adverse impact of the programme on other students who were not placed in the CMC group because they had a larger class and a non-specialist teacher due to the CMC programme group size and placement requirements.

Q1f: Is there evidence to support the logic model?

There is evidence to support some, though not all, elements of the pilot logic model (Figure 2).

There is evidence that the project inputs and activities were delivered largely as planned and were considered valuable and appropriate to support implementation of the programme in pilot schools (see full discussion of this evidence below in relation to Research Question 2e and 2f). The main difference was that additional coaching visits to schools were provided to support implementation. The evidence indicates that, while additional visits were valued, it would not be necessary to sustain intensive coaching support beyond the initial implementation period—that the intensive support initially (for example, weekly or fortnightly coaching support and contact) could be reduced substantially over time and focus on the specific needs of DI instructors.

There is also evidence that the programme was implemented with a reasonable level of fidelity; that most of the key CMC classroom features and outputs, as stipulated in the logic model, were implemented. Adaptations to these requirements related primarily to shorter than planned lesson times and reduced dosage overall (see evidence in relation to Research Question 2g, page 45) as well as some occasions of students incorrectly placed to receive the programme (see Research Question 2d, page 44).

However, staff and students did raise concerns that certain aspects of the programme might not be appropriate for the target children nor for the English context. These concerns related to the appropriateness of the programme in helping KS3 students to catch-up and then be in a position to return to the mainstream, age-appropriate maths curriculum and assessment. Particular challenges identified were

- the effectiveness of student placement;
- whole-class teaching (which limited the scope for differentiation);
- the lack of alignment of content with the National Curriculum and assessment requirements in England; and
- the extent of prescription and repetition relating to the DI classroom features of repetition, choral responding, and scripted lessons.

DI instructors' and students' views that the programme may have held back the progress of more able students in the intervention groups is particularly concerning. The challenges identified in the pilot might suggest that further investigation is required in order to both enhance the feasibility of the implementation of the CMC programme with this target group, and also explore the impact on student attainment after the reintegration of students back into mainstream maths provision following the highly distinctive and prescribed CMC approach. There is also evidence from the evaluation indicating that CMC may be more feasible in some contexts than others; it was more easily implemented in a couple of schools that already had a bespoke curriculum and/or small class sizes in place for students who were lower-attaining in maths.

There is preliminary evidence of positive outcomes on students' confidence in their maths understanding and ability, in particular, confidence in addition and counting as well as a self-reported positive impact for over half of students on how well they are doing in maths (see Research Question 1c). There is tentative evidence, from the student survey and interviews with school staff, that the Level D CMC programme was more beneficial for Year 7 students' maths learning, although the analysis is too limited to draw firm conclusions. There is also some evidence from discussions with school staff and students that CMC features led to some shorter-term positive outcomes on students (for example, confidence). This particularly includes features such as feedback, independent working, mastery, structure, consistent procedures, and motivation system. However, there is less evidence to indicate positive outcomes on students' mathematics motivation and engagement, and mathematics class behaviour, and potential of negative impact on students' own behaviour in mathematics lessons.

Staff interviews suggested that the programme has contributed to short-term positive outcomes for the teachers and school staff involved in terms of their understanding of the DI method, confidence in its use, and effectiveness and interest in using DI. All DI instructors interviewed as part of the evaluation reported that there were ideas from the CMC programme that they could adapt to enhance their own practice. Examples included some of the explanations, the programme structure and scaffolding, the emphasis on recall, and use of choral responding as one approach in a range of formative assessment approaches.

The pilot programme has thrown up issues that should be explored before going to a larger trial. The elements of the programme that were found to be challenging or less effective cannot be readily changed without the risk of diluting and modifying the DI approach and CMC programme, which has been developed in light of field-testing and evaluation research in the U.S. The evaluation evidence may indicate the need to review:

- the implementation approach—for instance, enhancing aspects of fidelity such as more accurate placement and ensuring an appropriate level of challenge for all students, perhaps with the provision of programme resources for students who finish independent work quickly, as well as considering timetabling, grouping, and staffing to deliver the programme;
- the targeting of this programme with KS3 students across Years 7, 8, and 9—the programme may be more suited to upper primary age, for which it was designed, or Year 7 students;
- whether a different intervention could be considered that draws on the elements that have been more effective—for instance, the programme structure, emphasis on mastery, feedback, and assessments and alternative explanations for maths concepts—and may be more suited to the English context, curriculum, and pedagogical culture; and
- whether a programme should be offered as a replacement for normal maths lessons or an additional intervention, or a hybrid of these models of implementation.

These points are revisited in relation to Research Questions 4a and 4e in considering the programme's readiness for trial.

Feasibility and scalability

This section presents the evaluation findings in relation to feasibility and scalability. The findings are presented against each of the key research questions, grouped into the following themes:

- demand for the programme and recruitment;
- feasibility and fidelity of delivery;
- staff training, materials, and support;
- staff and student engagement; and
- costs to schools to implement the programme.

Demand for the programme and recruitment

Q2a: Has there been sufficient demand from schools for the pilot?

The local delivery support team reported that schools approached during recruitment were interested in the programme and identified a need for provision to support the target group of students. They perceived that schools were attracted to the pilot as DI is a common topic of discussion (for instance, on Twitter), is gaining interest, has a substantial evidence base, and aligns with schools' current interests. This perception closely mirrors the reasons that school staff gave during interviews for being attracted to participate in the pilot.

However, not all schools that expressed initial interest went on to participate and the pilot secured fewer schools to participate (eight) than originally planned (12) indicating that there were difficulties in recruitment. The local delivery team interviewees suggested that this was due to schools' concerns about how to timetable, staff, and group students for the programme as a replacement for normal maths lessons and insufficient lead-in time to make such arrangements. There was some indication that schools may have preferred the opportunity to implement the CMC programme as an additional intervention, rather than as a replacement for normal maths lessons, to mitigate these challenges and ensure coverage of the National Curriculum.

Interviewees from all eight schools identified interest in continuing to use CMC. However, all identified the need for modifications to the pilot implementation—albeit to differing degrees—and the need for further evidence and review with colleagues before they could commit to embedding the programme. Modifications were suggested around:

- the target year group—three schools were considering continuing with a Year 7 and/or Year 8 group (but two schools intended to stop delivery to older year groups);
- one school was considering the grouping and ability level to target the lowest ability students only;
- two schools were exploring the use of DI principles but with content aligned to the National Curriculum; and
- two schools were interested in offering CMC sessions as an intervention in addition to, rather than as a replacement for, normal maths lessons.

Where schools were ceasing to deliver CMC or suggesting modifications, this was due to concerns both about the scope for differentiation (that more able students in the groups were being held back) and content—that students on the CMC programme were missing crucial National Curriculum content and could struggle to transfer the learning from the CMC programme once reintegrated back to the National Curriculum. One school had firmer plans to continue the delivery of CMC for at least the remainder of the academic year and it was exploring opportunities to continue to receive MAT coaching to support effective delivery.

There was some discussion from the delivery team and school staff as to whether CMC would work most effectively in English schools as a replacement or intervention, and issues were identified with each approach. The concern with running CMC as a replacement was that students would miss important National Curriculum content. The concern with running CMC as an intervention was that this would involve withdrawing students from other subjects and therefore risk narrowing the curriculum. One issue—discussed more fully in relation to Research Question 4e—is that the CMC programme has not been designed to be implemented as an intervention.

Q2b: Have recruitment methods been effective?

Recruitment to the pilot was via the local delivery team's existing networks and the local DI training hub, as planned, and it took place between April and June 2019.

While eight schools were successfully recruited, there were reports from across all interviewee groups of some challenges during the recruitment process and aspects about the programme requirements that required earlier clarification. This lack of clarity of information and insufficient lead-in time during recruitment led to issues with attendance at training and, in the case of one school, issues with implementation. This school implemented the programme as an intervention in addition to normal maths lessons, rather than as a replacement, as they signed-up to the pilot late and did not have time to staff and timetable the programme as a replacement.

Recruitment to a future trial would be aided by providing more lead-in time for schools to plan for the programme and make the necessary timetabling, staffing and grouping arrangements as well as providing more clarity about the programme requirements and levels available. The delivery team also suggested that primary schools may be interested in trialling CMC and that schools may be attracted to participate if they are able to offer more levels of the programme.

Feasibility and fidelity of delivery

Q2c: Is the intervention feasible to deliver in schools?

Both delivery team and school staff reported some challenges related to the logistics of delivering the CMC programme. These were primarily associated with timetabling and staffing groups according to the placement test and class size restrictions. These challenges were reported in just over half of the pilot schools. Schools faced particular difficulties implementing CMC where the number of students placing at Level D or the CMC class size restrictions were smaller than their typical class size. This meant that they had to secure additional staffing, run a group with non-level D students included, or over-fill other classes. One head of maths/senior leader suggested the programme was 'logistically a nightmare'.

Half of the pilot schools had timetabled maths lessons of 70 minutes or more and half of the schools had slightly shorter timetabled maths lessons (usually about one hour). Therefore, most schools did not find it feasible to deliver exactly the recommended 70-minute lesson length because this was either longer or shorter than timetabled maths lessons and to adjust this would have adversely impacted other subject areas. However, schools attempted to surmount this challenge by delivering CMC lessons continuously over their timetabled sessions, picking up where they finished in the programme of lessons at the next session. The developers confirmed this was compliant with programme fidelity and is how the programme is usually implemented in the U.S. Only five of the 17 intervention groups (across three schools) had daily timetabled maths lessons as the programme stipulates (Engelmann *et al.*, 2013). In a few schools with a two-week timetable, sessions were often irregularly spaced, which is not advisable for the programme due to the level of recall required. Overall it was not feasible for pilot schools to deliver the optimum dosage for the intervention of 70-minute daily lessons. However, the optimal programme dosage was considered from the start of the pilot likely to be unfeasible for pilot schools and hence a more realistic expectation of three to four lessons per week was regarded as feasible and achieved by all schools.

School staff interviewees also reported some behaviour challenges. Some behavioural issues were perceived to be exacerbated by issues with the content, extent of repetition, low level of challenge, and lack of differentiation. When behaviour challenges were well managed, progress with the programme was more evident.

In many cases, these challenges could be mitigated with more lead-in time and clarity about the programme requirements. In two schools, the staff interviewees explicitly noted how straightforward the programme was to implement. However, it is interesting to note that normal practice in these two schools for low-prior-attaining students involved either a bespoke curriculum and/or small class sizes and so there was some staffing flexibility and they were more easily able to adapt to the CMC requirements.

Developer and delivery team interviewees, as well as some DI instructors, suggested that challenges with student behaviour could be mitigated by selecting DI instructors with experience of behaviour management as well as knowledge of, and making clear links to, their school's behaviour management policy, rewards, and sanctions. Coaches also

suggested other attributes of DI instructors were key, such as experience of supporting and engaging low-attaining students and willingness to learn a new approach.

Most DI instructors reported challenges with the programme monitoring requirements as this was often an additional requirement for DI instructors (compared to their normal role) and presented issues in terms of completing the data in the required format, recording scores, and the lack of a secure and accessible system to transfer data to the local delivery team and developers. Such challenges are also indicated by some gaps in the programme monitoring information returned to MAT and NIFDI. However, most DI instructors valued the formative insights about student progress provided by some aspects of monitoring, for instance mastery tests. Challenges with the programme monitoring may be alleviated in future by specifying the monitoring requirements in more detail upfront and recommending that time is allocated for this to be completed on a weekly basis. This would also be helped by offering a suitable secure platform for transferring data and ensuring schools can gain access to this, and streamlining the process wherever possible with the developers and evaluators working together to develop a feasible tool to capture the required information whilst minimising unnecessary workload.

Q2d: Has the placement test been delivered as intended (fidelity)?

Schools generally followed the guidance for selecting students for placement testing. Schools typically gave the placement test to a subset of students from Years 7, 8, and 9 who either scored below 100 on maths KS2 SATs, were in the lowest attaining sets for maths, or were otherwise underperforming (an assessment of which was often derived, at least in part, from low scores on KS2 SAT results).

Schools implemented the placement test with a fairly high degree of fidelity, led by the member of staff who had attended training, and several commented that it was a straightforward process. There were only minor adaptations to the process, such as giving the three tests (D, C, and E) in one sitting, which may have resulted in some students not needing to do the subsequent Level C or E test (this appears to have been the case for 19 students), as opposed to the recommended staged process of administering test D first, then mark and give C or E accordingly depending on the number of errors on the initial Level D test. There were also very occasional instances of the follow-up tests C and E not being used in the process when students required them (this appears to have been the case for four students). Also, in at least one case, a colleague who had not received the training helped with the administration and marking of the tests. Other minor adaptations were reported, such as the test administrator not using a signal to prompt students to complete their answer.

Timing was a challenge for delivering the placement test to Year 7 students as the students only arrived at the pilot schools at the start of the academic year, leaving little time to test and group the students accordingly. This delayed delivery to all Year 7 groups.

The placement test was often delivered by the DI instructor themselves (in four schools), but also sometimes the SENCO, an exams officer, or another teacher took responsibility for this element (in four schools).

According to DI instructors in five schools, the intervention reached the intended target group of students who placed at Level D. In three schools, the CMC groups included some students who did *not* place at Level D and either placed at Level C or were too proficient. This was usually based on professional judgement and other assessments that they were a similar ability level to the group (which was acceptable for programme fidelity) or was a pragmatic decision to make the group sizes and staffing arrangements feasible (this is less desirable for programme fidelity).

The placement testing outcome data collected in the evaluation broadly confirms that placement testing was conducted with fidelity, although the results are partial as data was not received from Midland Academies Trust or from schools directly for all students in the intervention groups. Where placement testing outcome data was provided (N = 141/189), most students (79%) appeared to have been correctly placed in Level D according to the placement guidance based on the number of errors or parts passed for each test. However, in the region of 16% of students were not correctly placed according to the guidance. Of those students who did not appear to be correctly placed, slightly over half were ‘too proficient’ for Level D and just under half required the Level C programme (which is a lower level than Level D). This could be a factor contributing to the issues reported with some students being insufficiently stretched by the CMC programme and the challenge that some DI instructors described in meeting students’ varying needs. In five schools, some students appeared to have been incorrectly placed; in most cases, this was just a small number (between one and four students per school) but, in one school, this was substantial as half of the students believed to be receiving the

intervention appeared to be incorrectly placed. We are aware of grouping changes in some schools during the pilot so it may be that, in practice, some of these students did not receive the programme as our data is based on lists that schools provided at the start of term. However, the data still suggests there may have been some issues in the fidelity of placement testing.

In the pilot evaluation, challenges were encountered in obtaining placement test results and intervention group lists from MAT and schools. Schools were asked to share this data initially with MAT (which would then share it with NIFDI and the evaluation team). In practice, the evaluation team obtained most of the information directly from schools. One school had lost placement test scores for their students. In a couple of cases, placement test results were not received for Year 7 groups, perhaps due to DI instructors being busy getting the programme underway. In a future trial, it would be essential to collect and check placement testing results for *all* students prior to randomisation and the delivery of the programme and for this data to be made available to the evaluators.

In a future trial, there may be a need for greater scrutiny of the placement testing outcomes to ensure only students who are correctly placed in Level D receive the intervention. This may also be aided by providing information to schools about the likely target attainment level for the Level D programme (see also the assessment findings in relation to Research Question 3a) to help school leaders better judge whether they are likely to have sufficient students placing on the programme in their KS3 cohorts. Finally, more lead-in time may be required for placement testing and subsequent grouping, particularly for Year 7 students, for instance, the intervention could be started slightly later in the academic year.

Q2g: Has the suite of lessons been delivered as intended (fidelity)?

Overall, the programme was delivered with fidelity to most of the programme requirements. The evidence from DI instructors' self-reports, observations of delivery, and feedback from the local delivery coaches and developer trainer, all indicate that the key features of the CMC programme were apparent in implementation. This included fidelity to the script and use of programme resources, use of a signal, choral responding, and individual turns, independent work, mastery tests, and use of a motivation system with behaviour expectations linked to teacher/student points. There was also ample evidence that this level of fidelity was testament to the degree of support that DI instructors received from MAT and NIFDI to implement the programme and correct any nonconformities.

The programme monitoring data that was gathered indicated that all students were taking mastery tests after every ten lessons of CMC and were completing independent work.[24] Most students were making fewer errors over time, indicating that the lessons were delivered with increasing effectiveness during the pilot.

There was also some evidence from the student survey to indicate that changes were made to classroom practice during the pilot period that were in line with the expectations of a CMC classroom. Most noticeably, students' responses indicated a significant increase between baseline and endpoint in the frequency of working on maths activities as a whole-class in lessons ($\chi^2 = 16$, $p \leq 0.05$).[25] Conversely, and again as might be expected in a CMC classroom, the frequency with which students reported working on maths activities in small groups reduced between baseline and endpoint ($\chi^2 = 8$, $p \leq 0.05$). However, the student survey indicated that some aspects of the CMC programme that we might have expected to be stronger features of the DI classroom that students would notice were not evident. Namely, there was no difference between baseline and endpoint in students' reports of the frequency of aspects of lessons such as feedback from the instructor and practising learning until it is fully understood. These findings offer tentative insights that these aspects of students' experiences of maths lessons are likely to be equally present in business as usual practice, though perhaps achieved in a specific way in CMC lessons.

The programme was delivered primarily by seven maths teachers, and three learning support practitioners (two schools had two DI instructors, the other six had one DI instructor). It is recommended that the programme is delivered to each group by a single instructor so that they can monitor and respond to the students' learning. It is suggested by the developers that because of this, and because group sizes are relatively small, CMC classrooms do not need support from a teaching assistant, unless to support a student with particular needs. Insights from the evaluation suggested that it is feasible for CMC to be delivered by a single instructor.

[24] With the exception of students who were absent on the day the mastery test took place.
[25] Statistic based on the McNemar's chi-squared test for paired categorical data.

The main adaptations to programme requirements and planned implementation are discussed thematically below.

Reduced lesson dosage

None of the eight pilot schools delivered the recommended optimal programme dosage of daily 70-minute lessons. Lessons were either shorter than this (approximately one hour) or for fewer sessions per week or over a fortnight (for instance, three or four sessions per week). The recommended dosage amounts to 350 minutes of CMC per week. The average achieved timetabled session dosage was 251 minutes of CMC per week. Dosage was also variable across the pilot schools ranging from 170 to 300 minutes per week. As the programme was delivered as a replacement for normal timetabled maths lessons (with one exception in a school where the programme was delivered in addition to normal maths lessons) this may reflect general variation in the amount of time the schools allocate in their timetables for maths lessons. Thus, the pilot findings add weight to the assumed understanding advocated at the start of the pilot by the MAT delivery team that a more achievable dosage to deliver CMC in English schools as a replacement for normal maths lessons is three to four timetabled sessions per week.

Dosage was reduced further by a delayed start for many groups at the beginning of term, and due to staff absence and school events that suspended normal lessons. It also did not take into account individual students' attendance at lessons. As mentioned previously, the evaluation team aimed to gather student lesson attendance data and in discussion with, and with the support of, the local delivery team, data was obtained for five of the eight pilot schools. Because this data was incomplete, it was not possible to use it to analyse variation in dosage for individual students. However, the data suggested that students' attendance at maths lessons averaged 89% of lessons during the term.

The developers were particularly concerned about the adverse effects of two-week timetables where students had gaps of several days between lessons, which undermines the scope for regular recall and can slow progress. Interestingly, in a review meeting, the developers noted that their analysis of internal programme monitoring data indicated that groups that had more time available for CMC each week did not necessarily progress through the programme lessons more quickly than those with less time. This suggests other factors also had an influence on the pace of progression, such as the amount of time the DI instructor spent repeating aspects of the programme (for example, in response to students' errors or low participation).

Similarly, none of the schools achieved the recommended 40 to 60 CMC lessons during the autumn term. In practice, students progressed through the Level D programme from lesson one and reached lessons ranging from 14 to 30 in the series by the end of the autumn term. For several intervention groups, particularly the Year 7 groups, the start of intervention delivery was delayed as the first couple of weeks of term were required to test, group, and survey students before delivery could begin. This contributed to these groups completing fewer lessons.

Intervention rather than replacement

In one school, CMC was delivered as an intervention in addition to normal maths lessons rather than as a replacement. The school was late signing up to the pilot and was unable to staff and timetable the programme as a replacement. Instead, CMC was implemented by a learning support practitioner and students were withdrawn from a range of different lessons (including some maths lessons) so as to avoid students missing any subjects entirely.

Moderate levels of participation with programme data monitoring

Completion of programme monitoring forms included independent work summaries to record students' scores on independent work associated with each lesson, lesson progress charts to record lessons delivered each week, and students' mastery test and re-test scores completed every ten lessons. All schools submitted some programme monitoring data, and most completed the majority, though this aspect of the programme was not complied with in all cases. Sixty-six percent of weekly Lesson Progress Charts had been submitted by pilot schools to MAT and NIFDI by the end of the programme.[26] Independent work summaries had been submitted for all but one of the 17 intervention groups and most were complete for the number of CMC lessons each DI instructor reported delivering. Mastery test

[26] This figure is based on an assumed optimal completion of weekly Lesson Progress Charts across the 15 weeks of the term and for each of the 17 intervention groups (255 submissions). In practice, 169 submissions were shared by MAT with NFER. A submission was counted for the lesson progress of each intervention year group recorded on a single form. Duplicate Lesson Progress Charts for the same week were excluded.

forms also appeared to have been completed in the majority of cases in line with where each group had reached in the programme.

Programme monitoring data is a required aspect of the programme and provides crucial information to the local delivery team, developers, and evaluators to help monitor programme fidelity and diagnose and respond to issues. DI instructors valued the formative assessment insights provided by the mastery test scores and student independent work scores, which enabled them to monitor the progress of the group and tailor feedback and encouragement. However, school staff interviewees reported some issues with completing programme monitoring: issues included understanding the purpose of the monitoring forms and how and when to complete them, technical issues with collating and sharing the data with the developers, as well as workload challenges recording numerous scores on a regular basis and being required to complete a range of documents. The monitoring requirement increased the amount of marking and administration for teachers—and for learning support practitioners not always contracted to undertake such tasks or provided with time during the school day to do so. MAT and NIFDI coaches dedicated considerable time to supporting and encouraging DI instructors to complete programme monitoring.

There were also several further minor adaptations to the programme implementation requirements, which are discussed thematically in the sections below.

Group size

Generally, pilot schools were able to adhere to the recommended intervention group size of 14 students, with only occasional exceptions. The average number of students per intervention group was 13 in Year 7, 11 in Year 8, and 9 in Year 9. Group sizes ranged from one student to 16 and three groups were larger than the recommended size of 14 students, although usually just by one or two students. This was due to the effect of CMC class sizes on other non-CMC groups, as well as consideration of the needs of individual students who might benefit from the programme. In addition, there were several examples of grouping changes during the pilot and, where known, reasons for these related to behavioural issues and attainment.

Use of non-programme resources

In several cases, DI instructors reported using non-programme resources as extension and homework activities as they felt these were not provided as part of the programme.

The balance of choral responding and individual turns

Some DI instructors commented that they used both approaches and found that a balanced approach, rather than over-use of either, was the most effective.

Additional instructional clarification

Occasionally, DI instructors reported offering students additional instructional clarification to complement the programme instruction. For instance, where students asked questions or appeared not to understand, DI instructors provided additional (off-script) clarifications and explanations. Examples of queries from students related to clarifying what they needed to do (for example, the format to provide answers), clarifying their understanding (for example, asking whether 2 x 4 is the same as 4 x 2), and making additional comments to show their understanding (for example, spotting a pattern that all the numbers in the column of a table add up to a total sum).

Q2j: What is the normal, business as usual approach?

School staff interviewees explained that business as usual maths provision for the target group of students would have involved either a normal mainstream KS3 curriculum, a bespoke curriculum for lower-attaining students focusing on KS3 curriculum content and recapping missed content from KS2, mastery of basic maths skills, or additional specific maths interventions.

School staff interviewees indicated that CMC was a substantially different approach to their normal practice, particularly in the following ways:

- level of prescription and scripting—business as usual practice would be more flexible, with the teacher varying delivery styles and modes of interaction with students (for example, more discussion);

- the ratio of repetition and new content—business as usual practice would have less repetition and more new content;
- choral responding—business as usual practice would include a similar amount of formative assessment and teacher questioning, but the form of responding would be more likely to include individual turns or group responding, for example, by individual students writing answers on an individual wipe board and holding up for the teacher to see when prompted;
- consistent explanations—business as usual practice would involve providing students with various strategies for dealing with maths problems; and
- differentiation—business as usual practice would involve much greater emphasis on differentiation to the varying needs of students in the group, through approaches such as extension activities, and the teacher/learning support practitioner circulating the class to provide individual support to students.

Staff training, materials, and support

Q2e: Has the staff training been effective in preparing staff to deliver the intervention?

Developers and delivery team staff reported that programme training was effective. However, there was a need to run additional 'mop-up' training sessions for both the placement test and programme training, which required a greater investment of the trainer's time than planned. This was due to issues with initial communications with schools and timing. Also, during the delivery training, there were some issues with additional non-pilot DI instructors attending training, and coming and going, which created unnecessary distraction. These issues could be addressed in a future trial by communication with schools and participants to prepare them better for what is involved in the programme and who is eligible to attend the training. It was suggested that this could include a tele-meeting or webinar for all participants following sign-up, but before any training, to outline all the requirements and give them the opportunity to ask questions and clarify any concerns.

Delivery team and school staff interviewees were unanimously positive about the effectiveness of the training in preparing school staff to implement the programme (this included the placement test and CMC programme training). They praised the quality of delivery, the effective structure of the sessions, balance of theory and practice, modelling of techniques in action, and opportunities for interaction and practising delivery. The training was comprehensive and clear in explaining programme fidelity and provided the right amount of initial input (based on the two-day training). One DI instructor commented:

> '*Seeing it and being part of it makes so much more sense than if you were just reading it and trying to work it out yourself.*'

Interviewees made a number of suggestions for minor improvements to the training. These related to the need for clearer initial information about the training requirements, the level(s) available, who should be involved, which students to placement test, and the nature of participation required. This would help to mitigate some initial confusion, improve training attendance and engagement, and reduce issues with non-pilot delegates attending training.

For two DI instructors, the training was delivered during their school's holiday, which was not preferable. A couple of interviewees suggested that the one-day 'mop-up' training was intensive as the volume of information had to be condensed, and did not allow sufficient time prior to delivery for familiarisation with the materials, and therefore this training model was not recommended; the two-day format allowed for more practise and in-depth explanation.

Finally, interviewees suggested that the training could cover the data and monitoring requirements and processes in more detail (including providing examples of completed data and annotated forms to clarify terms and what was required). However, with such a lot to cover in the programme training, interviewees suggested that training on this element could be supplemented by follow-up support when DI instructors were first completing their data returns at the start of programme implementation.

Q2f: How effective have the materials and support been in helping staff to deliver the intervention?

School staff reported receiving support to implement the CMC programme in the form of:

- all the programme materials required—including teacher guide, teacher presentation book, presentation displays, individual copies of student workbooks, textbooks and answer books, and access to online resources;
- regular coaching visits (weekly or fortnightly) with modelling and feedback from local delivery team coaches, plus two face-to-face visits from the U.S. developer team:
    - feedback was provided by the MAT coach and, when present, the NIFDI trainer, to DI instructors at the end of each lesson observed during a coach visit;
    - the debrief involved the coach discussing with the DI instructor what had gone well in the lesson and areas for development; and
    - written feedback was also offered to DI instructors about their delivery of CMC via a Technical Assistance Form (TAF); and
- ongoing communication via email, text, and phone with the local delivery team.

DI instructors reported receiving support with all aspects of CMC delivery features to ensure they were delivering the programme effectively (for example, signalling, pace, behaviour management, error corrections, balancing choral responding and individual turns, and how to complete programme monitoring data).

School staff interviewees were unanimously positive about the support they had received from the MAT coaches and NIFDI trainer. They confirmed that the support was essential to helping them implement the programme effectively, confidently, and with fidelity. In practice, DI instructors received more frequent face-to-face coaching support from MAT coaches (weekly or fortnightly) than the originally envisaged three visits over the course of the pilot (at the start, midpoint, and endpoint of the term). The local delivery team increased this element of support to ensure that DI instructors were supported to implement the CMC programme with a high degree of fidelity and confidence. Schools valued this frequency of support and both school-staff and MAT interviewees agreed that the intensity of support was appropriate to implement such a technical programme. This included more regular support initially, with support reducing over time depending on need. DI instructors also valued the coaches' and trainers' expertise in delivering DI, and the opportunity to see them model best practice, and their supportive, encouraging, and responsive approach. One DI instructor said:

> '*It has literally been—whatever problem I've had, they've managed to find a way to solve it.*'

The local delivery team of coaches were recruited because they had prior experience of using DI in their own schools, and they believed in the potential of DI and were enthusiastic about developing the approach. They also had other valuable experience such as prior experience of coaching or delivering professional development and effective organisational and communication skills. Delivery team and developer interviewees suggested that, in a future trial, the primary selection criteria for additional DI coaches should be similar—prioritising the need for DI coaches to have experience in, and current opportunities to practise, delivering DI.

The capacity and expertise of the England-based team has been substantially developed in terms of DI expertise, knowledge, and coaching skills. Delivery team and developer interviewees regarded the team as being well equipped with the necessary skills and expertise to support schools to implement DI. This was a result of highly effective support from the developers for:

- the development of proficiency in the DI approach—NIFDI provided initial coaching for the MAT coaches on their own DI delivery to ensure they could deliver with absolute fidelity to the programme and hone their own DI practice; this included providing constructive feedback on video recorded DI lessons;
- the development of coaching skills:
    - NIFDI ran a five-day coaching institute which MAT coaches attended;
    - the NIFDI trainer and lead MAT coach also accompanied MAT coaches on visits to schools to model how to provide effective coaching support, including when to intervene and model practice, and how to provide constructive feedback; and
    - the NIFDI trainer also reviewed MAT coaches' feedback to the DI instructors on the Technical Assistance Forms (TAFs) to ensure feedback was precise, focused on observed student behaviours, and offered practical solutions for a manageable number of areas for development; and
- the implementation of monitoring processes—the NIFDI trainer (and initially the lead developer) had weekly meetings with the MAT coaches to review programme monitoring data (for example, lesson progress, mastery

scores and student independent work scores); this helped to diagnose any issues in schools' implementation and assess the need for subsequent support.

Furthermore, as part of the pilot, the NIFDI and MAT teams supported the development of numerous DI instructors in the local pilot schools, several of whom have displayed potential and interest in developing a role in supporting and coaching others to teach using CMC. This has further developed capacity in England to deliver effective DI in the future. The scalability of this support is explored in relation to Research Question 4e in the Readiness for Trial section.

School staff suggested the need for only very minor improvements to the support. This included: guidance on how the programme links to the English National Curriculum for maths, an opportunity early in the process to observe DI in a real classroom (either by video or in person), and opportunities for DI instructors to network and provide mutual support.

Staff and student engagement

Q2h: Have staff been fully engaged in the intervention?

All ten DI instructors remained engaged in the pilot. There were no cases where instructors 'dropped out' and ceased to implement the programme with their classes within the pilot timeframe.

Most DI instructors experienced some initial challenges with the approach. Some found it stressful, daunting, and an 'alien' approach and some faced issues with student behaviour and engagement. DI instructors who were new to the school, or who had limited experience of classroom behaviour management, found it particularly challenging.

As the pilot developed, most DI instructors reported that they became confident and fluent in the approach and started to see improved student engagement. Some were really enjoying the CMC approach. Coaches reported that most DI instructors were receptive to support and feedback and had become effective instructors. However, there was some variation in the speed at which instructors developed proficiency, but this did not seem to relate to any particular role or characteristics. The evidence from the pilot interviews with the delivery team and DI instructors suggested that teachers and learning support practitioners are equally able to implement the programme, as was anticipated by the programme developers and local delivery team.

Q2i: Have students been fully engaged in the intervention?

The endpoint student survey asked students to rate how much they liked or disliked the CMC programme in general as well as some of its core aspects. Table 20 below displays the results and shows that half of students liked the CMC approach, particularly the mastery tests and teacher and student points motivation system, which some DI instructors linked to rewards such as merits or house points. However, a substantial proportion of students were either more ambivalent or did not like the approach.

Table 20: Student survey—engagement with the CMC programme

	Dislike it a lot / a little % (N)	Neither like it nor dislike it % (N)	Like it a little / a lot % (N)	N
How much do you like or dislike the way you have been learning maths this term?	23 (33)	21 (29)	56 (79)	141
How much do you like … answering the teacher's questions as a whole class?	28 (40)	19 (27)	53 (74)	141
How much do you like … going over things until everyone in the class understands?	34 (48)	11 (16)	54 (77)	141
How much do you like … teacher and student points competition?	20 (28)	18 (25)	62 (88)	141
How much do you like … finding out how you are doing in mastery tests (that is, topic tests every 10 lessons)?	12 (17)	19 (27)	69 (97)	141

Source: NFER endpoint survey of students, December 2019; percentages may not sum to 100 due to rounding.

No evidence was found to suggest that students' responses varied according to their year group, gender, or the number of CMC lessons in the series that students had experienced (although cell counts were too low to allow robust analysis).

This limited analysis offers a tentative indication that students' attitudes to CMC are fairly mixed regardless of year group, gender, or dosage.

Qualitative views on student engagement were similarly somewhat divided. However, in general, school staff interviewees felt that students had been effectively engaged by the programme and that engagement had increased over the term of the pilot, as students and DI instructors became more familiar with the approach and the content became more challenging and varied.

Engagement was aided by four factors:

- DI instructors and students identifying aspects of the CMC programme that were motivating and engaging: choral responding (which encourages participation), the motivation system (which rewards good behaviour), and mastery tests and independent work (which provide students with feedback about their progress);
- DI instructors explaining to students the rationale for repeating work that may seem familiar and easy in order to increase proficiency in basic skills and lay stronger foundations for more complex work in future (for example, one teacher used the analogy of bricks in a wall);
- one DI instructor achieved more effective engagement by reducing the amount of choral responding (which students were not always willing to participate in) and using more individual turns as a method of students responding; and
- DI instructors altering classroom seating arrangements so that students who were being disruptive were separated.

One DI instructor commented positively on student engagement:

> *'I mean, I had one student who used to hate maths and her mum said to me, "She used to hate maths, but she's loving it right now."'*

One head of maths/senior leader also explained the effectiveness of the CMC structure and expectations in engaging students:

> *'I think, first of all, the clear routing and the clear instructions takes away any sort of wiggle room for misbehaviour, for lower end disruption, because it's very clear and precise and they all know that it all happens in a particular set way.'*

Around half of the 29 students who participated in evaluation group interviews said that they liked the DI approach, particularly the independent work, explanations and methods, immediate marking and feedback, repetition and ease of the work, and choral responding to help them keep focused and engaged without singling out individuals to answer questions. However, as mentioned previously, there were mixed views overall on choral responding. In observations, students appeared particularly engaged by the independent work (for example, they engaged in this activity even when they did not fully participate in choral responding) and students displayed enthusiasm for the teacher/student points game. One Year 9 student explained why they liked the programme:

> *'Last year, I used to be quiet and never used to speak in the lesson. This lesson I'll speak and then I'll get my answers right. Plus with the books that the school have provided us with … that's made life easier, because they've got the questions written down, all you have to do is answer and mark. So, it's just quicker.'*

This Year 8 student explained their more mixed view of the programme:

> *'I would say 50/50 because I like the independent work, the way that we get to answer the questions for ourselves and mark it ourselves and to be happy if we got it right. But I don't really like it because the way that we do it is repetitive and it is getting boring because every lesson we are doing the same thing just different questions. Sometimes we do the same questions for three lessons.'*

At least half of the DI instructors experienced some challenges with student engagement, behavioural issues, and disruption to varying degrees. Some students were reluctant to participate in choral responding and felt this was not an effective means of gauging their understanding as students could copy each other or mouth a response. One Year 8 student remarked: 'We sound like robots.' Some students complained that they found the programme repetitive, boring, and easy. Occasionally, students identified the timing pressures within the programme and that they did not always

have sufficient time to think before a response was required. In observations, there were occasionally signs of students being bored and waiting for other students to finish the work, which led to low level disruption. One student explained: 'It's boring, because we do the same thing again and again. Like simple addition, we take a few minutes to do easy stuff.' Another said: 'We don't have anything to do. There's other work that could be done. But we don't get given any work.'

Coupled with the earlier finding reported in Research Question 1e regarding the deterioration in students' self-reported behaviour over the term of the pilot, these further comments from staff and students raise again the need for a future trial of the programme to address this issue so that all students feel adequately challenged and engaged.

Around half of interviewed students wanted to carry on learning maths using CMC (repeating comments outlined previously that they liked the mastery elements of small increments in learning and opportunities to practise learning until they fully understood). However, the other half of interviewed students preferred learning maths in the normal (business as usual) way as they could work at their own pace, rather than as a group, and cover more new content.

Costs to schools to implement the programme

Q2k: What are the staff and other marginal costs for schools to deliver the intervention?

School staff reported very few additional financial costs to implement the CMC programme during the pilot. The main cost identified was paying staff to attend the two-day programme training during the summer (or giving this time back in lieu). There were no travel costs as the training was delivered locally. One school purchased some folders and coloured pens for students to use in CMC lessons, accruing a minor cost. Other resources used to present the CMC materials, such as laptops and visualisers, were already available in schools. However, one school questioned the affordability of the programme if it was not subsidised by the EEF given the extent of programme resources.

DI instructors reported spending additional time to implement the CMC programme during the pilot. This included additional time to attend training, familiarise and practise the scripts, mark and check students' independent work and mastery tests, record and submit programme monitoring data, meet with the coach for debriefs and feedback, and re-write other materials to align with CMC (for example, maths intervention lessons, homework, and revision guides). Interviewees estimated that they were spending between 30 minutes to five hours additional time on CMC per week compared to their normal workload. The additional time that DI instructors were spending on these activities was offset to some extent by reduced time spent planning lessons for the groups of students involved.

Interviewees suggested this additional time came from a combination of their planning, preparation, and assessment (PPA) time as well as their own time (working additional time in the evenings and weekends). So to some extent, it impinged on instructors' time for other activities related to their role. In one case, the additional time spent on CMC had reduced the time that a learning support practitioner could spend on other activities and they reported that they would not normally be required to undertake marking. There was some indication that the additional time requirement of piloting this programme was particularly noticeable for learning support practitioners as activities such as lesson preparation and marking would not normally be part of their role and they did not have PPA time in school to cover these activities.

Outcome measure piloting

This section summarises the evaluation findings in relation to the piloting of a student maths attainment outcome measure for use in a potential future trial.

Q3a: Which PUMA assessment has the best distribution profile for students who received the intervention at Level D?

As part of the pilot evaluation, two assessments were trialled with the purpose of establishing an appropriate outcome measure for a future trial for the target group of students who placed as requiring the Level D CMC programme. At the end of the pilot (one term of CMC), students were given either a PUMA Year 6 spring assessment or a PUMA Year 6 summer assessment. The assessments were selected in close consultation with the local delivery team. The spring and summer papers were allocated to students at random. A total of 83 students sat the spring paper and 77 students sat the summer paper—so the samples were small.

The two following charts (Figure 3 and Figure) display the distribution of raw total scores on each of the tests. The mean total score on the spring assessment was 10.65 out of a total of 50 possible marks. The mean total score on the summer assessment was 7.97 out of a total of 50 possible marks.

Figure 3: Distribution of students' raw scores on the spring assessment

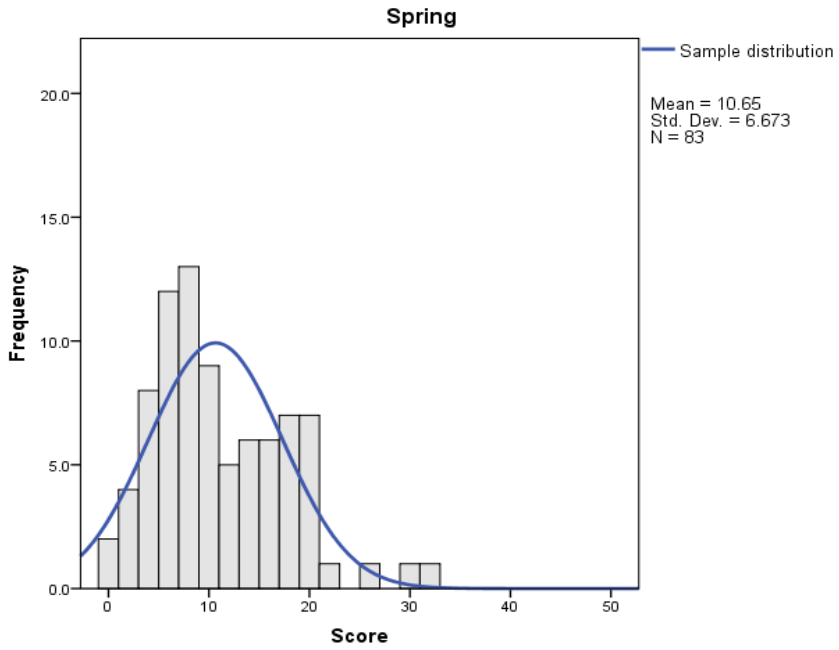
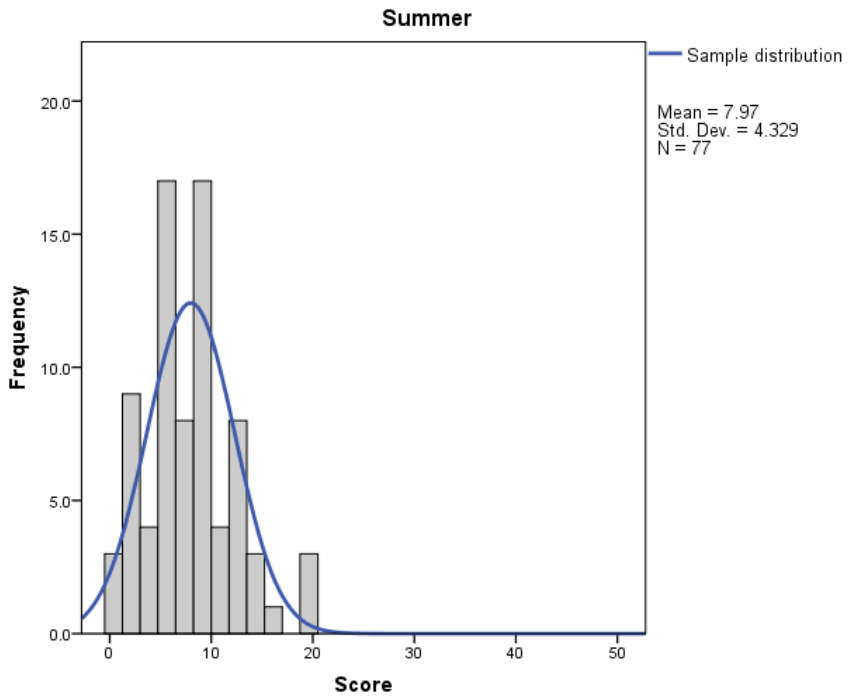


Figure 4: Distribution of students' raw scores on the summer assessment



If the assessments were an appropriate level of challenge for the target group of students, we would expect to see a normal 'bell shaped' distribution of scores with most scores falling in the middle of the score range and with a smaller number of lower and higher scores to form the tails of the distribution. The distributions for both assessments are located towards the lower score range which indicates that neither the PUMA Year 6 spring or summer papers were an

appropriate assessment of the maths capabilities of this target group of students after one term of CMC Level D. The difference between the distributions of actual scores for both assessments and the expected normal 'bell shaped' distribution of scores which would have been expected if this was an appropriate test, was significant for both assessments (spring: $p \leq 0.05$; summer: $p \leq 0.05$).

These findings suggest that these assessments are inappropriate for this target group who have completed just one term of the CMC Level D programme. Based on the standardised scores and Hodder scales for the assessments, this target group of students (that is, those placing at Level D) are performing near what would be expected of students in the autumn term of Year 4. This has been estimated based on the achieved mean scores of the spring and summer Year 6 tests, which equate to a Hodder Scale score (the Hodder Scale is a common spine measure to enable the tracking and predicting of progress for all PUMA primary tests). The mean scores of the pilot sample on the Year 6 spring and summer tests were equivalent to a Hodder Scale score of 3.3. This Score of 3.3 approximately matches the mean standardised performance on the PUMA Year 4 autumn paper.

Therefore, selecting an outcome measure for a future trial could be informed by this indication of the likely starting point of students on the CMC Level D programme along with information about the length of the programme in a trial (for example, three to six terms of CMC) and consultation with the local delivery team and developers about the expected rates of progress for this target group (for example, are they expected to make average or slower than average rates of progress?). In a future trial, it would appear that an assessment aimed at the Year 4 level would be an appropriate assessment for the target group when they enter the CMC programme at Level D. Standardised tests, such as PUMA (Hodder), Progress Test in Maths (PTM; GL Assessment), or KS2 maths scores, if appropriate, could be used to measure progress from this starting point (as a baseline) and a corresponding assessment selected for the endpoint of the trial. There would also be potential to track progress midway through implementation if assessments such as PUMA or PTM were used, and if this were desirable, as these have termly tests available.

We also conducted further analysis to explore the relationship between the placement test (Level D only) and the PUMA assessments to help inform the selection of an appropriate baseline measure in a potential future trial. This analysis was limited by small numbers, missing placement test results, and some inconsistencies in the recording of placement testing outcomes.[27] The analysis was conducted on matched individual-level data where we had a placement test error score on the Level D placement test and a score on the PUMA assessment at endpoint.[28] We conducted a multilevel model analysis to investigate the effect of the placement test error score (independent variable) on the PUMA assessment score (dependent variable). The models controlled for the school cluster effect. For the spring PUMA assessment, the effect size of the placement test error score on the PUMA score was -0.02 (-0.11, 0.07), $p = 0.68$. For the summer PUMA assessment, the effect size of the placement test error score on the PUMA score was -0.06 (-0.17, 0.04), $p = 0.22$. As the confidence intervals for both models include zero, we cannot reject the null hypothesis of no effect of the placement test error score on the PUMA score. This means that there is no evidence that students' scores on the placement test influence their scores on the PUMA assessments after one term of CMC. If the placement test score had a significant effect on the endpoint assessment score, this would indicate that the placement test and endpoint assessment were comparable measures.

Readiness for trial

This section summarises the evaluation findings in relation to the intervention's readiness for trial at a larger scale. It explores several research questions on this theme:

- Is the intervention ready and suitable for a full trial?
- Can a sufficient number of schools be recruited?
- What key contextual factors might facilitate or impede successful implementation?
- Is the programme affordable to schools, and how should the trial be administered?

[27] Total number of students included in the analysis, N = 114; total number of students in this analysis receiving the spring assessment, N = 60; total number of students in this analysis receiving the summer assessment, N = 54.
[28] As not all pupils received the Level C and E placement tests and there were some inconsistencies in whether these were correctly administered, the placement test error score for this analysis is based on the Level D placement test only.

Q4a: Is the intervention ready and suitable for a full trial?

The pilot evaluation gathered evidence that suggests there could be interest from schools in the CMC programme. Several elements of the intervention were valued by participants - including DI instructors, senior leaders/heads of maths, and students themselves – for instance, the assessment and feedback, mastery approach, structure of the programme, motivation system, explanations of concepts, and student independent work. Furthermore, the approach to training and supporting schools to implement CMC was highly valued by DI instructors and school senior leaders and, as such, with appropriate increases in capacity, the intervention could be considered suitable for a trial involving a larger number of schools. However, the early signs of impact of the approach on students' attitudes to maths are mixed: positive impacts on students' maths confidence and understanding contrasted with negative impacts on students' behaviour in maths lessons. While the programme was generally successfully implemented in pilot schools, feedback from participants indicates a number of concerns relating to the feasibility and attractiveness of the programme to support KS3 low-attaining maths students as a replacement for mainstream maths lessons. In summary, a number of issues raise concerns about whether the programme, if replicated exactly as it was implemented in the pilot, is suitable for a full trial in English schools.

A future trial should consider how to address the following issues that were identified in this pilot.

Meeting students' varying needs

School staff raised concerns about whether the Level D programme and the DI approach of whole-class teaching provided the right level of challenge for some of their students. There was a concern that some students were held back as the programme stipulates that students should not move ahead when they have completed independent work (Engelmann *et al*., 2013), which led to perceptions of disengagement and poor progress in some cases. The emphasis on whole-class teaching conflicted with some teachers' beliefs about effective teaching and the importance of differentiation. Even with a placement test and guidance from other assessments, students who placed at Level D in the pilot presented a variety of needs, learning styles, and processing speeds and were not thought to be sufficiently homogeneous in their abilities to facilitate the extent of emphasis on whole-class learning in the CMC programme. There were instances of students being incorrectly placed in the CMC Level D group and this could have exacerbated this issue and raises ethical issues to be considered in a potential future trial. However, the majority of students in the pilot did place as requiring the Level D programme with a difference between the lowest and highest error scores for each group ranging from four to seven. This suggests that some variation in the groups occurred despite the placement process. In larger scale implementation of CMC in the U.S. there is scope for movement of students between groups to accommodate different rates of learning and further consideration of how this could be facilitated in any future trial in English schools may be fruitful (for instance, offering multiple intervention groups within a year group grouped on the basis of maths attainment). Interviewees advocated the need for more extension resources within the programme to help provide greater differentiation, though it is not clear if this is in line with the programme theory. As DI instructors in the pilot reported using extension and homework materials (including CMC programme materials as well as non-CMC programme materials), this suggests that challenges to fidelity and compliance to this aspect could arise in a future trial.

Lack of alignment to KS3 curriculum

The lack of alignment of the CMC programme content to the KS3 maths National Curriculum was one of the major concerns voiced by interviewees, particularly school senior leaders. Although school staff saw the value of the emphasis of the programme on developing strong foundational maths skills, there were concerns that the programme was not covering the recommended National Curriculum content and, ultimately, not preparing students for the English system of assessments that their progress would be judged on. School senior leaders are likely to require reassurance regarding how the programme aligns with the National Curriculum before they commit to trialling the programme. The trial design would need to consider the ethical implications (including the need to secure parental consent) if intervention students were to follow a programme substantially deviating from the National Curriculum for a sustained period of time. The issue of reintegrating students into mainstream maths lessons after CMC would also need careful consideration given its highly distinctive approach. We understand that, in the U.S., the CMC programme is typically used as a whole-school core-instruction programme for teaching younger students (primary age) maths, with each level of the programme designed to meet the curriculum standards (Common Core State Standards) required for a particular age group. The application of the programme in the pilot was quite different: it targeted students who were older and substantially behind

age-related expectations to help them catch-up. The issues of U.S. terminology (for example, monetary references) in the programme would also need to be addressed in a future trial.

Behaviour issues and disengagement

There was evidence in the pilot of some behaviour issues and student disengagement. Aspects such as the extent of repetition and choral responding, where all students are required to respond in unison and in a particular way, appeared to be at the root of these issues (along with the concerns outlined in the first subsection relating to level of challenge). While the programme can help some students feel more confident with basic maths skills and become more proficient, if they feel that they are repeating work unnecessarily and do not feel adequately challenged or see progression in their learning, this can result in disengagement. There was some evidence to indicate behaviour problems were exacerbated in groups where students were incorrectly placed, however this picture is not clear as there were also instances of low-level behaviour issues in groups where students were correctly placed. This would be another ethical consideration for a future trial, particularly considering the student target group already have low prior attainment in maths and any risk to their engagement could further impact their progress and outcomes.

Logistics of implementation

Some pilot schools found it challenging to timetable, group, and staff CMC classes based on the placement testing outcomes and class size restrictions. In a future trial, school staff at all levels will need to be much better informed from the outset about the programme content, implementation, and the student target group. This should include emphasis on the information being effectively cascaded within schools via a key contact and greater direct communication with staff delivering the programme. The local delivery team and developers also suggested that initial information could be enhanced by providing videos of sample DI lessons delivered by an expert DI instructor to provide potential participants with a clearer understanding of the programme and insight into high-quality delivery. School staff will also need this information earlier to allow sufficient time to undertake placement testing and to prepare for programme implementation. Selected students may also need more information about the rationale for the programme, why they have been selected, and what it will involve so that they are adequately prepared for the change in approach. In addition, consideration will need to be given to whether a future trial should target all year groups of Key Stage 3, as in the pilot, or focus on particular year group/s, such as Year 7. In the pilot, challenges were also associated with the time burden of programme monitoring requirements; consideration will need to be given to how this could be minimised while still maintaining the integrity of the programme.

Training, support, and management capacity

The training, support, and management capacity during the pilot were regarded as being effective. In a future trial, this capacity would need to be substantially increased to replicate the same type and extent of support. We understand that NIFDI is considering deploying a member of the team to provide full-time England-based support to the Midland Academies Trust team and schools directly, delegating increasing responsibility for programme training and monitoring to the local team, based in England, to build future capacity and sustainability. In a future trial, substantially more local delivery coaches would need to be recruited, trained, and deployed to support schools in a similar way to the pilot support. We understand that there is potential to recruit some coaches from the pool of DI instructors in the pilot and others from MAT's existing networks. The delivery team, developers, and school staff have suggested that the level of coaching support during initial implementation should be replicated but could reduce once the programme has become embedded. Delivery of the programme on a larger scale would also require an increased project management and strategic leadership function. This would include overseeing the delivery of the support to schools, communicating effectively with schools and NIFDI colleagues, facilitating efficient programme and evaluation data collection, and providing timely direction to tackle any challenges encountered. Practically, the local delivery team would also need secure and accessible processes and platforms to facilitate more consistent and systematic data monitoring.

Q4b: Can a sufficient number of schools be recruited to a trial?

Delivery team staff are confident there is considerable and growing interest in the DI approach across schools in England. Pilot schools were aware of wider evidence supporting the DI approach and interested to learn more. This suggests that schools across the country may well express a similar level of interest in the approach.

Some schools that expressed interest in the pilot did not proceed due to concerns about the programme requirements. The pilot originally set out to recruit 12 schools to participate and, in practice, only eight schools signed a memorandum of understanding and proceeded with the pilot. This indicates that, without some modifications to the programme or the implementation design, it is unlikely that a sufficient number of schools could be recruited to a trial.

More time would be required for recruitment to a trial. Recruitment was rushed for the pilot and some schools were unable to participate as they did not have sufficient lead-in time to plan for the programme. As mentioned above, schools would need clearer initial information about the programme and implementation requirements and more time to sign-up and prepare for implementation.

The pilot evidence indicates that there is likely to be demand and appetite for a full trial if the programme implementation can be modified in such a way to ensure it is feasible for a large number of schools to implement and is adapted for the English context. Pilot schools were interested in continuing CMC but only with some modification. This indicates that recruitment to a trial in sufficient numbers may depend on the extent to which the programme and/or programme implementation can be acceptably modified to address the issues identified in the pilot.

Q4c: Are there any key contextual factors that appear to facilitate or impede successful implementation?

The factors below appeared to facilitate successful implementation where they were in place and, conversely, where they were not in place they could impede successful implementation.

- Timetabling: the delivery team reiterated the importance of regular scheduled maths sessions (for example, a minimum of four sessions per week) in facilitating successful delivery.
- Alignment with similar practice in schools for teaching maths to low-attaining students was perceived helpful by some school staff: for example, a focus on foundation and core maths skills, prior use of bespoke schemes of work for students who are low-attaining in maths, an emphasis on repetition to secure and consolidate learning, and delivery in small class sizes. There was some suggestion that the CMC programme aligned better with the Year 7 maths curriculum and that older students, who had had more time to get used to the mainstream approach of maths teaching at secondary school, found it harder to transition to the CMC approach than Year 7s who were new to secondary school approaches. However, there were some counter perspectives that indicated that Year 8 and Year 9 students responded better to the programme and were able to behave more maturely in lessons.
- Class size: group sizes of up to 14 students appeared to work well in line with the delivery team and developer's recommendation for the target students. Larger class sizes than this meant there was too much variation in abilities and greater scope for disruption. Generally, DI instructors suggested that students from lower-attaining groups in maths benefited from smaller group sizes anyway. One school piloted the CMC programme with just one student but it was not considered effective as the student felt singled out and disengaged.
- Student characteristics: where students were readily engaged, compliant, and able to progress primarily with whole-class rather than individual support, the approach was regarded by school staff and the delivery team as being more successful. Half of school staff reported instances of lessons that were disrupted by challenging behaviour from individual students who were less engaged by the CMC programme than they may be by more traditional approaches. Also, a couple of school staff reported that sometimes students with particular learning needs, who needed more support, held up the rest of the group, which led to behavioural issues, and school staff found it challenging to meet their varied needs given the whole-class approach of CMC.
- Teacher characteristics: the pilot evidence from interviews with delivery team and school staff appears to support the programme recommendation that the CMC programme can be equally effectively delivered by subject specialist maths teachers or learning support practitioners. However, implementation was facilitated by the DI instructors having established behaviour management techniques, positive attitudes to their own learning and development, and understanding of how to support low-attaining and SEN students. Implementation was also smoother where the DI instructor was an established member of staff in the school and familiar with aspects such as school routines, homework, and behaviour policies.

- School characteristics: implementation was facilitated in schools with established behaviour management policies, including rewards and sanctions to which DI instructors could link the programme motivation system. The programme was also facilitated by support and enthusiasm from senior leaders.

Q4d: Is the intervention likely to be affordable for schools?

There is some suggestion that the intervention is likely to be financially expensive for schools compared to business as usual given the extent of required resources.[29] The resources were regarded by school staff as being very high quality and effective. However, the resources are entirely specific to the programme so would be an additional cost for schools as they would typically create their own programme of lessons (scheme of work) and would not necessarily provide individual copies of student textbooks. However, these costs would be largely one-off start-up costs as the programme resources could be re-used (though schools would need to purchase additional hard copies of student workbooks on an ongoing basis).

For the pilot schools that received the programme materials for free, there were virtually no additional or ongoing financial costs to implementing the CMC programme.

The programme was associated with some time demands over and above business as usual. These were particularly associated with the level of programme monitoring (for example, checking and recording independent work and mastery test scores). This is likely to be a concern for senior leaders in considering whether or not to trial the programme if they are seeking to reduce teacher workload in the context of national workload reduction policies in England. Every effort should be made to minimise the time burden associated with the programme while retaining its integrity.

Q4e: If the intervention is ready for a full trial, how should this be administered?

A future trial design would need to consider the aspects of administration detailed below.

Scale—the scale of a future trial would need to be sufficiently large to enable a robust measurement of outcomes. The target students (that is, those who meet the criteria for receiving the placement test and then place as required by the programme) would need to be identified *prior* to randomisation so that only students of interest eligible for the programme are subsequently analysed in the final model. The trial design would also need to consider the level of randomisation (school or student level) taking into account the likely cohorts of target students in schools and issues such as contamination between the intervention and control groups. The level of randomisation would be an important factor in determining the scale of a trial: school-level randomisation would require a greater number of schools than student-level randomisation as there would be increased variation in characteristics and contexts between schools. It may also be important for a future trial design to control for the effects of school-level and class-level intracluster correlation (to account for variation between and within schools and classes, as students in the same school are likely to be similar in terms of socioeconomic status and geography, and students in the same class are likely to have similar prior attainment in maths). Other parameters, such as the effect sizes detected in other studies of DI programmes, would also need to be considered. For illustration purposes only, a future trial may need to involve in the region of 50 to 100 schools.

Replacement or intervention—interviewees reported the pros and cons of the replacement approach and there was clearly some appetite from schools for implementing the CMC programme as an intervention in addition to normal maths rather than as a replacement. This would alleviate concerns about covering National Curriculum content requirements. However, there are numerous issues with this, not least that this would require a further pilot phase, but also it raises the risk of narrowing the curriculum and makes comparability to business as usual more challenging as other schools could be using different types of interventions. Furthermore, the CMC programme is not designed as an intervention: it is designed as a core maths programme and needs to be delivered within all of the available scheduled maths sessions in order to get close to the recommended dosage. In a trial, it would be important to ensure that all schools can commit to the selected design otherwise this would undermine the basis for comparison with a control condition.

Modifications—consideration needs to be given to the aspects of the programme and its implementation that schools found challenging, ineffective, or unfeasible during the pilot and how to overcome these challenges and barriers in a future trial—for example, meeting students' varying needs, lack of alignment to the KS3 National Curriculum, behaviour

[29] We understand the license for the programme materials per student per year is equivalent to £76.

issues and disengagement, logistics such as timetabling, dosage, group sizes, staffing, and student selection and targeting, and programme monitoring.

Dosage and length of the programme—interviewees suggested the need for a longer period of time to implement CMC to embed the approach, progress further with the content, and explore impact on student progress and attainment. It was not considered feasible to achieve the recommended dosage for the programme of 70 minutes, five days a week within English schools although in a trial it may be worth stipulating the regularity of sessions as a minimum requirement (for example, a minimum of four maths lessons per week).

Class sizes of 14 or fewer students—the pilot found this class size recommendation typically worked effectively for teaching maths to this target group of students who benefit from a lower instructor-to-student ratio although some schools found this difficult to accommodate as it adversely impacted the class size of other teaching groups and, in some cases, required additional staffing. A future trial would need to consider the implications of this requirement in terms of the attractiveness and feasibility of the programme at scale. In addition, a future trial could also attempt to separate the impacts of smaller class size from the CMC intervention by comparing these conditions (alongside the control condition) in a three-arm trial.

Target group—in a future trial it may be desirable to tighten the focus on a target group of students within KS3. There was some quantitative and qualitative evidence in the pilot that the programme was more suitable for Year 7 students because it aligned more with the curriculum, was an easier transition from primary teaching, plus slightly more students placed on the programme in Year 7, suggesting there may be a higher demand in this group, and Year 7 students tended to have more positive attitudes to maths throughout the programme. Nevertheless, this finding is tentative and may reflect general age differences in attitudes and that Year 7 students may be less enculturated to business as usual teaching approaches in secondary school. Providing prospective schools with an indication of the target attainment level the Level D programme is pitched at could help inform their decisions about participation and whether they are likely to have cohorts of students who require this programme.

Compliance—a future trial would also need to define the aspects of the programme implementation required to categorise schools' level of compliance. The pilot findings indicate that this would need to include aspects such as accurate placement in intervention groups, optimal dosage, attendance at programme training, and intended use of programme materials.

Recruitment—the pilot findings align with broader developments in other studies conducted for the EEF that suggest the benefit of greater lead-in time to recruit schools and to enable schools to prepare for implementation, including to seek the necessary permissions for students and staff to participate, complete the placement testing, timetable lessons, and make staffing arrangements.

Ethics—a future trial would need to consider the ethical implications of students potentially being incorrectly placed to receive the programme, students' reduced exposure to National Curriculum maths content (if the programme was offered as a replacement) or other subjects (if the programme was offered as an intervention), and potential negative impacts on student behaviour and engagement in maths learning.

Evaluation—a trial evaluation could involve consultation with a similar range of stakeholders to the pilot and similar data collection methods. The intended primary and secondary outcomes of the programme would need to be clarified and suitable methods to measure these identified. We suggest this would need to include the shorter- and longer-term outcomes and impacts identified in the logic model and could capitalise on any existing administrative and school-level secondary data, alongside primary data collection, to minimise burden on participants. The approach to monitoring implementation fidelity would require review, particularly in terms of capturing data on individual students' attendance, as both the original proposed approach and the approach adopted in practice in the pilot presented challenges. We suggest this would need to take into account the existing monitoring requirements of the programme to minimise burden on participating schools while also enabling a robust measurement of intervention dosage and compliance (particularly given that this was variable and, in some cases, lower than intended in the pilot).

Conclusion

Table 21: Summary of pilot findings

Research question	Finding
Is there evidence of acceptability and promise?	There is preliminary evidence that the CMC programme increased students' confidence in their maths understanding and ability, particularly in Year 7. However, the perceived effectiveness of the programme elements was mixed. Evidence also suggested some signs of potentially adverse impacts on students' behaviour in maths lessons, although behaviour challenges were perceived to have abated over the course of the pilot. The lack of alignment to the mainstream KS3 curriculum content and lack of differentiation to students' varying needs was also a concern for supporting students' maths learning.
Is the approach feasible and scalable?	The CMC programme is feasible to deliver, however the specified lesson duration and timetabling, group size, and student selection process presented logistical challenges that suggest a risk to delivery at scale.
Which maths attainment outcome measure is most suitable for future trials?	Hodder Education's Progress in Understanding Mathematics (PUMA) Year 6 spring and summer papers were tested for use in a future potential trial. These were too challenging for the target group of students and a measure that better matches student attainment will need to be identified for future trials.
Is the approach ready to be evaluated in a trial?	In its current form, the CMC programme is not ready for trial as a replacement maths programme for KS3 students with low prior maths attainment. Modifying the programme to address the issues encountered in the pilot is not feasible as this would undermine the integrity of the programme.

Formative findings

The CMC intervention itself is a well-developed and tested maths programme in the U.S. for whole-school delivery with primary-age students. This study sought to pilot the approach in a distinctive way, as an alternative approach to teaching secondary-age students who struggle with maths. The outcomes of deploying the programme in this way in English schools were inconclusive and, indeed, the evaluation findings present a mixed picture of successes and drawbacks. The successes of the pilot relate particularly to establishing an indication of schools' interest in utilising evidence-based DI approaches, the sequence and structure of the CMC programme in connecting and revisiting mathematical concepts, the delivery of highly-valued implementation and coaching support, and development of the capacity of the MAT England-based DI coaching team to support the further use of DI.

However, the drawbacks of the pilot suggest that some adjustments would be required if the CMC programme is to be deployed effectively in a larger study with the target group of KS3 students in English schools. However, advice would be required from the developers to understand more about what degree of modifications are permissible while maintaining fidelity to the programme.

Improvements to this pilot would need to address the following issues: meeting students' varying needs, curriculum-aligned content, behaviour issues, logistics and training, support, and management capacity. Each of these themes is discussed in further detail below.

Meeting students' varying needs

Pilot schools found it challenging to meet the needs of the range of abilities of students placed as requiring the Level D CMC programme and this was particularly noted in terms of the pace of learning and ensuring all students were engaged and appropriately challenged. The aim of the placement testing process is to create instructional groups that are as homogeneous as possible in terms of ability (Engelmann *et al*., 2013). In the majority of cases students were placed accurately according to the placement test results, however, around one in six students may have been incorrectly placed, which may account in part for a more diverse range of abilities than expected. This process could be improved in future by allowing more time to familiarise students with the test format (which follows the same instructional format as CMC lessons), requiring full compliance with the placement testing process, and analysing the effects of any non-compliance on implementation and outcomes. However, there is evidence that some schools would find it challenging

to group students for instruction solely on the basis of placement testing, and the relatively minor scale of incorrect placing indicates that this may not account wholly for the challenges faced with meeting students' varying needs. The main issue underpinning this challenge appeared to be that English instructors and students are familiar with a more differentiated approach. Interestingly, a study of CMC by Wellington (1994) also identified variation in teachers' acceptance of the approach: this particularly related to the scripted delivery and departure from their usual approaches using manipulatives and discovery. In the pilot, DI instructors suggested that improvements such as the provision of more independent work programme materials for students who completed work faster than their peers and resources to extend and consolidate learning at home would help them to better meet the needs of students receiving the intervention. In addition, they required more scope to differentiate their lesson delivery, for instance with opportunities to provide more tailored and individualised support within the lessons for students who were struggling. More consideration is needed regarding the extent to which these approaches would be acceptable within the requirements of the programme.

Curriculum-aligned content

Pilot schools found that the content of the CMC programme did not always align sufficiently closely with the content they were required to cover for the English maths National Curriculum, and the indication from pilot schools was that a closer alignment of content was required for the approach to be acceptable in English schools. Concerns about curriculum coverage may have been particularly exacerbated at the time of the pilot by the context of changes to the Ofsted Inspection framework in September 2019, which focused on curriculum, behaviour, and development (Ofsted, 2019). Some interviewees indicated that the CMC Level D programme was more closely aligned to the Year 7 curriculum content than to Year 8 or Year 9. An exercise to map the CMC content to the KS3 maths National Curriculum may help schools to identify the extent of alignment and any specific gaps that could be filled with additional instruction and materials before students return to National Curriculum study. Another related issue was the balance of new content versus repetition in the CMC programme, with the predominant focus being on repetition. To align more closely to the English maths curriculum, this balance may need to shift in the direction of more new content and reduced repetition. There was also a suggestion from some students that the emphasis on repetition could be demotivating. However, such a change to the balance of new and repeated content would be contrary to the DI incremental step design of the CMC programme as only 10% to 15% of new material is introduced per lesson (Engelmann *et al*., 2013). Future developments of this study may also benefit from exploring the transferability of learning on the CMC programme to mainstream maths provision and how students progress when they return to the National Curriculum.

As there was some appetite amongst schools in the pilot study for a maths intervention that could be delivered in addition to core-curriculum maths lessons, the developers have indicated that an alternative DI programme may be more suitable than CMC. This is Corrective Mathematics (CM),[30] which has shorter lessons and is designed to supplement the main maths curriculum rather than provide the core instruction programme as with CMC, and which would be suitable for use with KS3 students. Indeed, it is stipulated in the CMC Level D teacher's guide that the programme is not designed for, and should not be used as, a supplemental programme (Engelmann *et al*., 2013). At the start of this pilot, both CMC and CM were considered as options to explore the potential of a DI-based maths programme with the target group of KS3 students and the decision was made to pilot the CMC programme as a replacement for mainstream maths lessons. It would be interesting to explore the potential of the CM programme further in closing the gap in attainment between KS2 and KS3 that some students face. The developers recommend that if CM was piloted as an intervention for KS3 students with low prior attainment in maths, once students reached a level of mastery of basic operations they should be able to cease the intervention and better access the National Curriculum. One of the potential benefits of both of these DI programmes is that they can be delivered by any trained staff, rather than be reliant on the availability of maths specialist teachers.

Finally, if the CMC programme is to be pursued for use in England, some of the programme materials would need to be rewritten to improve the relevance of the content, for instance, sections on money. The authors of the CMC programme have developed some inserts that will appear in the next revision of the programme materials. They modify the lessons that involve monetary calculations to reflect the pound system so that they apply to the English context.

Behavioural issues

[30] See further information at: https://www.nifdi.org/programs/mathematics/corrective-math.html

Pilot schools encountered some issues with low-level disruptive behaviour during the intervention, although there was evidence that this was abating over the course of the pilot and as DI instructors and their students became increasingly familiar with the approach. Nevertheless, there were concerns raised by school staff and students themselves regarding some of the central features of the programme that contributed to some students' disengagement. These related to the lack of challenge, high component of repetition of content, prescriptive nature of the programme, and emphasis on choral responding. It may be helpful to clarify with the developers what degree of adaptation is permissible in regards to these features to enable DI instructors to tailor their delivery to students' needs and preferred learning styles—for instance, to what extent DI instructors can use their discretion to vary choral responding and individual turns, and to move forward with the content of the programme where they judge that students have demonstrated sufficient understanding.

Logistics

Some schools found it challenging to staff and group students based on the placement testing and class size restrictions. While there is limited flexibility here as these are central aspects of the CMC programme, in future, schools would benefit from greater lead-in time to test, place, and group students and prepare for implementation. Schools also found it challenging to deliver the required dosage of CMC lessons. Other literature, such as Stockard (2019) and Stockard *et al*., (2018) indicated that lower levels of fidelity to DI programme requirements can undermine the effectiveness of the programmes for student outcomes, and greater exposure is generally associated with increased outcomes. This suggests that less than optimal exposure to CMC during the pilot and the short timeframe may have been limiting factors. The developers recommend that schools achieve as close to possible as the recommended delivery of 70-minute lessons five days per week with a minimum frequency of three lessons per week. Continuous delivery of the programme across sessions is also acceptable so long as all aspects of the content are delivered in sequence (that is, that independent work is not skipped and follows the respective instruction).

Training, support, and management capacity

Although the training, support, and management of the programme were generally very well regarded by participants, there were some suggestions for minor improvements. One of these related to the need for earlier, more detailed information to be provided to schools—and cascaded within schools to the key staff involved—on programme implementation and monitoring requirements so that they know what they are signing up to and have sufficient time to prepare and allocate resources. In terms of programme monitoring, schools would also benefit from the provision of a secure platform to enable consistent and efficient completion of programme monitoring requirements. In practice, schools also needed more intensive coaching support than the weekly and fortnightly coaching visits/contacts originally envisaged; although this additional support was achieved and much valued by participants in the pilot, this would require considerable capacity to replicate at scale.

Interpretation

The pilot evaluation indicates that the CMC programme for KS3 students has the potential to improve students' confidence in their maths understanding and ability, particularly in foundation topics such as addition and counting. This is an indication that the programme could help students with low prior attainment in maths at KS3 to develop positive attitudes that may enable them to learn maths successfully. However, in the absence of a control group, the extent to which this improvement can be directly attributed to the programme is unclear as some improvement would also be expected both as students mature and as part of other 'business as usual' teaching methods, as well as potentially as a result of small class sizes.

There are also some other signs of positive impacts of the programme. Around half of the students in the pilot reported that the CMC programme had helped them to understand maths better and do better in maths. In interviews, both DI instructors and students themselves provided anecdotal examples of positive impacts on maths learning. Positive impacts on DI instructors' knowledge of, and efficacy in using, CMC were also indicated in qualitative interviews with instructors themselves as well as the developers and local delivery team. Furthermore, there was no attrition of schools or intervention groups during the study; all DI instructors continued to implement the programme for the full duration of the pilot and all had interest in continuing to use the approach (although with certain modifications)—indicating their interest in exploring its potential further.

However, the evaluation also gathered contrasting perspectives and there was less evidence of positive impacts on students' maths engagement and motivation and potentially negative changes in student behaviour in maths lessons over the course of the pilot. Around two-fifths to a half of students also reported that the CMC programme had 'no' or 'only a little' impact on their understanding and progress in maths. However, these changes cannot be attributed to the programme and could have happened anyway, particularly as this target age group of students tend to have deteriorating attitudes to school and learning.

In interviews, both DI instructors and students themselves identified aspects of the programme that they regarded as contributing to positive benefits. They valued the emphasis on mastery, feedback, independent work, and the way maths concepts were explained. However, there were several aspects of the programme that school staff and student interviewees reported to be ineffective or challenging, including the lack of differentiation, lack of alignment to the mainstream KS3 curriculum content, and the extent of prescription and repetition.

Overall, there is evidence to support some, but not all, elements of the logic model that underpinned the pilot evaluation. The lack of evidence that several of the intended short-term outcomes of the programme were achieved within the pilot evaluation and the challenges encountered with delivering some of the core features of the programme (for example, achieving the required lesson length and dosage, grouping by placement, choral responding, and scripted delivery) means that it is difficult to fully validate the logic model. The logic model could also be enhanced by reflecting the increased intensity of coaching support initially, and also the addition of further contextual factors which support—or can be a barrier—to effective implementation, particularly relating to the existing teaching culture and practices and expectations at KS3.

Overall, the evaluation found that it was feasible to deliver this programme in schools and it was delivered by DI instructors with a considerable degree of fidelity and increasing confidence during the pilot. However, pilot schools were not able to achieve the recommended optimal dosage and the pilot recruited fewer schools and students than originally planned. These findings indicate some challenges with the feasibility and attractiveness of the programme, particularly associated with timetabling, group sizes, and selecting students according to a specific programme placement test. This indicates that, although there may be a growing interest from schools in England to explore the potential of DI programmes more generally, without some modifications to the CMC programme design and implementation, schools may have concerns about the suitability of the approach and this could affect recruitment to a future trial.

The programme is well resourced with high-quality materials and specification. The implementation of the programme in schools was also effectively supported by NIFDI and Midland Academies Trust and there are indications that it would be feasible to replicate this support in a larger-scale implementation of the programme in English schools with appropriate increases in capacity. The pilot evaluation indicates that this programme may be best targeted at students in the lower age and attainment range of KS3 students.

While the success of the application of the CMC programme with this group of KS3 students is mixed in this pilot evaluation, there is a clear need for high-quality maths provision to support KS3 students who struggle with maths. There is a sense that existing approaches have not been successful historically in reducing the gap in maths attainment outcomes between disadvantaged students and their peers.

The pilot evaluation has revealed a demand and need for alternative approaches for students with low prior attainment in maths at KS3 and a growing number of schools in England are utilising structured DI programmes, indicating teachers' confidence in the approach. The CMC programme has considerable merit based on empirical evidence of impacts of its use in the U.S. and there are signs in this evaluation that the approach has much to offer as an alternative approach in England—particularly associated with the sequenced structure of the programme and emphasis on mastery of foundation concepts in maths. There would appear to be value in exploring the potential of this programme, and the DI approach upon which it is based, through further investigations that perhaps explore alternative approaches to the implementation of the programme and the effectiveness of its use in different contexts. This would help to identify how it can be most effectively deployed and whether the same benefits of the approach can be realised in English schools as have been seen in the U.S.

The evaluators recommend that, although there is some evidence of promise of this approach, some adjustments would be required before the programme was ready to be trialled at scale by a greater number of schools and students. It would also be valuable to conduct a pilot study that enabled the potential impacts of the programme to be measured

over a longer time frame of at least one academic year. This would enable exploration of whether pilot schools continued with the approach independently and the impacts on students' maths learning as they became more familiar with the approach and progressed through more challenging content of the programme. In this pilot evaluation, much was achieved in a short space of time in terms of training and equipping DI instructors to deliver the programme and there were signs that it was delivered with increasing proficiency and that initial 'teething' problems were abating over time.

While the programme itself cannot be readily modified without further field testing and undermining the evidence-based principles of the approach, a further pilot evaluation could explore modifications to the implementation of this programme, possibly considering:

- a focus on younger students—for instance, primary age and/or Year 7 students;
- provision of, and clarity around, extension materials; and
- more lead-in time to enable schools to timetable, group students, and staff the programme.

Finally, there may be an appetite amongst some schools for a pilot of a DI maths programme implemented as an intervention in addition to normal maths lessons (for instance the DI Corrective Maths programme), which would enable coverage of the National Curriculum while providing students with additional instruction and opportunities to build their confidence in more foundational maths content. However, if this option were to be pursued it would be advisable to consider how students would integrate and apply learning from the intervention into their mainstream lessons and assessments, and how the intervention would be timetabled.

Limitations

The pilot itself was small in scale, with only eight schools involved, fewer than originally planned. This means that insights are drawn from only a small number of self-selecting schools, some of which had existing knowledge of, and enthusiasm for, DI, and which represented a limited range of school contexts. The pilot evaluation also had a very limited sample size, partly due to fewer schools than planned being involved, but also partly due to fewer than anticipated students placing as requiring the programme (at either Level C or D). This limited the analysis and the scope to detect trends: for instance, the student survey response categories had to be collapsed, which reduced the sensitivity of the evaluation tools to detect changes over time. Furthermore, the students were spread across three year groups and not all schools ran the intervention with each year group, which made the small overall sample size smaller still for subgroups. This limited the scope for comparison across year groups and means the finding suggesting that CMC Level D may have been more suited to Year 7 students was based on a sub-sample (of seven schools and 92 students). Thus, any observations in the findings of changes over the course of the pilot should be regarded as tentative and treated with caution. The evaluation also draws almost entirely on evidence self-reported by either participants or the developers and delivery team staff and, hence, may be subject to biases and specific contexts that may not be widely applicable.

The pilot was conducted over a relatively short period of time restricting the evaluation to only the initial phases of implementation; later phases are likely to have been the most challenging. Furthermore, senior leaders, DI instructors, and students' experience of the CMC programme in the pilot was partial and limited to the initial sessions that focus on consolidating basic mathematical skills and concepts whereas, as the programme progresses, it covers a broader range of content. The short timescale of the pilot also restricted insights as to whether schools continued to deliver CMC—which would have provided an interesting testament to their beliefs about the programme. Furthermore, the short timescale for the baseline and endpoint survey of just three months may not have captured potential changes in attitudes to maths that may take longer to be realised.

Finally, the pilot evaluation findings are limited by the absence of a comparison group, which means that it was not possible to estimate the level of improvement that would have occurred in the absence of the programme.

Future research and publications

We recommend that the CMC programme would benefit from further study to investigate its potential to support students with low prior attainment in maths in English schools. The evidence from the pilot suggests that piloting or trialling with Year 7 only would be a more appropriate next step than across the whole of KS3. A study across the whole of KS3 would need a very large sample to allow comparison across year groups and raises concerns ethically in relation to potentially negative impacts on behaviour and engagement as well as issues regarding the lack of alignment to the

National Curriculum how it might affect imminent GCSE programmes of study for older KS3 students. A future pilot or trial may benefit from a three-arm design comparing CMC, business as usual, and usual maths teaching to small class sizes—as these conditions may be important influences on any observed outcomes for students. Alternatively, if a DI-based programme such as Corrective Mathematics were piloted or trialled, a comparison could be made to existing maths interventions and business as usual. Finally, future study of the CMC programme applied in a similar way to this pilot may need to consider the ethical implications given the potential deviation from the National Curriculum and the highly distinctive teaching approach which was reportedly disengaging for some students, including possibly the need for parental opt-in consent. Furthermore, a future study would benefit from a longer timeframe and could consider whether a DI programme should be offered as an additional 'intervention' to help support students to reduce the attainment gap with their peers. As the pilot findings were mixed, it would also be useful to explore through further research whether there are other student characteristics or implementation contexts (in addition to those measured in this evaluation) that are associated with the success of the programme. Future research could build on the evaluation instruments developed in this pilot, utilise the evidence from the piloting of a potential maths attainment outcome measure, and could be strengthened by the inclusion of a comparison/control group design.

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Appendix A: Memorandum of Understanding (MoU)

Agreement to Participate in the Direct Instruction in Key Stage 3 Connecting Maths Concepts Programme and Evaluation
Memorandum of Understanding (MoU)

Aims of the programme

The Education Endowment Foundation (EEF) has provided grant funding to the Midland Academies Trust (MAT) and US-based National Institute for Direct Instruction (NIFDI) to deliver a pilot maths intervention, Connecting Maths Concepts, to Key Stage 3 students. The National Foundation for Educational Research (NFER) will evaluate the programme.

The programme is based on the Direct Instruction model of teaching, which emphasises clearly specified, scripted lessons, designed around small learning increments. It aims to:

- increase students' confidence, enjoyment, knowledge and motivation to study maths
- increase students' attainment in maths, whilst also improving their behaviour in, and motivation to attend, maths lessons
- provide teachers with the skills required to use direct instruction with lower attaining students.

Aims of the evaluation

NFER's independent evaluation will explore whether:

- there is preliminary evidence that the programme has impacted positively on participating students and teachers
- the programme is feasible to deliver
- the programme is ready to be scaled up and evaluated as part of a larger scale study.

What is the Direct Instruction in Key Stage 3 Connecting Maths Concepts Programme and how will it work?

Connecting Maths Concepts (CMC) is a comprehensive mathematics programme which replaces normal Maths lessons for students who participate in the Direct Instruction in Key Stage 3 CMC pilot study. Classes are taught in single year groups, comprising a maximum of 14 students each. Three classes will participate in the pilot. This will comprise one each from Year 7 and Year 8, with the option of a Year 9 group, or another Year 7 or Year 8 group, dependant on placement test results.

As with all Direct Instruction (DI) instructional programmes, CMC employs an incremental-step design, which insures a high degree of student success in acquiring critical skills and concepts if students are placed correctly in the programme and taught every lesson to mastery. Students will sit a programme placement test, and the results of this will determine which students will participate. In Year 7, only students testing into level 'C' will participate, due to the need to pre-order material for September. In Year 8 (and optionally in Year 9), placement test results in June 2019 will determine the CMC level for the group (either 'C' or 'D').

The lessons involve two phases of instruction – group responses, which can require up to 50 minutes per lesson, and independent work later in the sequence which can require up to 20 minutes.

The teacher cues the students to answer chorally on group responses to maximise efficiency of delivery and practice on critical content. Teachers correct every error and repeat portions of the material missed during group instruction according to an error correction rubric in order to foster student mastery of the content. Student independent work is reviewed as a class, and students correct any errors that occur.

In-programme Mastery Tests occur every 10 lessons and are group-administered. Teachers present pre-determined remedies for the parts of the mastery tests that students miss. They record the lesson covered by each class on Lesson Progress Charts (LPCs) and the results of the mastery tests on Student Test Summaries (STS). Teachers motivate students through oral praise and through the use of a point system.

Data protection

NFER and MAT/NIFDI will collect personal data about teachers delivering the intervention, delivery staff, and students involved in the pilot in order to effectively deliver and evaluate the programme. NFER and MAT are joint Data Controllers for this project and will jointly decide on the means and purposes of processing personal data. NIFDI is a Data Processor for the purposes of delivering the CMC programme.

All data will be stored and transferred securely. No participants or schools will be identified in any evaluation report that NFER writes.

As part of your agreement to participate in this pilot, we ask that you ensure that all participating school-staff and the parents/carers of students who are taking part are provided with the attached Privacy Notices which outline how their data will be processed for this pilot study. There is a Privacy Notice for Teachers and Delivery Staff, and a Privacy Notice for Parents/Carers. Electronic versions of these documents can be found on this webpage: https://www.nfer.ac.uk/for-schools/participate-in-research/evaluation-of-direct-instruction-in-key-stage-3-connecting-maths-concepts-cmc-pilot/

What does participation involve?

Participating teachers will:

- Attend online training on how to administer the student placement test in June 2019.
- Identify students who scored below age-related expectations in the KS2 statutory maths assessment (i.e. those students with a scaled score of below 100).
- Administer the placement test to selected Year 7 and 8 students in June 2019 (who will be in Years 8 and 9, respectively, when they receive the CMC programme in the Autumn term 2019), and to Year 7 students in September 2019. Note: the training and administration of the tests can be carried out by a suitably experienced member of support staff, e.g. exams officer.
- Mark the placement tests and use the results to allocate up to 14 students per year group to the intervention, in line with the guidance provided by MAT/NIFDI. If there are too few Year 9 students who meet the criteria for the intervention the school can decide to run an additional intervention group in either Year 7 or 8.
- Attend training in August 2019 on how to deliver the intervention.
- Receive face-to-face coaching support from NIFDI staff in September 2019. Additional support will be provided by MAT and NIFDI staff for the remainder of the pilot.
- Deliver the intervention to participating students for the whole of the autumn term 2019.
- Complete regular simple monitoring information logs to record lesson duration and student attendance, and programme delivery records, such as Lesson Progress Charts (LPCs) and Student Test Summaries (STS), and share these electronically with MAT/NIFDI/NFER.
- In line with GDPR and data protection regulations, keep all personal information secure and confidential and notify us of any breaches as soon as possible.
- Take part in evaluation requirements as set out below.

The school will:

- Nominate a named teacher contact for the project and supply lists of students taking part in the intervention in each year group
- Release participating teachers/staff so that they can attend the training sessions and take part in the programme.
- Timetable Direct Instruction maths group(s) for a maximum of 14 students per year group for the duration of the pilot.
- Allow teachers, staff and students to take part in evaluation activities, including baseline and endpoint student surveys, endpoint maths assessment, lesson observations, and telephone or face-to-face interviews.
- Ensure the shared understanding and support of all school staff for the project and personnel involved.

What support will my school receive?

MAT/NIFDI will provide:

- Training for school staff on administering the CMC placement tests which will take place in two after-school sessions delivered remotely by a US-based expert via conferencing software.
- Training for teachers on critical delivery techniques for CMC which will take place at a central location over two days and will be delivered by two experienced trainers from NIFDI. Separate sessions will be provided for teachers who will be delivering Level C and those who will be delivering Level D of the programme. Schools will assign teachers to deliver one of the programme levels only. Teachers will receive instructional training followed by individual feedback from the NIFDI trainers, who will assess each participant on DI techniques on the last day of the training.
- Access to all resources (both printed and electronic) needed to deliver CMC with their students for the duration of the pilot (including Level C and D programmes)
- At least three on-site coaching visits to each school to support delivery of the programme (initial, midpoint and final visit). Onsite coaching will occur in two phases: in-class observations and post-observation feedback. The MAT/NIFDI coaching staff will observe teachers instructing groups and take data on the delivery of CMC and the responses of students. Where barriers to the successful acquisition of skills and concepts by students are identified during the lessons, live coaching may take place. Verbal feedback will be provided during each visit. After each visit, the MAT/NIFDI coaching staff will provide written feedback on what they observed and what they recommend to improve student acquisition of critical content. The coaching visits will be non-evaluative. The focus of the visits will be on student performance and participation.
- A trial of video annotation software as a method of providing specific, time-stamped feedback will also take place. Separate permission for sharing video images outside of the EU will be required, so that videos can be shared with NIFDI. A template letter will be provided.

NFER's evaluation requirements

All participating teachers and students, together with selected heads of maths, will be expected to participate in a series of light-touch evaluation activities, where invited to do so. The main evaluation activities are described below.

Students

All participating students will be required to complete a short:

- baseline online survey prior to starting the programme, in July 2019 for students who will be entering Year 8 and 9 (if applicable) in the following academic year, and September 2019 for new Year 7 students
- end-point assessment (December 2019)
- end-point online survey towards the end of the programme (December 2019).

In addition, small groups of Year 7, 8 and 9 students in four case-study schools will need to:

- take part in group discussions which will explore their views on the programme (December 2019). Separate groups will be convened for each of the different year groups that take part.

Teachers delivering the programme

All teachers will be required to:

- take part in a telephone or face-to-face interview towards the end of the pilot to discuss and reflect on their experiences of taking part in the programme (December 2019).

In addition, selected teachers will be invited to:

- be observed delivering the CMC programme, share their thoughts about the training they have received, and provide early impressions of how the programme is going (September 2019).

Heads of Maths

The Head of Maths in four case-study schools will be required to:

- take part in a face-to-face interview towards the end of the pilot to discuss and reflect on their views of the programme (December 2019).

Key dates for the programme and evaluation

Dates	Programme activities	Evaluation activities
May 2019	Recruitment closes	
June 2019	Initial training on how to administer the placement test	Observation of training session
	Placement tests administered to Year 7 and 8 students (who will be in Years 8 and 9, respectively, for the intervention). Students allocated to the programme	
July 2019		Provide lists of students taking part in the intervention in each year group
		Baseline survey of Year 7 and 8 students (who will be in Year 8 and 9, respectively, for the intervention)
27-28 August 2019	NIFDI/MAT train teachers on how to deliver the programme	Observation of training session

September 2019	Placement test administered to new Year 7 students. Students allocated to the programme	Baseline survey of new Year 7 students
	Delivery of the intervention commences	Visits to four schools to observe early programme delivery
	Coaching delivered by NIFDI/MAT	Complete fidelity log
October 2019	Coaching delivered by NIFDI/MAT	Complete fidelity log
November 2019	Coaching delivered by NIFDI/MAT	Complete fidelity log
December 2019	Delivery of the intervention finishes	End-point survey of students
		Case-study visits to four schools + telephone interviews with teachers
		Student end-point assessment

Please sign two copies of this MoU, retaining one and sending one to the Midland Academies Trust (MAT) via email to directinstruction@midlandacademiestrust.co.uk, or via post:

Direct Instruction Pilot

The Midland Academies Trust

North Warwickshire and Hinckley College

Hinckley Road

Nuneaton

CV11 6BH

We commit to the Direct Instruction in Key Stage 3 Connecting Maths Concepts Programme as detailed above.

Participating teacher (key contact):

Signed:..... Date:.....

Name:..... Role: .....

Headteacher:

Signed:..... Date:.....

Name:.....

School name: ..... School postcode:.....

Appendix B: Evaluation information sheet

NFER Evaluation of the Direct Instruction in Key Stage 3 Connecting Maths Concepts Pilot for the Education Endowment Foundation (EEF)

Evaluation Information sheet for schools

Please read this evaluation information sheet in conjunction with the '*Direct Instruction Mathematics pilot – Memorandum of Understanding*' which gives details about the Connecting Maths Concepts programme.

What are the aims of the evaluation?

The Education Endowment Foundation (EEF) is funding the Midland Academies Trust (MAT) and US-based National Institute for Direct Instruction (NIFDI) to deliver a pilot maths intervention, Connecting Maths Concepts (CMC), to Key Stage 3 students. The programme is based on the Direct Instruction model of teaching, which emphasises clearly specified, scripted lessons, designed around small learning increments.

It is intended that the programme will increase students' confidence, enjoyment, knowledge and motivation to study maths, and ultimately their attainment in maths, whilst also improving their behaviour in, and motivation to attend, maths lessons.

The pilot is being undertaken between April 2019 and March 2020 and will involve 12 secondary schools who will each be delivering the programme to up to 42 students across years 7 to 9.

The aims of the evaluation are to explore:

- **evidence of promise** – including what needs the programme addresses, the quality of teaching provided and perceived outcomes
- **feasibility to deliver** – including whether the right students are reached, the suitability of the staff training arrangements and delivery approaches, areas for improvement and scalability
- **readiness to be evaluated in a trial** – including what factors would support or hinder a successful randomised controlled trial to robustly evaluate the impacts of the CMC programme, and how it should be administered.

What activities will the evaluation involve for schools?

The evaluation involves six key activities in gathering data from the schools involved in the pilot. These are described below.

1. ***Baseline and end-point survey of students***

We will administer an online survey with all of the students who are participating in the pilot. The first survey, which will help us to establish a 'baseline' position, will be administered in

September 2019 before students begin CMC lessons. It will take around 10 minutes to complete. It will include a range of Likert-style questions in which students will be asked to assess their confidence, enjoyment, knowledge and motivation to study maths.

We will then administer a 15 minute end-point survey at the conclusion of the pilot in December 2019. This will ask students a similar set of questions to the baseline, which will allow us to assess any changes over time. It will also incorporate questions exploring students' views on the maths teaching that has been received, and any challenges they might have faced.

2. *Interviews with project managers/developers*

We will conduct semi-structured telephone interviews with: two key representatives from NIFDI; the senior leader from MAT; the MAT programme manager (if different); and the two MAT local coaches. The interviews will explore: the programme content and delivery approach; engagement of schools and teachers and demand for the programme; success of recruitment to the pilot and the feasibility of recruitment for the main trial; training approaches; and any anticipated delivery challenges. Interviews with NIFDI and the programme managers will take place at the start and end of the pilot to provide context and understanding, while interviews with local coaches will take place in December 2019 so that they can comment on their involvement with schools during the pilot.

3. *Observation of training and interviews with trainers*

The evaluation team will observe the online training sessions on how to administer the programme placement test in June 2019 to gain an understanding of the assessment, its content/outcomes, how it is administered, teachers' feedback, and the threshold for student selection for the programme intervention.

We will also observe the two-day training event for the teachers who will be delivering the intervention in August 2019. This will ensure we gain an understanding of delivery expectations and capture any initial feedback from teachers. As part of this we will carry out interviews with two of the NIFDI coaches providing the training to gather their views of how the sessions went, what worked well and what enhancements are needed.

We will visit four schools in September 2019 to observe early programme delivery. We will use a structured observation schedule to observe at least one intervention class from Year 7, 8 or 9 in each school, which will explore whether the intervention is delivered as intended. As part of the visits to the four schools, we will observe one of the NIFDI visits to a school when they provide coaching to teachers and observe delivery. We will observe responses from staff and students, alongside facilitating a short discussion with teachers and students.

4. *Case-study visits to schools*

We will conduct case-study visits to four schools towards the end of the pilot in November/December 2019. The purpose of the visits is to explore participants' views on: the programme aims, content and delivery; student selection; the feasibility of programme implementation; level of fidelity and any adaptations; dosage and reach; who has delivered

the programme (e.g. a specialist/non-specialist/TA); perceptions of impact and pupil progress; and financial and in-kind costs incurred.

In each case-study school we will carry out in-depth, face-to-face semi-structured interviews with the following:

- **Head of Maths**, to gain a perspective on the ease and challenges of programme implementation including staffing, facilities, timetabling; perceived impact on participating and non-participating students; and financial and in-kind costs to the school
- **teacher delivering the programme,** to explore: views on programme content; confidence to deliver the programme; whether they have been able to deliver it as intended (and if not why not and challenges faced); and their perceptions on impact on pupils during the pilot and the potential longer-term impact of further delivery
- **up to three groups of 4-6 students participating in the programme from each of the year groups (Year 7, 8 and 9, if appropriate)**, to explore their attitudes towards maths and their views on the programme content and its impact on them.

We will also observe programme delivery to a Year 7, 8 or 9 class in each school to assess whether it is delivered as intended and to observe responses from staff and students.

5. ***Telephone interviews with the teachers delivering the programme in each of the remaining pilot schools***

These interviews will also be undertaken in November/December 2019, and will explore the same themes as those covered with teachers as part of the case-study visits to schools.

6. ***Student endpoint assessments***

In December 2019, we will administer a maths test to all participating students in eight of the 12 pilot schools. At the time of writing, our preferred test is Hodder Education's Progress in Understanding Mathematics KS3 (PUMA KS3), a standardised test with three levels (one per term) across each year of KS3, that takes a maximum of one hour to complete. The drivers in selecting this instrument include the published validity and psychometry, correlation with KS2 results, as well as the relative brevity of the test and ease of administration for teachers.

Should the intervention be scaled up at some future point and evaluated as a randomised controlled trial (RCT), it will be necessary to administer such a test in order to establish the impact of the intervention on students' maths attainment and understanding of key maths concepts. While the findings of this test will be of interest to the evaluation team, the small size of the pilot means that that these findings will only be indicative of the possible impacts of the intervention. Rather, the main purpose of administering this test as part of the pilot is to allow us to check the usability of the test for schools in terms of burden and cost, ease of administration as part of a trial, and whether it correlates well as a measure of the intervention.

What other activities will the evaluation involve?

Alongside the telephone and case study interviews with staff and students, the evaluation will utilise information collected by MAT and NIFDI delivery teams to monitor programme fidelity. This will include fidelity logs which capture lists of participating students, and their attendance at each maths session, as well as teacher and developer monitoring and evaluation data, which will be collected after every session.

When will I need to get involved?

1. Baseline and end-point surveys of students	• September 2019: baseline survey for Year 7, 8 and 9 students • December 2019: end-point survey for all students
2. Observation of training and delivery	• June, August and September 2019
3. Complete fidelity logs	• September-December 2019
4. Case-study visits to schools	• November - December 2019
5. Telephone interviews with a teacher delivering the programme in each of the remaining pilot schools	• November - December 2019
6. Student end-point assessments	• December 2019

Who is NFER?

NFER is an independent research organisation with many years' experience of undertaking research and evaluation with schools. For more information please visit: http://www.nfer.ac.uk/

Who can I contact for more information?

Jennie Harland, the Project Leader at NFER, is very happy to answer any questions you might have. Please contact her on 01904 567606 or at: j.harland@nfer.ac.uk

Thank you very much for your support with this evaluation.

Public

Appendix C: Parent Privacy Notice

Parent/carer Privacy Notice for Direct Instruction in Key Stage 3 Connecting Maths Concepts pilot

1 Why are we collecting this data?

Connecting Maths Concepts (CMC) is a comprehensive maths programme for students of different ability levels. It covers a range of maths topics, concepts and procedures, and is taught to students using a sequence of scripted lessons and activities that teachers refer to as 'Direct Instruction'. The programme is structured to help students to master key mathematical concepts and correct any misconceptions before they move on to other related concepts; thus facilitating manageable and secure increments in learning. It is intended that the programme will increase students' confidence, enjoyment, knowledge and motivation to study maths, and ultimately their attainment in maths, whilst also improving their behaviour in, and motivation to attend, maths lessons.

The Education Endowment Foundation (EEF) has provided grant funding for the Midland Academies Trust (MAT) and US-based National Institute for Direct Instruction (NIFDI) to pilot the CMC programme with Key Stage 3 students who are assessed as requiring support with their maths learning. The pilot is being undertaken between April 2019 and March 2020 and will involve 12 secondary schools who will each be delivering the programme to up to 42 students across Years 7 to 9 during the autumn term 2019. Your child/children's school has elected to participate in this pilot study.

The programme will be independently evaluated by the National Foundation for Educational Research (NFER). The evaluation aims to explore the most effective way of delivering the CMC programme with students, and whether it shows potential to achieve its intended outcomes. The evaluation ultimately aims to inform a decision about whether the CMC programme could be used to support the maths learning of a wider group of students. The evaluation will require students to take part in a range of activities. These will include a short online survey, to be completed at both the start and end of the programme, group interviews with other students, class observations, and a maths test at the end of the programme.

Student participants' personal data will be collected as part of MAT/NIFDI's recruitment of schools and the delivery of the programme, and by NFER as part of the evaluation of the pilot. NFER and MAT are joint Data Controllers for this pilot. This means both organisations are jointly responsible for the personal data that is collected, which is needed to both deliver and evaluate the CMC programme. NIFDI is a Data Processor, which means they will use or 'process' some of the data that is collected to help deliver the CMC programme.

Last updated: 09/08/2019
Restricted

2 What personal data is being collected by this project?

MAT and NFER will collect the following personal data about each student participating in the CMC programme:

- Students' names, school name, year group and gender will be provided by the school to MAT/NFER
- Students' initial maths assessment results will be provided by the school to MAT/NFER. This will include the score and level on an initial 'placement' test which will be used to select the appropriate level of the CMC programme for students, and students' scaled maths SATs scores
- Students' ongoing maths assessment results will be provided by the school to MAT. This will consist of the mastery test scores after each 10-lesson module of the CMC programme
- Students' maths assessment results at the end of the programme based on an assessment administered by NFER
- Students' attitude to maths will be collected via a survey at the beginning and end of the programme administered by NFER. The surveys will collect each student's name, date of birth, year group and gender in order to match baseline and endpoint responses and compare maths attitudes over time and by different groups.
- Students' views on and experiences of the CMC programme will be collected by NFER as part of group interviews with small numbers of students in some of the participating schools, and observations of CMC lessons by NFER and MAT/NIFDI coaches
- Students' attendance at CMC lessons provided by the school to MAT/NFER.

Schools will use NFER's secure school portals to transfer student data electronically. All student personal data collected in hard copy by NFER will be transferred using a secure courier service.

All student personal data collected by MAT from schools will be collected electronically, password protected and transferred via secure cloud storage. Personal student data collected by MAT and shared with NFER will be transferred via NFER's secure portal.

In addition, as part of monitoring the effectiveness of teachers' delivery of the CMC programme, CMC lessons may be videoed by MAT and shared with NIFDI to enable additional and ongoing training and coaching to be provided to the teachers. Your child/children's school will provide you with a form to check whether you are happy for your child/children to appear in any video recordings as part of the pilot and for this to be shared with NIFDI.

3 What is the legal basis for processing activities?

The legal basis for processing your child/children's personal data is:

- GDPR Article 6 (1) (f) which states that 'processing is necessary for the purposes of the legitimate interests pursued by the controller(s) or by a third party except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of the personal data'.

Last updated: 09/08/2019
Restricted

MAT, NIFDI and NFER's legitimate interest for processing personal data for this pilot is to deliver and evaluate the CMC programme, which has potential to benefit students' maths learning.

Parental consent will be required for video recording of CMC programme lesson delivery and transfer of any videos to the US.

As mentioned above, your child/children's school will provide you with a form to collect your consent for your child/children to appear in any video recording as part of the pilot. If you do not give consent your child/children will not appear in any video recordings for the purposes of this pilot but they will still receive the intervention. The section below entitled 'can I stop my child/children's data being used?' sets out how you can withdraw consent for your child/children to be videoed.

4 Who will personal data be shared with?

Only NFER will see students' attitudes to maths, their views and experiences of the CMC programme, and end-point assessment scores.

Student names and placement scores will be shared securely between MAT and NFER using NFER's Secure Portal.

MAT will only share anonymised student data with NIFDI for the purposes of supporting schools to deliver the CMC programme, with the exception of videoed CMC lessons where students may be identifiable. Videoed lessons will be shared securely between MAT and NIFDI using the IRIS Connect online platform.

At the end of the evaluation, NFER will produce a report based on anonymised findings. This will be made available to EEF as well as MAT and NIFDI and will inform a decision about the appropriateness of a larger scale trial of the CMC programme. No individual student participants or schools will be identified in any report that NFER writes as part of the evaluation. No individual participant's views or responses will be identifiable from the reports NFER will write.

5 Is personal data being transferred outside of the European Economic Areas (EEA)?

NFER will not store or transfer any personal student data outside of the EEA as part of the evaluation.

Only anonymised student data collected by MAT as part of the delivery of the programme (e.g. student mastery scores) will be shared with NIFDI, based in the US.

Video recordings of CMC lessons will be shared with NIFDI. The consent obtained for making these recordings also covers their transfer to NIFDI who are based in the US. Videoed lessons will only be shared with NIFDI where the consent of parents/carers of the students in the videoed group has been obtained by the participating school.

6 How long will personal data be retained?

MAT, NIFDI and NFER will delete any personal student data within one year of the submission of the final internal report of the pilot.

7 Can I stop my child/children's personal data being used?

MAT, NIFDI and NFER will handle your child/children's personal data in accordance with the rights given to individuals under data protection legislation. If at any time you wish us to withdraw your child/children's data from the pilot or correct errors in it, please contact MAT at directinstruction@midlandacademiestrust.co.uk or NFER at j.harland@nfer.ac.uk.

In certain circumstances, data subjects have the right to restrict or object to processing. They have the right to withdraw any consent to processing that they have given at any time. They also have the right to make a subject access request to see all the information held about them. To exercise any of these rights, please contact MAT at directinstruction@midlandacademiestrust.co.uk or NFER's Compliance Officer at compliance@nfer.ac.uk.

8 Who can I contact about this project?

MAT is responsible for the day-to-day delivery of the programme. Contact the programme team at directinstruction@midlandacademiestrust.co.uk with any queries.

NFER is responsible for the independent evaluation of the programme. Contact Jennie Harland at j.harland@nfer.ac.uk with any queries.

If you have a concern about the way this project processes personal data, we request that you raise your concern with MAT and NFER in the first instance (see the details above). Alternatively, you can contact the Information Commissioner's Office, the body responsible for enforcing data protection legislation in the UK, at https://ico.org.uk/concerns/.

9 Updates

We may need to update this privacy notice periodically so we recommend that you revisit this information from time to time. The date when this privacy notice was last updated is shown in the footer at the bottom of this document.

Last updated: 09/08/2019
Restricted

Appendix D: Teacher Privacy Notice

Teacher and delivery staff Privacy Notice for Direct Instruction in Key Stage 3 Connecting Maths Concepts pilot

1 Why are we collecting this data?

The Education Endowment Foundation (EEF) has provided grant funding for the Midland Academies Trust (MAT) and US-based National Institute for Direct Instruction (NIFDI) to deliver a pilot maths intervention, Connecting Maths Concepts, to Key Stage 3 students. The programme will be independently evaluated by the National Foundation for Educational Research (NFER). Teachers' and delivery staffs' personal data will be collected as part of MAT/NIFDI's recruitment of schools and the delivery of the programme, and NFER's evaluation of the pilot. Please note, student personal data will also be collected for this pilot and this is covered in a separate Privacy Notice for the students' parents/carers, available at this link: https://www.nfer.ac.uk/for-schools/participate-in-research/evaluation-of-direct-instruction-in-key-stage-3-connecting-maths-concepts-cmc-pilot/

The Connecting Maths Concepts programme is based on the Direct Instruction model of teaching, which emphasises clearly specified, scripted lessons, designed around small learning increments. It is intended that the programme will increase students' confidence, enjoyment, knowledge and motivation to study maths, and ultimately their attainment in maths, whilst also improving their behaviour in, and motivation to attend, maths lessons.

The pilot is being undertaken between April 2019 and March 2020 and will involve 12 secondary schools who will each be delivering the programme to up to 42 students across Years 7 to 9.

NFER's independent evaluation will explore whether:

- there is preliminary evidence that the programme has impacted positively on participating students and teachers
- the programme is feasible to deliver
- the programme is ready to be scaled up and evaluated as part of a larger scale study.

The evaluation will involve teachers and delivery staff in telephone and face-to-face interviews to explore their perceptions of the programme, and observations of training and delivery to explore the extent to which the programme is delivered as intended.

NFER and MAT are joint Data Controllers for this pilot and will be jointly responsible for teachers' and delivery staffs' personal data in order to deliver and evaluate the CMC programme. NIFDI is a Data Processor for the purposes of delivering the CMC programme.

Last updated: 28/06/2019
Restricted

2 What personal data is being collected by this project?

Teacher and delivery staff personal data for this project includes data about teachers and staff members delivering the CMC programme and Heads of Maths in participating schools, as well as MAT/NIFDI coaches. We will collect:

- the name and role of teachers/staff members delivering CMC and MAT/NIFDI coaches, contact details and school name, obtained via the Memorandum of Understanding which all schools sign as they join the programme, which will be collated by MAT and shared with NFER
- practices in delivering the CMC programme obtained via monitoring information logs collated by NFER (e.g. teachers' names, roles, CMC lesson dates, duration and topics) and observations conducted by NFER
- the extent to which implementers (e.g. teachers) adhere to the intended treatment model, obtained via face-to-face and remote coaching discussions with MAT and NIFDI coaches, via completion of programme delivery information (e.g. teacher training feedback forms, Lesson Progress Charts and Student Test Summaries) which will be collated by MAT, and observations by MAT/NIFDI coaches
- views on and experiences of the CMC programme obtained via interviews with teachers (or other school staff delivering CMC), Heads of maths, and MAT and NIFDI coaches, undertaken by NFER.

Please note, teachers (or other staff delivering the CMC programme) should not name individual students in coaching discussions with NIFDI staff or share any other personally identifiable student information directly with NIFDI – all student data shared with NIFDI will be anonymised.

Schools will use NFER's secure school portals to transfer teachers' and delivery staffs' personal data electronically. Teachers' and delivery staffs' personal data collected in hard copy by NFER will be transferred using a secure courier service. Teachers' and delivery staffs' personal data collected by MAT will be collected electronically and shared via secure cloud storage with NIFDI.

In addition, as part of monitoring the effectiveness of teachers' delivery of the CMC programme, CMC lessons may be videoed by MAT and shared with NIFDI to enable additional and ongoing training and coaching to be provided to teachers. Your school will provide you with a form to collect your consent or dissent for you to appear in any video recordings as part of the pilot and for this to be shared with NIFDI.

3 What is the legal basis for processing activities?

The legal basis for processing teachers' and delivery staffs' personal data is:

- GDPR Article 6 (1) (f) which states that 'processing is necessary for the purposes of the legitimate interests pursued by the controller(s) or by a third party except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of the personal data'.

Last updated: 28/06/2019
Restricted

MAT, NIFDI and NFER's legitimate interest for processing personal data for this pilot is to deliver and evaluate the CMC programme, which has potential to benefit students' maths learning.

Your consent will be required for video recording of CMC programme lesson delivery and transfer of any videos to the US.

As mentioned above, your school/organisation will provide you with a form to collect your consent or dissent for you to appear in any video recording as part of the pilot. If you choose to dissent, you will not appear in any video recordings for the purposes of the pilot. Please see the section below entitled 'can I stop my data being used?' for details about how to withdraw at any time from the processing of your personal data as part of this pilot.

4 Who will personal data be shared with?

Teachers' and delivery staffs' personal data in the form of names, contact details, roles, and CMC practices and fidelity to the programme design, will be shared securely between MAT and NFER using NFER's Secure Portal. MAT will also share personal teacher data (e.g. data about CMC practices and fidelity to the programme design) with NIFDI for the purposes of supporting schools to deliver the CMC programme effectively, this data will be transferred electronically via secure cloud storage. Only NFER will see teachers' and delivery staffs' personal data in the form of views on and experience of the CMC programme obtained via NFER interviews.

At the end of the evaluation, NFER will produce a report based on anonymised findings. This will be made available to MAT, NIFDI and EEF and will inform a decision about the appropriateness of an efficacy trial of the CMC programme. No individual teachers' or delivery staffs' views or responses will be identifiable from the reports NFER will write. No individual teachers, schools or delivery staff, will be identified in any report that NFER writes as part of the evaluation.

5 Is personal data being transferred outside of the European Economic Areas (EEA)?

NFER will not store or transfer any teacher or delivery staff personal data outside of the EEA.

Teachers' and delivery staffs' personal data collected by MAT as part of the delivery of the programme (e.g. teachers' experiences of the training, CMC practice) may be transferred outside of the EEA to NIFDI, based in the US. Teachers' consent to transfer their data to NIFDI based in the US will be obtained. Videoed lessons will only be shared with NIFDI where the consent of the teacher in the video has been obtained by the participating school.

6 How long will personal data be retained?

MAT, NIFDI and NFER will delete any personal teacher and delivery staff data within one year of the submission of the final internal report of the pilot.

Last updated: 28/06/2019
Restricted

7 Can I stop my personal data being used?

MAT, NIFDI and NFER will handle your personal data in accordance with the rights given to individuals under data protection legislation. If at any time you wish us to withdraw your data from the programme or correct errors in it, please contact MAT at directinstruction@midlandacademiestrust.co.uk or NFER at j.harland@nfer.ac.uk.

In certain circumstances, data subjects have the right to restrict or object to processing. They have the right to withdraw any consent to processing that they have given at any time. They also have the right to make a subject access request to see all the information held about them. To exercise any of these rights, please contact the NFER's Compliance Officer at compliance@nfer.ac.uk or MAT's data protection team at directinstruction@midlandacademiestrust.co.uk.

8 Who can I contact about this project?

MAT is responsible for the day-to-day delivery of the programme. Contact the programme team at directinstruction@midlandacademiestrust.co.uk with any queries.

NFER is responsible for the independent evaluation of the programme. Contact Jennie Harland at j.harland@nfer.ac.uk with any queries.

If you have a concern about the way this project processes personal data, we request that you raise your concern with MAT and NFER in the first instance (see the details above). Alternatively, you can contact the Information Commissioner's Office, the body responsible for enforcing data protection legislation in the UK, at https://ico.org.uk/concerns/.

9 Updates

We may need to update this privacy notice periodically so we recommend that you revisit this information from time to time. The date when this privacy notice was last updated is shown in the footer at the bottom of this document.

Last updated: 28/06/2019
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Appendix E: Parent evaluation withdrawal form

Direct Instruction in KS3 Connecting Maths Concepts pilot – Evaluation opt-out form

Dear Parent / Guardian

We are writing to let you know that your child's school has agreed to be part of a research study: Direct Instruction in Key Stage 3 Connecting Maths Concepts pilot.

Connecting Maths Concepts (CMC) is a comprehensive maths programme to help students of different abilities to master maths. It covers a range of maths topics, concepts and procedures, and is taught to students using a sequence of scripted lessons.

Midland Academies Trust (MAT) and US-based National Institute for Direct Instruction (NIFDI) are supporting the delivery of the CMC programme in schools. The National Foundation for Educational Research (NFER) has been commissioned to evaluate the CMC programme by the Education Endowment Foundation (EEF).

In order to evaluate the CMC programme, certain data about your child will be collected. The Privacy Notice (available here https://www.nfer.ac.uk/for-schools/participate-in-research/evaluation-of-direct-instruction-in-key-stage-3-connecting-maths-concepts-cmc-pilot/ and attached with this form) outlines how this research will gather, use and protect data. This includes details about what type of data will be collected about your child. NFER have robust procedures in place to make sure that we comply with the increased governance and accountability requirements of GDPR.

If you are happy for your child's data to be used for this evaluation, **you do not need to return the reply slip.** However, please inform your child's teacher if you would like to withdraw your child's data from the evaluation at any subsequent stage. If you would prefer your child's data not to be shared, stored and used for this evaluation, please complete the form below and return it to your child's school.

If you have any queries please contact us via email at mathsconcepts@nfer.ac.uk

Yours sincerely,

Kathryn Hurd
Head of Survey Operations
National Foundation for Educational Research

Direct Instruction in KS3 Connecting Maths Concepts pilot – Evaluation Opt-out Form

You only need to complete this form if you do NOT wish your child's data to be shared, stored and used for this evaluation.
I DO NOT give permission for data about my child that is collected as part of the Connecting Maths Concepts pilot to be shared, stored or used for research purposes.

Your child's name……Child's class:……..

Name of school……....

Your full name……..

Your telephone number (optional)……

Your signature…… Date……....

Restricted 1

Appendix F: Teacher consent form to share data with NIFDI

TheMidland AcademiesTrust

Midland Academies Trust
Hinckley Road
Nuneaton
CV11 6BH

Chief Executive – Marion Plant OBE, FCGI

T: 024 7624 3000

W: www.midlandacademiestrust.co.uk

Consent to share personal data with the National Institute for Direct Instruction

In order to provide participating staff with support and coaching from the National Institute for Direct Instruction in the USA, it is necessary for The Midland Academies Trust to obtain your consent to share your personal data outside of the European Economic Areas (EEA). Personal data shared is detailed in the Teacher and delivery staff Privacy Notice.

By signing this form you are consenting to the data outlined to be shared with the National Institute for Direct Instruction, specifically including the transfer and sharing of videoed lessons via the IRIS Connect secure online platform.

You can withdraw your consent at any time by contacting The Midland Academies Trust via email at directinstruction@midlandacademiestrust.co.uk

Signed _____ Date _____

HARTSHILL SCHOOL Heath Lane Academy The George Eliot School the Nuneaton Academy

The Midland Academies Trust, North Warwickshire & Hinckley College, Hinckley Road, Nuneaton, Warwickshire, CV11 6BH
Telephone: 024 7624 3000 Fax: 024 7632 9056 Visit: www.midlandacademiestrust.co.uk

Appendix G: Parent cover letter and video permission template

Template for cover letter to parents

Dear parents / guardians

We are pleased to inform you that our school has been selected for a regional mathematics pilot programme this autumn, and that your child will benefit from participating in it.

Details of the pilot are enclosed, but in brief this is a pilot of an approach to teaching mathematics called Direct Instruction. It has been proven to make a significant impact on student confidence and progress in maths in the USA, and the purpose of the pilot is to show that it can also work in UK schools.

We will be working closely with partner schools in the region who have experience in delivering Direct Instruction and will also receive support from the National Institute For Direct Instruction (NIFDI) in the USA. The success of this pilot will be independently evaluated by the National Foundation for Education Research (NFER).

The information enclosed provides further information regarding the programme and the information which will be collected during the pilot. Please be assured that the findings of this pilot will not identify individual students or schools, and that wherever possible, student data shared during the course of the programme will be anonymised.

As part of the training for our staff, the programme coaches may provide feedback to our staff through a secure video recording platform called IRIS Connect. These videos will be held securely by IRIS Connect and permission to view them will only be given to coaches for the sole purpose of staff development.

As part of the coaching support provided from the USA, we require your permission for these videos to be made available outside of the UK. We would appreciate you signing and returning the permission slip below.

Permission to share video images outside of the European Economic Areas (EEA).

I give permission for video images of my child to be shared with the National Institute For Direct Instruction based in Oregon, USA.

I understand that these videos will be held securely on the IRIS Connect platform and will be viewed only for the purpose of providing support and training for teachers delivering the Direct Instruction mathematics pilot programme between August and December 2019.

I understand that I can withdraw my consent at any time by contacting [school to insert relevant details].

Child's name _____

Signed _____ Date _____

Appendix H: Student mathematics attitudes survey: Factor analysis

The results of the factor analysis of students' responses to the mathematics attitude survey at baseline are presented in this Appendix. Factor analysis is a statistical technique that summarises information from a number of survey items into a smaller set of reliable outcome measures. It combines survey items that are correlated and assess the same underlying latent construct by grouping together question items that have similar patterns of responses. This enables more robust and straightforward analysis than reporting single items. We used the factors derived through this analysis as our outcome measures to report the survey findings in this report.

Factors were selected that met the following criteria:

- strong internal consistency of each factor which indicates reliability (indicated by a high Chronbach's Alpha statistic on a range from 0 to 1)
- loadings above 0.3 which indicate an association between items and the underlying factors. The relationship of each item to a factor is expressed by a factor loading. Factor loadings are similar to correlation coefficients – a higher value on a range from -1 to 1 indicates a stronger correlation with the factor
- Eigenvalues greater than 1 which indicate strong validity of the factors (the additional variance explained by bringing items together into a single factor)
- low levels of correlation between factors, indicating that each factor is measuring something slightly different.

Some questions and items were either not entered into factor analysis as they measured related but distinctive constructs (such as the first three bullet points in the list below), or were entered into factor analysis but did not load onto factors reliably (the fourth bullet point in the list below). These items are analysed separately in the report. These questions include:

- confidence in understanding mathematics topics (fractions; measurement; equations; addition; subtraction; counting; money; multiplication; and division)
- experiences of mathematics lessons (including working on activities as a whole class, and practising learning until everyone understands)
- experiences of mathematics teaching (including teacher explanations and feedback)
- student behaviour in mathematics lessons (the item statement 'I behave well in maths lessons').

Details of the five factors that emerged in factor analysis are provided in the following tables, which present the reliability of each factor and the loadings for each of the items that make up the factor.

Table 21: Student survey: mathematics motivation factor

Mathematics motivation: item statements	Loading
Reliability of measure: Alpha = 0.826	
I enjoy learning maths	0.887
I find maths interesting	0.792
I like coming to school when I have a maths lesson	0.789
I want to do well at maths	0.471

Table 22: Student survey: relevance of mathematics factor

Relevance of mathematics: item statements	Loading
Reliability of measure: Alpha = 0.674	
I need to learn maths because it will be useful for getting a job	0.779
I think learning maths will help me in my daily life	0.751

I would like to do a job that involves maths	0.426

Table 23: Student survey: school motivation factor

School motivation: item statements	Loading
Reliability of measure: Alpha = 0.745	
I am keen to do well at school	0.815
I am interested in what I learn at school	0.617
I like school	0.405

Table 24: Student survey: mathematics class behaviour factor

Mathematics class behaviour: item statements	Loading
Reliability of measure: Alpha = 0.606	
Students listen to what the teacher says in maths lessons	0.734
My maths teacher makes sure all students are concentrating in lessons	0.408
There is often noise and disruption in maths lessons[31]	0.327

Table 25: Student survey: confidence in mathematics understanding and ability factor

Confidence in mathematics understanding and ability: item statements	Loading
Reliability of measure: Alpha = 0.833	
I understand most of the work in maths	0.804
I am confident at maths	0.762
I am doing well in maths	0.738
I learn things quickly in maths	0.722
I feel good when I can do difficult maths problems	0.361

[31] As this item was negatively worded, responses were reversed so that a positive response to this item became a negative score in the analysis.

Appendix I: Observation schedule – CMC intervention training

NFER

EECM Training Observation Schedule – CMC Intervention

The purpose of the observation is to provide an insight into how teachers/staff are trained to deliver the CMC programme.

Have *all* training materials to hand

Background information	
NFER researcher:	
Training session focus (CMC intervention)	
Training session number (1/2) and date:	
Number and ID of (NIFDI) trainer(s) present:	
Number and ID of MAT team present:	
Number of attendees: (and total number of schools represented if known):	
Role(s) of attendees: (e.g. senior leader / teacher / TA / other) *Ask for a list of attendee job roles if not obvious on the day*	
Observation duration: (e.g. start and end times, keep to time?)	

Main aims and objectives of the event:

Researcher: Please populate prior to observation, using protocol and training materials. Note: What resources were provided to attendees during training?

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Sequence of events record

Activity / focus of the session (i.e. objectives outlined)	**Time**	**Very brief notes of delivery** (e.g. delivery mode, content of session)	**Researcher observations and impressions about the session** (e.g. delivery quality, participant engagement, participant questions/comments)

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Summary of session

Quality of delivery:	
How (well) were core 'fidelity' features of the intervention explained in the training? • **Staffing:** Various staff can deliver (maths teachers/TAs). However, staff delivering the intervention must have attended all the training. • **Deliver CMC programme Level D** to selected students in Year 7, 8 and 9 (Yr 9 optional) based on selection criteria • **Timetabling** (CMC replaces all maths lessons for Autumn term – approx. 4 lessons per week x 10 weeks) • **Length of sessions** (1 hour 10 minutes per lesson, comprising 50 minutes instruction and 20 minutes independent working) • **Follow script and sequence of lessons** (from lesson 1 to 40-60) • **Complete mastery tests** (after every 10 lessons) • **Resources:** use only the programme resources provided (e.g. Teachers' Guide, presentation, displays and students' workbooks) • **Pedagogical features:** feedback, error corrections, motivation system, choral responses, independent work • **Programme monitoring and coaching:** requirements, frequency etc.	
Was the content/nature of the session as planned? (Any details of the content/nature of	

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the intervention that differ from our understanding?)	
What further support, after the two-day training, is mentioned to attendees? (e.g. coaching visits, email MAT/NIFDI coaches with queries)	
How (well) were the NFER evaluation requirements explained? (e.g. student baseline and endpoint survey; fidelity logs; endpoint assessment; observations; case study visits/telephone interviews) Any issues about evaluation activities raised?	
What challenges/barriers (if any) were identified by attendees when considering carrying out the intervention? What suggestions were given for overcoming these? • Re: the principles of the intervention – degree of 'buy in' and whether assumptions are challenged • Re: the practicalities of the intervention – logistical challenges and opportunities identified • How are attendees planning to implement the intervention?	
What key pieces of advice for successful implementation of the intervention ('what works') were discussed?	
Did the event meet with delegates expectations? Do delegates feel/appear prepared for implementation? (if possible talk to delegates to explore these questions. Note whether delegates appear to understand the	

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intervention requirements, any queries and concerns they have, Q&A)	
Were there any differences in style/quality of the delivery of NIFDI trainers (if applicable)?	
Responsiveness of attendees:	
To what extent do delegates appear to be engaged in the training session? (what opportunities was there for delegates to participate? were they more or less engaged during particular activities?)	
What questions were asked by delegates and what experiences were shared? (record a comment on adequacy of response from the trainer/s if possible to judge)	
Any other researcher observations:	

If possible speak to trainers after the training:

1. Were you happy with how the event ran today?
2. To what extent was what I observed a typical training session (for training schools to use the CMC programme)? Reasons for anything atypical?

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3. What are your perceptions of the delegates' engagement with the training today?

4. How prepared do you feel delegates are to now implement the CMC programme?

5. Is there any other support or training that delegates will get ahead of implementing the CMC programme?

6. Is there any key learning you have taken from your experiences of delivering this training? (e.g. implications for future training, CMC delivery in schools)

7. Anything else you want to say?

Thank you.

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Appendix J: Student mathematics attitude questionnaire

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PUPIL ID. | NFER No.

Pilot evaluation of Connecting Maths Concepts: Student maths attitude survey - endpoint

Introduction

Your school is taking part in research which is looking at teaching maths this term using a new programme called 'Connecting Maths Concepts'. We would like to ask you some questions about what you think about maths now that you have been taught maths in this way for almost one term.

Please think about your most recent experience of maths lessons.

What you say will be kept confidential and your teachers will not see your answers. It will only be seen by the researchers.

There are no right or wrong answers, so please answer honestly. You do not have to take part, but we would really like to hear what you think about maths.

The survey will take about 10 minutes to complete.

If you have any questions please speak to your class teacher.

If you would like to find out more about how we use the information you provide, please go to this webpage: https://www.nfer.ac.uk/for-schools/participate-in-research/evaluation-of-direct-instruction-in-key-stage-3-connecting-maths-concepts-cmc-pilot/

Thank you very much for your help with this survey.

About you

1 **What is your full name (first name and surname)?**

Please note: we will only use this so we can see what you think about maths now compared to a few months ago. We will not share your name or your answers with anyone else.

First name | Surname

2 **What is your date of birth? (dd/mm/yyyy)**

_____ _____ _____

3 **What year group are you currently in?** *Please tick one box*

Year 7 ☐ Year 8 ☐ Year 9 ☐

55039 EECM | Confidential 1 | PQ

4 **Are you male or female?** *Please tick one box*

Male ☐ Female ☐ Prefer not to say ☐

How you feel about maths

5 **How much do you agree or disagree with these statements about how you feel about maths?** *Please tick one box per row*

	Disagree a lot 1	Disagree a little 2	Neither agree nor disagree 3	Agree a little 4	Agree a lot 5
I enjoy learning maths	☐	☐	☐	☐	☐
I want to do well at maths	☐	☐	☐	☐	☐
I feel good when I can do difficult maths problems	☐	☐	☐	☐	☐
I find maths interesting	☐	☐	☐	☐	☐
I like coming to school when I have a maths lesson	☐	☐	☐	☐	☐

How you feel you are doing in maths

6 **How much do you agree or disagree with these statements about how you feel you are doing in maths?** *Please tick one box per row*

	Disagree a lot 1	Disagree a little 2	Neither agree nor disagree 3	Agree a little 4	Agree a lot 5
I am confident at maths	☐	☐	☐	☐	☐
I understand most of the work in maths	☐	☐	☐	☐	☐
I learn things quickly in maths	☐	☐	☐	☐	☐
I am doing well in maths	☐	☐	☐	☐	☐

How you feel you are doing in maths topics

7 **How confident are you in your understanding of the following maths topics…?** *Please tick one box per row*

	Very confident 1	Quite confident 2	Not very confident 3	Not at all confident 4	Don't know 5
…**fractions** (e.g. finding out one-half, three-quarters)	☐	☐	☐	☐	☐
…**measurement** (e.g. using a ruler)	☐	☐	☐	☐	☐
…**equations** (e.g. 3 + a = 5)	☐	☐	☐	☐	☐
…**addition** (e.g. adding numbers together, 3 + 3 = 6)	☐	☐	☐	☐	☐
…**subtraction** (e.g. taking one number away from another, 3 – 1 = 2)	☐	☐	☐	☐	☐
…**counting** (e.g. 1, 2, 3, 4…)	☐	☐	☐	☐	☐
…**money** (e.g. recognising coins, 10p, 5p, £1)	☐	☐	☐	☐	☐
…**multiplication** (e.g. times tables, 2 x 2 = 4)	☐	☐	☐	☐	☐
…**division** (e.g. dividing one number by another, 6 ÷ 3 = 2)	☐	☐	☐	☐	☐

How you feel about maths lessons

8 **How often do you do these things in your maths lessons?** *Please tick one box per row*

	Often 1	Sometimes 2	Rarely 3	Never 4
When we learn new topics in maths, we see how they link to topics we already know	☐	☐	☐	☐
We work on maths activities on our own	☐	☐	☐	☐
We work on maths activities as a whole class	☐	☐	☐	☐
We work on maths activities in small groups	☐	☐	☐	☐
We practise what we have learned in maths lessons until we really understand it	☐	☐	☐	☐
We move through maths topics quickly	☐	☐	☐	☐
We link what we learn in maths to daily life	☐	☐	☐	☐

How you feel about maths teaching

9 How much do you agree or disagree with these statements about your maths lessons?
Please tick one box per row

	Disagree a lot 1	Disagree a little 2	Neither agree nor disagree 3	Agree a little 4	Agree a lot 5
My teacher uses different equipment and examples to help me understand maths (e.g. a number line, counters)	☐	☐	☐	☐	☐
My teacher explains maths in ways that make it clear and easy to understand	☐	☐	☐	☐	☐
My teacher tells me when I have done well in maths	☐	☐	☐	☐	☐
My teacher tells me when I need to do better in maths	☐	☐	☐	☐	☐
My teacher sets me work to suit what I can do in maths	☐	☐	☐	☐	☐

How you feel about behaviour in maths lessons

10 How much do you agree or disagree with these statements about behaviour in your maths lessons? *Please tick one box per row*

	Disagree a lot 1	Disagree a little 2	Neither agree nor disagree 3	Agree a little 4	Agree a lot 5
My maths teacher makes sure all students are concentrating in lessons	☐	☐	☐	☐	☐
Students listen to what the teacher says in maths lessons	☐	☐	☐	☐	☐
I behave well in maths lessons	☐	☐	☐	☐	☐
There is often noise and disruption in maths lessons	☐	☐	☐	☐	☐

What you think about maths in daily life and jobs

11 How much do you agree or disagree with these statements about maths in daily life and jobs? *Please tick one box per row*

	Disagree a lot 1	Disagree a little 2	Neither agree nor disagree 3	Agree a little 4	Agree a lot 5
I think learning maths will help me in my daily life	☐	☐	☐	☐	☐
I need to learn maths because it will be useful for getting a job	☐	☐	☐	☐	☐
I would like to do a job that involves maths	☐	☐	☐	☐	☐

What you think about school in general

12 How much do you agree or disagree with these statements about how you feel about school in general? *Please tick one box per row*

	Disagree a lot 1	Disagree a little 2	Neither agree nor disagree 3	Agree a little 4	Agree a lot 5
I like school	☐	☐	☐	☐	☐
I am keen to do well at school	☐	☐	☐	☐	☐
I am interested in what I learn at school	☐	☐	☐	☐	☐

Your views on maths lessons this term using a new maths programme (called Connecting Maths Concepts)

13 How much do you like or dislike the way you have been learning maths this term? *Please tick one box*

Dislike it a lot 1	Dislike it a little 2	Neither like it nor dislike it 3	Like it a little 4	Like it a lot 5
☐	☐	☐	☐	☐

14 How much do you like or dislike the following things about your maths lessons this term?
Please tick one box per row

	Dislike it a lot 1	Dislike it a little 2	Neither like it nor dislike it 3	Like it a little 4	Like it a lot 5
Answering the teacher's questions as a whole class	☐	☐	☐	☐	☐
Going over things until everyone in the class understands	☐	☐	☐	☐	☐
Teacher and students points competition	☐	☐	☐	☐	☐
Finding out how you are doing in mastery tests (i.e. topic tests every 10 lessons)	☐	☐	☐	☐	☐

15 Has the new maths programme you used this term…
Please tick one box per row

	Not at all 1	A little 2	Quite a lot 3	A lot 4
…helped you understand maths better?	☐	☐	☐	☐
…helped you do better at maths?	☐	☐	☐	☐
…made you more confident at maths?	☐	☐	☐	☐

You have reached the end of the survey.
Thank you very much for answering our questions.

Appendix K: Statistical analysis plan (Evaluation Plan Annex)[32]

Survey analysis

All students who are present in the pilot will be invited to complete a baseline questionnaire in September 2019 and an end-point questionnaire in December 2019 to explore their attitudes to mathematics. A research question (see 1c) of this pilot is to assess whether the intervention has an impact on students' attitudes to mathematics. Students will be presented with a set of statements (items) about mathematics attitudes and experiences to which they respond by selecting from a scale ranging from 'Disagree a lot' to 'Agree a lot'. These items will be repeated in the end-point questionnaire.

The end-point questionnaire will include a small number of additional questions that will explore students' views of CMC lessons and the extent to which the programme has helped their mathematics learning. These additional questions will be measured using a five-point rating response scale (Likert scale) e.g. ranging from 'not at all' to 'a great extent'.

We aim to carry out the following two analyses using the survey[33]; an analysis of the change over time and an analysis of the additional end-point questions.

Survey analysis: change over time

Firstly, we will carry out an explanatory analysis of the responses to the baseline questionnaire. We will carry out a factor analysis at baseline to obtain a smaller set of underlying factors which represent the bulk of the correlation structure. The eigenvalues and scree plot will be examined to consider a suitable number of factors for further investigation. Items will be loaded into factors based on their correlation to these underlying factors. We will use principal axis factoring and varimax rotation to extract these factors. We will combine those variables which have large positive or negative loadings on each factor to create a factor score which is the sum of the scores of items that cluster together. We will then replicate the method of creating these factor scores to the end-point questionnaire, only selecting questions that appear in the baseline questionnaire

We will investigate whether there is a difference in students' attitude to mathematics at baseline and end-point. We will conduct a paired t-test, for each factor, to test if there is a significant difference in students' overall factor score between the two time points. A significant *p*-value of less than 0.05 will suggest that there is a statistically significant difference between the baseline and end-point factor scores.

Factor scores at end-point will be dependent variables in separate multilevel models (depending on the number of factors) containing two levels (school and student). The covariates entered into this model will be the factor score at baseline, gender, year group and treatment dosage. These models will be produced to investigate whether these covariates are associated with a student's response at end-point. This analysis will help to inform the measurement of students' mathematics attitudes in a future trial.

Survey analysis: additional end-point questions only

Selecting questions that have appeared in the end-point questionnaire only, we wish to test whether there is a significant difference in students' end-point response between the following categorical variables:

- Gender
- Year group
- Treatment dosage

[32] The analysis plan was originally written as an annex to the evaluation plan prior to the start of implementation of the CMC programme.
[33] Please note that the results should be treated with caution given that the time between pre- and post-test for the survey is very short in this pilot.

We will use ANOVA (analysis of variance) to compare the means of students' score between groups. A significant *p*-value of less than 0.05 will indicate that there is sufficient evidence to suggest a statistical difference in responses between groups.

The treatment dosage measure is given by the total hours of the CMC intervention that each student receives. As the expected dosage for each school is 40-60 lessons, it is likely that most students will attend a similar number of lessons and within this range. The number of lessons a student attends will be multiplied by the average length of lessons to create the total hours spent on the intervention dosage measure. The table below summaries the different categories of the treatment dosage[34].

Level of dosage	Description (total hours spent on the intervention)
None	0 hours
Low	1-30 hours
Medium	31-40 hours
High	41 hours and above

End-point assessment analysis

We will also carry out analyses of the end-point assessments (see research question 3). We will select up to three PUMA assessments to test. We propose to select from tests that target between the autumn term of Year 5, to the summer term of Year 6. The selection of tests will be guided by the amount of students placing in Level D of the intervention and review of the tests to consider the level of difficulty in relation to the Level D CMC programme.

The analysis of the end-point assessments will consider the distribution of raw scores from each test to identify which PUMA test has the best distribution profile for students that received the intervention at Level D. The best distribution is identified as the test which when producing a histogram to show the distribution of test scores, closely resembles a bell shape. These histograms will also investigate the appropriateness of the tests, as a heavily skewed distribution would indicate that the test is either too easy or too difficult.

To investigate the relationship between the placement test and end-point measure, we will carry out a multilevel regression model with two levels (school and student), the end-point assessment score as the dependent variable and the placement test score as a covariate. This analysis will help to inform the selection of an appropriate baseline measure in a future trial.

[34] The categorisation of dosage was revised during the analysis phase after the end of the pilot and was based on the number of lessons of the CMC programme delivered, as recorded in lesson progress charts and provided by MAT and NIFDI: low = 14-17 lessons of CMC; medium = 18-24 lessons of CMC; high = 25-30 lessons of CMC.

Appendix L: Analysis of student survey responses by year group, gender and CMC dosage

Table 26 below displays the results of the multi-level model analysis to explore the influence of three covariates (year group, gender and CMC dosage) on the five survey factor scores measuring students': confidence in mathematics understanding and ability; mathematics motivation; views on the relevance of mathematics; class behaviour in mathematics lessons; and school motivation.

Table 26: Multi-level model analysis of student survey responses by year group, gender and CMC dosage

Outcome	Variable of interest	Effect size (confidence interval)	p-value
Factor 1: confidence in mathematics understanding and ability	Baseline	0.10 (0.07,0.12)	0.00
	Gender (Male)	0.22 (-0.03,0.47)	0.08
	Year 8	-0.40 (-0.75,-0.06)	0.02
	Year 9	-0.23 (-0.67,0.21)	0.30
	CMC (Medium)	-0.04 (-0.4,0.32)	0.80
	CMC (High)	0.20 (-0.22,0.61)	0.36
Factor 2: mathematics motivation	Baseline	0.11 (0.06,0.15)	0.00
	Gender (Male)	0.12 (-0.22,0.46)	0.49
	Year 8	-0.50 (-0.96,-0.05)	0.03
	Year 9	-0.60 (-1.19,-0.01)	0.05
	CMC (Medium)	0.42 (-0.05,0.89)	0.08
	CMC (High)	0.45 (-0.10,1.00)	0.11
Factor 3: school motivation	Baseline	0.2 (0.15,0.25)	0.00
	Gender (Male)	0.14 (-0.16,0.43)	0.37
	Year 8	0.09 (-0.32,0.49)	0.68
	Year 9	-0.36 (-0.88,0.16)	0.17
	CMC (Medium)	-0.01 (-0.42,0.47)	0.97
	CMC (High)	0.34 (-0.15,0.85)	0.17
Factor 4: relevance of mathematics	Baseline	0.14 (0.09,0.19)	0.00
	Gender (Male)	0.17 (-0.1,0.44)	0.21
	Year 8	0.15 (-0.24,0.54)	0.43
	Year 9	-0.11 (-0.59,0.37)	0.64
	CMC (Medium)	0.09 (-0.33,0.56)	0.67
	CMC (High)	0.05 (-0.43,0.54)	0.83
Factor 5: class behaviour in mathematics lessons	Baseline	0.09 (0.04,0.15)	0.00
	Gender (Male)	0.11 (-0.14,0.36)	0.39
	Year 8	-0.42 (-0.81,-0.05)	0.03
	Year 9	-0.56 (-1.06,-0.09)	0.02
	CMC (Medium)	0.35 (-0.07,0.89)	0.11
	CMC (High)	1.12 (0.66,1.68)	0.00

This document is available for download at https://educationendowmentfoundation.org.uk

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