Increasing Competence and Confidence in Algebra and Multiplicative Structures (ICCAMS) Evaluation

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Protocol Amendments

- General changes throughout: Updating language e.g. proposed intervention to intervention to reflect activities now undertaken.
- Evaluation Summary: Minor changes
- Added team details at beginning of document.
- Note/Acknowledgement: Minor changes including additional acknowledgement of investigator team.
- Background: Minor changes only including updating language.
- Existing research: Minor changes only e.g. extra references, learners changed to students.
- The ICCAMS Maths Intervention: Substantial changes to describe the intervention more accurately/usefully.
- ICCAMS 2 Development…: Minor/general changes only
- ICCAMS 2 Main trial…: Minor/general changes and expansion of bullet point 4
- Research questions: Minor/general changes overall and more substantial alteration of research questions 6-10.
- Impact evaluation design: Minor/general changes only

- Randomisation: Major changes to reflect actual process, which include introducing 3 categories of data for two strata (FSM and GCSE %) to overcome confounding, outlining steps taken (Step 1: Setting Criteria for High, Medium, and Low; Step 2: Dealing with Missing data; Step 3: Inspecting blocks by area and applying tolerances; Step 4 – Setting Allocation rules and allocating schools)
- Participants: Substantial changes to reflect actual process.

  Introducing Figure: Block definition for randomisation within regions; and Table: Allocation for even sized blocks (Intervention/Control)

  Details of participation agreement and process added

  Details of recruitment process added including non-exclusion of previous KS3 MR project; Table of final recruitment and randomisation per region was also included.

  - Sample size calculations: Minor/general changes only.
  - Outcome Measures: Small changes to ‘baseline outcome’, substantial changes to ‘primary outcome’ and small changes to ’secondary measures’. Major changes to the final part of this section including insertion of detailed ‘additional measures’.

Baseline outcomes: Additional details requested from schools in order to match pupils added; funding of control schools added.

Primary outcome: Revised to raw scores on adapted version of MALT including some details of adaptations made; addition of invigilators and markers blind to condition and dates of testing.

Added recalibration of previously validated scales using pilot data for dispositions; testing of linear assumption; baseline and post-test nature of student survey.

Added additional measures section (page 18) to describe the need and process of constructing measures of (perceptions of) teaching practice.

- Implementation and process: Major changes including additional sections on potential issues, overview of IPE, and student surveys.

Added IPE focus; potential reasons for lack of difference with control schools; Added a table with an overview of IPE.

- Surveys: Added section on student surveys including inclusion of items on perception of teaching
  - Capturing fidelity: Major changes to reflect actual process.

  Addition of PD observation of ICCAMS lessons and observation measure; process of validation through double marking; development of simpler scoring system.

  - In-depth longitudinal: Minor/general changes only
  - Analysis plan: Minor changes
  - Ethics and registration: Substantial addition of details of ethical processes undergone.
  - Risks: Minor changes only
  - Timeline: Small changes to update.
  - References: Minor revisions and additional references.

Evaluation Summary	
Age range	Secondary (Key Stage 3, Years 7 and 8)
Number of students	Estimated 11000 (based on an average of 100 students per school) Recruited 21500 (approximately)
Number of schools	Estimated 110 schools Recruited 109 schools
Design	Two arm (2-year) cluster randomised control trial
Primary Outcome	Maths attainment gains as measured by a maths test at end of Year 8

Independent Evaluation of Project ICCAMS Maths

A two-arm 2 year Cluster Randomised Control Trial

TRIAL PROTOCOL

Chief Evaluator: Dr Maria Pampaka

Protocol Version: 2

Protocol Date: September 2016

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Funder: Education Endowment Foundation

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Note/Acknowledgement: The **ICCAMS Maths** study was proposed by the Investigator Team (from Nottingham University, led by Professor Jeremy Hodgen, with the subcontracted Team from the Centre for Evaluation and Monitoring, Durham University, led by Victoria Menzies and Gemma Stone). Many of the main study design elements were proposed by the Investigator Team in their initial funding application to the EEF. These and many other aspects of the study and the detail of the evaluation were discussed collaboratively between the three teams and EEF. The independent

randomisation, the data collection of primary and secondary outcomes and analysis of the ICCAMS Maths study for the EEF report are the responsibility of the independent Evaluation Team, led by Maria Pampaka. Without compromising the independence of the evaluation, we have consulted throughout and benefited from the advice of the Investigator Team. The purpose of this document (the Evaluation Protocol) is to describe that evaluation process and, in line with EEF policy, is authored by the Evaluation Team, but in order to do that well the study research proposal has been incorporated within this evaluation protocol.

Table of Contents

BACKGROUND: THE ICCAMS STUDY

The ICCAMS Maths intervention was developed in a recently completed 4.5 year ESRC-funded project[1], which focused on improving teaching and learning in Key Stage 3 mathematics. ICCAMS Maths is designed to teach two mathematical areas that are a key part of the Key Stage 3 curriculum, but which cause particular problems to students: algebra and multiplicative reasoning. The teaching development programme is comprised of 40 lesson plans, 20 associated mini-assessments, 20 revisit activities and an extensive professional development (PD) programme.

The lessons are designed to help teachers use formative assessment (and feedback) in mathematics, helping them to identify the problems students struggle with and how to address them. Activities are set in contexts that students can engage with, are collaborative, and use visual representations to help develop understanding. The lessons are designed to address the key conceptual ideas underlying the Key Stage 3 mathematics curriculum in algebra and multiplicative reasoning, and are aligned with the revised mathematics National Curriculum.

The current study aims to compare the effect of the ICCAMS Maths intervention (when delivered 'at distance' through the institutional network of Maths Hubs) to a 'business-as-usual' control group in a cluster randomised controlled trial, and with a particular focus on addressing the mathematical learning needs of low attaining students in deprived socio-economic contexts.

During the first development / pilot year of the project, the ICCAMS Maths intervention was adapted (i) for teaching over two years (rather than over one academic year as in the original project) and (ii) to provide particular support for low attaining students and their classes. In addition, the University of Nottingham team developed material that explicitly describes the ICCAMS Maths PD programme so that it can be delivered independently and with a degree of fidelity (including materials to train and support the Professional Development (PD) leads).

THE EXISTING RESEARCH EVIDENCE

The initial ICCAMS ESRC study (ICCAMS 1) aimed to investigate ways of raising students' attainment and engagement with the use of formative assessment in order to inform teaching and learning of mathematics in secondary school. The focus was on the mathematical areas of algebra and multiplicative reasoning for Key Stage 3, which are considered to be the cause of particular problems for students. The first phase of the study involved a longitudinal national survey of Year 9 students which used tests first developed in the 1970s under the framework of Concepts in Secondary Mathematics and Science (CSMS) in order to provide up-to-date empirical evidence on (i) current lower secondary students' understandings of and difficulties with algebra and multiplicative reasoning, (ii) rates of progression across Key Stage 3 (KS3), and (iii) differential performance across the cohort. In addition, this survey enabled a comparison of students' understanding over time. This comparison provided evidence of a decline in students' understanding in algebra and ratio since the 1970s (Hodgen, Brown, Küchemann, & Coe, 2010; Hodgen, Coe, Brown, & Küchemann, Under review). In response to this, the 'ICCAMS 1 team' suggested the need for a more topic-focussed formative assessment approach to the teaching of these areas (Hodgen,

[1] The ICCAMS Maths intervention was developed in the ICCAMS 1 project (Increasing Competence and Confidence in Algebra and Multiplicative Structures), which was funded by the Economic and Social Research Council (ESRC), grant reference RES-179-25-009 (2008-2012). For more information, see: http://iccams-maths.org/

Brown, Kutchemann, & Coe, 2010). Research suggests formative assessment is an effective approach to increasing attainment and engagement (Black, Harrison, Hodgen, Marshall, & Serret, 2011; Black & Wiliam, 1998a). Indeed, although Formative Assessment (FA) is not currently included amongst the topics in the EEF Toolkit, three key elements of FA are amongst the approaches with the highest impact: feedback, peer tutoring and metacognition/self-regulation.

However, despite widespread take-up of FA nationally and internationally, there is a developing body of evidence that teachers have considerable difficulties implementing these ideas (e.g. Smith & Gorard, 2005). This may be because formative assessment has been described vaguely and is thus difficult to implement, or at least it is difficult to be sure when it is being authentically implemented (Bennett, 2011). It may also be – particularly for secondary contexts where pedagogy is formulated as Pedagogical Content Knowledge - because formative assessment has largely been described generically rather than in subject-specific terms (Watson, 2006). There is evidence that teachers find it more straightforward to implement the generic and more procedural techniques of formative assessment such as traffic lights, and 'no hands up and lolly sticks' practices (Marshall & Drummond, 2006). Whilst these techniques can be a useful means to an end, they do not embody the key aspects of formative assessment that have been shown to be effective. For example, the evidence on effective feedback indicates that it should be specific to the task, yet metacognitive in purpose (e.g., see the EEF Toolkit, and Wiliam, 2007). Teachers' ability to use formative assessment in mathematics is therefore limited by their knowledge about key mathematical ideas, how they develop in context, and the likely progression of student learning in them. Thus if teachers focus on teaching mathematical procedures they may find it difficult to see what is causing problems for students in mastering and applying these, and may thus have difficulty responding to the students' difficulties (Hodgen, 2007; Watson, 2006). What is needed – in conclusion – is mathematically and task situated formative assessment practices: this is what ICCAMS Maths aims to provide.

In developing this mathematically oriented approach to formative assessment, the ICCAMS approach was guided by the following principles, drawn from the research literature on mathematics teaching and learning:

1. To set activities in *realistic* contexts (e.g., Streefland, 1991). By realistic, we do not mean that all the activities are set in real life contexts that students may have encountered, but rather contexts that the students can imagine and engage with.
2. To make *connections* between mathematical ideas (e.g., Askew et al, 1997)
3. To encourage students to *collaborate* and *talk* (e.g., Slavin et al, 2009).
4. To use *multiple representations*, such as the Cartesian graph or the double number line, to help students better communicate, understand and connect mathematical ideas and to help teachers appreciate students' difficulties (e.g., Gravemeijer, 1999).

The ICCAMS approach to PD is informed by the literature on teacher professional development (Adey, 2006; Adey, Hewitt, Hewitt, & Landau, 2004; Cordingley, Bell, Evans, & Firth, 2005) and by the same principles that guide the ICCAMS lessons.

In the original ESRC-funded study, the ICCAMS approach was evaluated in the third phase through an intervention study with a group of Year 8 students in a wider group of schools. This intervention study showed that ICCAMS students made greater

progress than a matched control group, a gain equivalent to typical growth in scores over a year (Hodgen, Coe, Brown, & Kuchemann, 2014, p. 171).

THE ICCAMS MATHS INTERVENTION

The ICCAMS Maths Intervention consists of 40 lessons, 20 mini-assessments and 20 revisit tasks to be taught over the first two years of secondary school: Year 7 and Year 8. The lessons are organised in pairs: two closely linked lessons that are preceded by a related mini-assessment (10-15 minutes) (see Figure 1). Revisit tasks are short (10-15 minutes) designed to enable teachers to follow up and consolidate key ideas. The order of lessons reflects the revised KS3 National Curriculum. Some optional lessons are provided that have been designed to enable teachers to adapt the intervention for low attaining students/classes and for high attaining students/classes.

Figure 1: The structure of ICCAMS lesson pairs and mini-assessments

The current intervention aims to provide opportunities for teachers to collaborate in school as well as in professional development (PD) sessions, which are centred around the mini assessments and lesson pairs. Some lessons are dealt with in more depth during the PD than others are, but sessions are designed to ensure that during the project the teachers consider the key ideas underlying Key Stage 3 algebra and multiplicative reasoning, and how they are developmental in practice in their classrooms. In each PD session, teachers observe and discuss a video either of ICCAMS class activities or of a small group of students grappling with a key idea in algebra or multiplicative reasoning.

During the first year of the intervention, delivery of lessons is as shown in Table 1.

Table 1: Planning and delivery of lessons during first year of intervention

Location	**Teachers**
PD Session	• do (and extend) the mathematical tasks that the students will do • consider the possible difficulties students will have (including errors and misconceptions) • collaboratively plan how they will teach the lessons in their own classes
School	• teach the lesson
PD Session	• reflect on the students' learning, the potential for its development in 'generalisation', the mathematics involved, the formative assessment strategies used, and how the lesson fits within the sequence of lessons • consider possible adaptations of the lesson • plan for how they will deliver the cascade training for those lessons they have already taught to the other teachers in the school
School	• deliver cascade training

During the second year of the intervention, lead teachers conduct their reflection on lessons taught with colleagues at their own school, then go on to deliver cascade training immediately following this, without the intermediary step of reflection at a PD session.

The CPD-pedagogic model of this intervention involves two teachers from each school deemed to have potential and recommended as such by the school, to lead and support the ICCAMS delivery in the school, (with one of them being ideally the Maths Head of Department or someone of clear influence for the school 'cascade') attending the formal PD. These teachers are then responsible for cascading the training to their colleagues in school. It should be noted that materials for cascade training will be provided for the core teachers. Over the two years of the project, there will be nine PD sessions (six sessions in 2016/17 and three sessions in 2017/18) for teachers, which will be organised and led by the PD Lead in each area. Where there is teacher turnover PD Leads will provide catch up training on an as-required basis.

Teachers will be provided with a handbook containing details of the intervention, lesson plans, the mini-assessments, revisits and guidance on adapting the intervention for low and high attaining students/classes.

The PD Leads recruited to deliver the intervention have significant professional development experience in secondary mathematics education. Durham University have created a programme of training for the PD Leads which involved a three-day training session in May 2016, two days training in September 2016, and ongoing single days of training throughout the project. PD Leads will also regularly network with the Developer team and each other through regular conference calls (fortnightly in the first year and monthly during the second year).

The Developer team are working with the National Centre for Excellence in Teaching Mathematics (NCETM) in the delivery of the ICCAMS intervention. Specifically this involves working with nine Maths Hubs across the five recruitment areas. In each area, the Maths Hub supported recruitment to the trial and will continue to promote and support schools doing the intervention during the trial through the forming of an ICCAMS work group. The work group will be led by an Assistant PD Lead who will support the PD Lead during the project while developing the skills to lead the training after the trial. This Assistant PD Lead will be nominated by the Maths Hub in each area, ideally located in a school not involved in the trial. They will be expected to attend all the PD sessions for schools in their area, deliver the ICCAMS lessons and cascade training in their schools and to support the PD Lead in the delivery of the PD Sessions (becoming progressively more involved over the two years). There will also be two days of training for the Assistant PD Lead led by Durham in December 2016 and September 2017. The Maths Hubs will be compensated for the time required for the Assistant PD Lead (15 days) in the form of a £3000 payment to the lead Maths Hub in each area for their role in the project.

One aim of this study is to deliver the ICCAMS Maths PD intervention in such a way that it can be delivered without direct support from the original developers, the University of Nottingham team. Hence, the Durham team will be responsible for leading the trial and the training for PD leads, although the University of Nottingham team will provide expert advice and support. In addition, the Durham team will be responsible for collecting data on implementation fidelity and for maintaining contact with participating schools (in conjunction with the PD leads).

This CPD model has implications for the implementation of the intervention (i.e. it is designed to be relatively feasible for schools nationwide) and it creates opportunities for the evaluation to consider whether different implementations of PD led to differential effects (e.g. greater effects for those directly involved in the PD than cascade teachers).

METHODS

The ICCAMS2 study was designed to be implemented in two main phases. Phase 1, the Development and Piloting was led by Nottingham, whilst Phase 2, the Main Trial, is led by Durham and the Evaluation by Manchester.

ICCAMS2 PHASE 1 - DEVELOPMENT AND PILOTING

Phase 1 took place between June 2015 and July 2016 with a primary objective to design and pilot the research methodology. The particular aims of this stage stemmed from the teams' interest in better understanding (a) the specific difficulties that low attaining students faced in mathematics classrooms, (b) how the ICCAMS Maths intervention could be better adapted to suit these students' learning needs, and (c) how teachers could be supported to more fully adopt the ICCAMS Maths approach and lessons with low attaining students. During this stage a replicable model of PD for the intervention was developed and described (Durham). Finally, and more relevant to the evaluation, fidelity measures were developed and initially piloted, alongside piloting the other relevant instruments for the secondary outcomes. The main objectives (along with roles and actions) for this phase are listed below:

- Development and adaptation of approaches to specifically support the implementation of the ICCAMS Maths pedagogic methods with low attaining groups (Nottingham).
- More explicit description of the ICCAMS Maths PD programme so that it can be delivered independently and with some sort of metric of fidelity. (Nottingham with support from Durham.)
- Development of a cascade model of the delivery of PD to other teachers in school (Nottingham with advice from Durham).
- Adapt the ICCAMS intervention for delivery over two years rather than one as in the original project (Nottingham).
- Develop and pilot fidelity evaluation and measures for the intervention (Durham, with support from Manchester and Nottingham).
- Pilot MALT tests for calibrating the sub-measure of multiplicative reasoning and algebra (Manchester).
- Pilot student attitudinal measures and teachers' attitudes and practice (Manchester).

The newly developed training model for PD Leads, the teacher PD and the new resources were piloted in a piloting phase with eight to ten schools in one area (close to Nottingham) between January 2016 and July 2016. Data was collected through (a) interviews with students in small groups about mathematics, (b) evidence from students work (via examples), (c) interviews with teachers and students about the ICCAMS2 intervention, (d) observations of lessons and PD sessions, and (e) piloting of fidelity and other measures to be used for the main trial with students and students.

The final Logic Model for the study is presented in Figure 2:

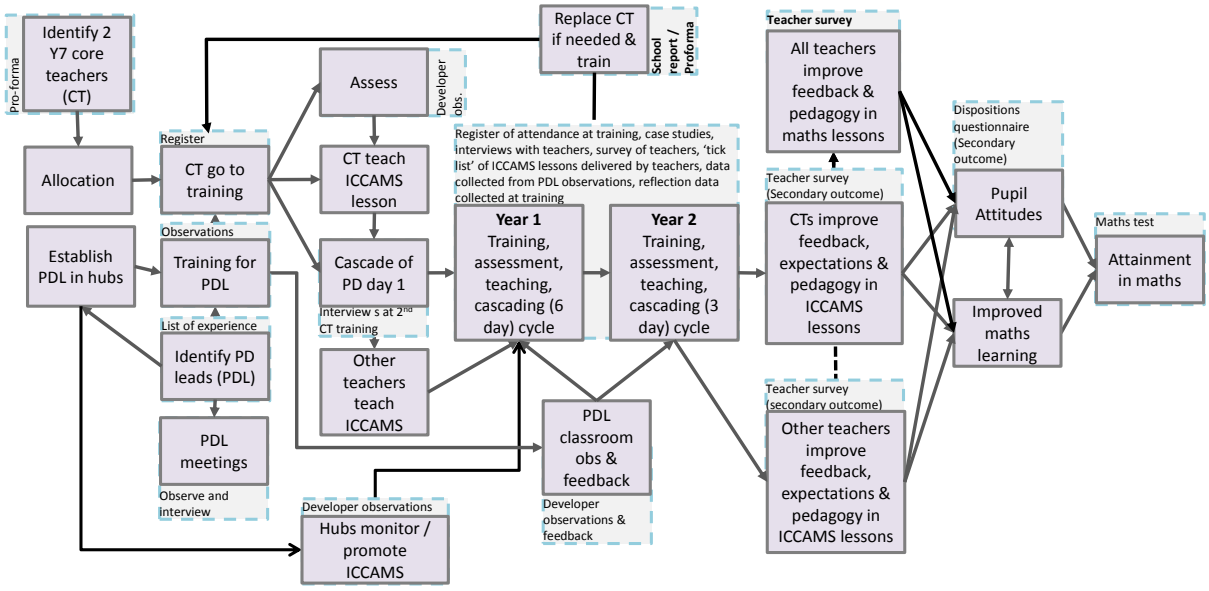

Figure 2: Logic Model for ICCAMS2

ICCAMS2 PHASE 2 - MAIN TRIAL DESIGN

The main trial is a cluster randomised controlled trial which will run for two academic years with the intervention schools running the intervention for all students in Year 7 initially and for the same students again when they are in Year 8 (September 2016 to July 2018). The roles in the trial will be as follows:

- Durham (with support from Nottingham) to recruit nine Maths Hubs across five centres.
- Manchester to randomise schools within each hub to intervention or 'business-as-usual' control in July 2016.
- Durham will be responsible for the delivery of the intervention and maintaining contact with intervention and control schools during the project (with guidance from Nottingham).
- Manchester will be responsible for conducting the primary and secondary outcome assessments, which will be collected at the end of the second academic year as well as the baseline survey measures collected in September 2016.
  Durham and Manchester will collaborate in the creation of implementation and process evaluation indicators, while main responsibility for collection of data against each indicator lies with each institution respectively. These indicators will be finalised by September 2017 and the protocol updated with these indicators in an Appendix by October 2017

RESEARCH QUESTIONS

The evaluation is designed considering the following principal question:

"Does the ICCAMS-trained teaching practice improve students' learning outcomes in Year 8, as compared to 'business as usual' teaching practice?"

In addition, the evaluation will investigate and where possible measure the effects of the ICCAMS Maths intervention on (a) changes in teaching / pedagogy, (b) changes

in students' algebra and multiplicative strategies and reasoning, and c) changes in students' disposition towards mathematics.

The following research questions (RQ) will guide the impact evaluation:

Primary Question:
RQ1: Do students in schools implementing ICCAMS Maths over a two-year period demonstrate improvements in overall mathematical attainment compared to students attending control schools?

Secondary Questions:
RQ2: Do students in schools implementing ICCAMS Maths over a two year period demonstrate improvements in attainment in algebra (2a) and multiplicative reasoning (2b), compared to students attending control schools?

RQ3: Are effects on attainment different for students eligible for FSM? If so, how?

RQ4: Do students in schools implementing ICCAMS Maths over a two-year period change their dispositions to learning mathematics compared to students attending control schools?

RQ5: Is there an interaction between fidelity and attainment change for the treatment schools?

Implementation and Process Evaluation Questions:

The main questions to be addressed through this process evaluation are listed below:

RQ6: How, and to what extent do the involved stakeholders (e.g. PD Leads, schools and teachers) practise and adhere to the principles, guidance and materials?

- RQ6a: How much of the training have teachers attended, and how was it delivered?
- RQ6b: How frequently do teachers report they implement the ICCAMS materials and for how long?
- RQ6c: To what extent do ICCAMS materials and PD support PD Leads to deliver ICCAMS? Are there ways in which these can be improved?

RQ7: How, and to what extent does the method by which training is offered (e.g. PD lead or cascade) relate to how ICCAMS is delivered in the classroom?

- RQ7a: Are there differences in fidelity between Core and Cascade teachers?
- RQ7b: What are the contextual factors that afford or constrain the quality of implementation and the cascading in school?
- RQ7c: To what extent to ICCAMS materials and PD support the cascade model of training? Are there ways in which these can be improved?

RQ8: How do students engage with the ICCAMS, including lessons, materials, and related practices?

RQ9: What relevant mathematics and PD systems and practices are in place in schools randomly allocated to 'business-as-usual' control group?' And how do these

relate with the impact seen on primary and secondary outcomes (i.e. attainment and dispositions) identified at classroom or school level?

RQ10: To what extent do pedagogical factors, (e.g. transmissionist or connectionist approaches, confidence in teaching ICCAMS, fidelity of the intervention) mediate or moderate the impact of ICCAMS on primary and secondary outcomes?

IMPACT EVALUATION DESIGN

A 2-year cluster-randomised trial was utilized. Participating schools were the unit of randomisation.

RANDOMISATION

Random allocation was at the school level and took place in July 2016, after the receipt of the school file with relevant information (%FSM and %GCSE A* to C). The initial plan was to perform randomisation within each regional hub with expected maximum of 30 schools to randomise, and thus using block stratified randomisation (Torgerson & Torgerson, 2008). In order to ensure balance in regards to previous attainment and proportion of FSM, blocks were expected to be defined by the proportion of students in each school to achieve 5 A*-C in the 2015 GCSE examinations (above median and below median) and the proportion of students in each school to be eligible for Free School means (above and below median). This implied that there were up to 4 blocking variables (or strata) made up of the combinations of these two variables. Preliminary investigation of the given school information based on the medians of the two strata (FSM and GCSE %) within each area revealed some problems especially with confounding of the two variables in some areas. In order to account for this confounding, deal with the missing information (i.e. not available) for some schools, as well as ensure balance in the overall design and school split it was considered more useful to define the groups/blocks based on 3 categories per strata (i.e. low, medium and high). Randomisation of schools within each of the five regional Maths Hubs (to achieve a 50:50 allocation) was then performed with the following steps:

Step 1: Setting Criteria for High, Medium, and Low: Cut values of 50% and 70% (inclusive) were chosen for GCSE, and 20%, 50% for FSM. The cut-values of 50% and 70% (GCSE), and 20% and 50% were selected as reasonable cut lines by inspection of the whole distribution of scores.

Step 2: Dealing with Missing data: Schools with missing data were assigned to cells by imputation: using the probability that they should fall in a given cell in their area, based on existing frequencies of cells in that area. For example, with a school where low FSM is reported but no GCSE data is provided, we look at how the low FSM schools are distributed across low, medium and high GCSE figures.

A first set of random numbers was used for this step using the Random Number Generation in Excel's built-in Analysis ToolPak Add-in, with settings of 109 numbers with values between 0 and 1 from a uniform distribution, using the random seed of 27783. These were matched to schools in the order given in the original order of the spreadsheet.

Step 3: Inspecting blocks by area and applying tolerances: Once the locations of the schools with missing data were imputed within the blocks defined in Step 1, each area's scatterplot was inspected for borderline cases, block size and potential outliers (i.e. single cases). The following rules are applied:

- Tolerance of ±2% at the cut-offs is applied to allow for some schools that would otherwise be placed in a cell on their own or result in an odd cell frequency
- Rare single cases moved to the nearest neighbour block.

Step 4 – Setting Allocation rules and allocating schools: A second random number was generated for each school using the same Random Number Generation tool and settings as above, except for a different random seed of 19135. The rules for allocation were as follows:

- Sort the dataset by area, FSM group, GCSE group and second random number.
- Within each FSM/GCSE block, the schools with the higher random numbers will be allocated to the intervention (experimental) arm and the lower random numbers to control.
- *Selections from blocks with odd frequencies:* Assignment of schools to the Intervention groups in the 'smaller areas' were privileged (marginally) by assigning to these groups the even number in an odd cell (e.g. a cell containing 11 schools would get 6 intervention -schools in these smaller areas, to ensure that there were at least ten E-schools). For the larger groups the opposite was applied (e.g. the even number will be assigned to the control group first).
- In the event of more than one odd blocks in the same area the 'privilege' was alternated on the order of the blocks shown in Figure 3 (chosen arbitrary in advance for consistency).

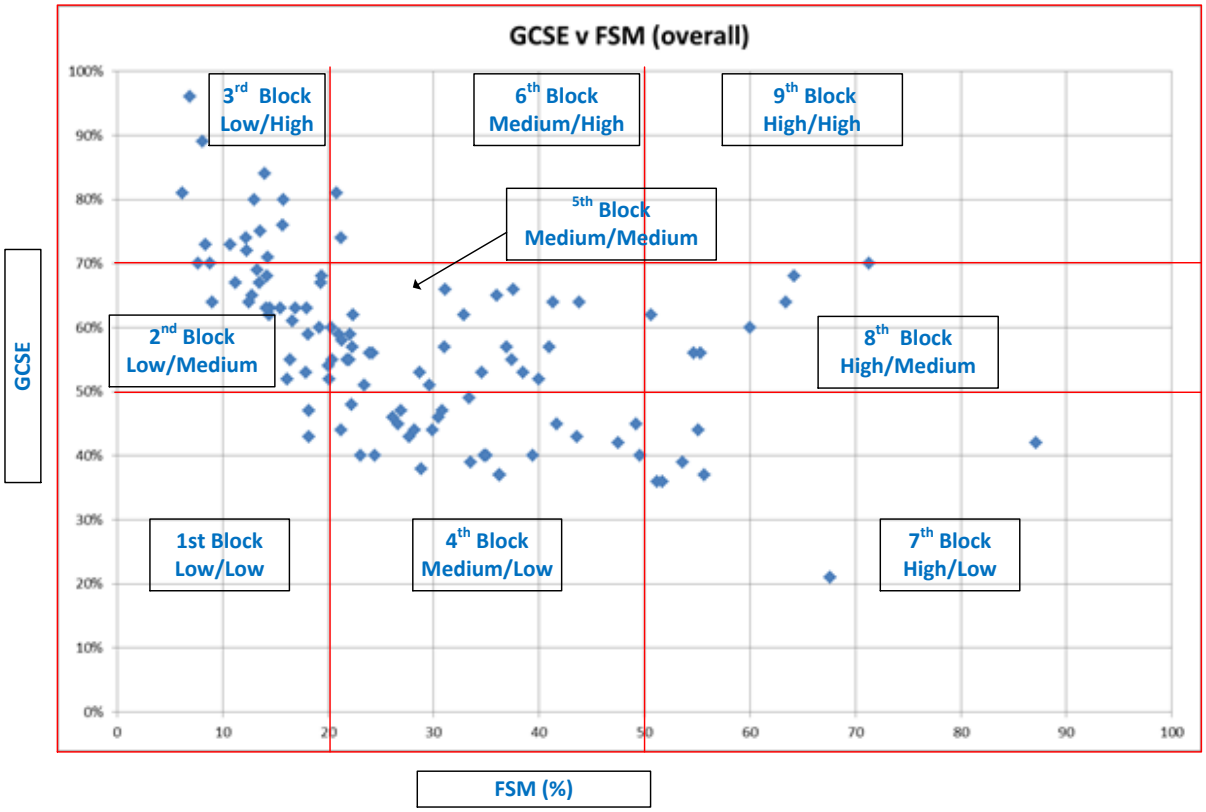

Figure 3: Block definition for randomisation within regions

The actual manifestations and how this split is to be implemented is shown in Table 2. As shown, there were only 4 instances of off block frequencies.

Table 2: Allocation for even sized blocks (Intervention/Control)

	Area 1	Area 2	Area 3	Area 4	Area 5

1st Block	0	0	0	0	0
2nd Block	2	4	6	2	**7 (3/4)**
3rd Block	2	4	2	2	**7 (4/3)**
4th Block	**7 (4/3)**	0	**7 (4/3)**	11 **(5/6)**	4
5th Block	6	4	4	8	6
6th Block	0	0	0	0	0
7th Block	2	0	0	2	2
8th Block	0	8	0	0	0
9th Block	0	0	0	0	0

As a result of this process, which was repeated in each of the 5 regions, there were 55 schools assigned to the Experimental group and 54 to the Control group in total (see Table 2 for the resulting split per area).

The details of the randomisation process have been recorded (both school lists and employed tool for the algorithm) and the outcome was shared with the delivery team. The schools were then informed (by Durham) of their random allocation in July, in order to make the necessary arrangements needed for the teachers to attend the ICCAMS PD sessions. All Year 7 students and teachers are expected to complete the first 'Disposition' Questionnaire (students) and teaching practice surveys (teachers) (i.e. pre-survey) at the beginning of the academic year 2016-17.

Schools allocated to the intervention arm of the trial will be trained and supported to implement the ICCAMS intervention over a two-year period. Schools allocated to the control arm of the trial will be encouraged to continue practice as usual during the same period. £1500 will be offered to control schools as compensation for time and to avoid attrition: £500 at the beginning of the trial (upon provision of UPNs and completion of pre-survey) and £1000 following the completion of post-test measures. Schools in both arms of the trial will be required to sign a memorandum of understanding before randomisation, committing them to comply with the evaluation protocol whichever arm they are allocated to.

PARTICIPANTS (SCHOOL AND STUDENTS SAMPLE)

Eligible schools were mainstream English state secondary schools (or middle schools) with more than two class intake for Year 7 (ideally not in special measures) and with, ideally, higher than average levels of FSM eligibility. Schools were only eligible to take part in the study if they agree to all of the study requirements outlined in the Participation Agreement between the Universities and Schools and the form was signed by the head teacher (a copy of the Participation Agreement is included in Appendix 1) The trial schools were recruited (by Durham, supported by NCETM and the Maths Hubs, and Nottingham) in five regionally-based groups to facilitate the hub-based PD. (It was aimed to minimise the number of schools also taking part in the Schools, Students and Teachers Network SSAT trial, "Whole school Embedding Formative Assessment Project" or any other special program deemed related.)

It was aimed to recruit between 100 and 110 schools (to ensure that the trial was sufficiently powered with a low level of school-level attrition) to take part in this trial (55 in each arm). This included schools spread across the five areas with up to 30 schools in each area. The project recruited 109 schools to the trial with the spread of schools across each area indicated in the table below. All eligible schools within each area were invited (in writing) to the local recruitment events, or to attend a webinar, as well as being sent information about the project. Discussions with NCETM and EEF,

regarding further recruitment criteria, decided that other related projects (for example, the KS3 Multiplicative Reasoning Project[2]) were not similar enough to prevent schools in the KS3 Multiplicative Reasoning project (originally an exclusion criteria) from taking part in the ICCAMS project. Durham and Nottingham worked with the Maths Hubs in each area to increase prominence and reach of the project to support recruitment. The Maths Hubs sent out information about the project to schools registered with them and promoted the local events. PD leads also supported recruitment of schools to the project through using their local network contacts and by attending local recruitment events. At a National Level, NCETM promoted the project by including it in their news updates to schools and in their termly magazine. The TES also included a short article to raise awareness of the project.

Final Regions and Maths Hubs involved in the project are shown in Table 3, along with the randomisation.

Table 3: Final recruitment and randomisation per region

Maths Hub Centre	Number of schools recruited	Final Regions	Maths Hub(s)	Randomisation Split
1	19	South/ South West	Jurassic and Solent	Intervention: 10 Control: 9
2	20	London	London SE and London Thames	Intervention: 10 Control: 10
3	19	East Anglia	Norfolk, Suffolk and Cambridge	Intervention: 10 Control: 9
4	25	East Midlands	East Midlands East and East Midlands South	Intervention: 12 Control: 13
5	26	Yorkshire	Yorkshire Ridings	Intervention: 13 Control: 13

All **students** in Year 7 at the beginning of the 2016/17 school year are the target cohort (excluding those without parental consent). We estimated a sample of 11,000 students, based on an estimated average of 100 per school. Since the target year is Year 7, it will not be possible to collect UPNs from the schools or obtain opt-out consent until September, which is after randomisation.

Children eligible for FSM will be a sub-group for this trial – the effect of the intervention will be analysed within this sub-group in view of EEF's primary remit of narrowing the attainment gap for such students and in line with differential gains established for children from poorer socio-economic backgrounds for related universal programmes.

SAMPLE SIZE CALCULATIONS

The sample size, i.e. the number of cluster (schools) needed for each of the two arms of this study, has been determined based on the following assumptions:

- a minimum detectable effect size of 0.15. This was deemed a worthwhile effect given the estimated cost of the intervention and the cascade delivery of PD within schools. The previous evaluation of ICCAMS (Hodgen et al., 2014) also suggests an effect size of this order is a reasonable target.

- 80% power and alpha of 0.05,
- ICC of 0.12, based on a combined consideration of suggestions/assumptions in relevant literature (Hedges & Hedberg, 2007; Spybrook & Raudenbush, 2009)
- A pre-test post-test design with 0.65 correlation

With these assumptions, it was estimated that 50 schools will be required per trial arm (assuming number of students in Year 7/8 in these schools ranging from 75 to 150 based on the eligibility criteria set earlier). [2]

OUTCOME MEASURES

Baseline Outcome: Schools will be asked to provide name, unique pupil number (UPN), gender, EverFSM 6 status, date of birth (DOB), KS2 Maths Result, class and math teacher, for all eligible students at baseline. This will allow us to collect all Key Stage 2 (KS2) results from the National Pupil Database (NPD) and match pupils to their teachers. Control schools will receive £500 upon submission of pupil and teacher data and returning the surveys.

The **primary outcome** will be the raw scores on a revised version of the Mathematics Assessment for Learning and Teaching (MALT) test for Year 8 (MALT13). Revisions include the removal of two items and the addition of 4 algebra related items to strengthen this dimension (the measures have been piloted and results reviewed by independent members of the EEF's Evaluation Advisory Group). This assessment is a test of general maths but also includes some conceptual elements of maths and will be complemented with the four extra items to strengthen the secondary dimensions listed below (and in particular algebra). Attainment will be measured at the end of Year 8, with the revised MALT test (paper – 45 minutes). Administration and invigilation of the tests will be implemented under exam conditions in schools in June/July 2018. This will be overseen by the independent evaluator team and then marked by markers blind to condition.

Three **secondary outcomes** will also be measured:

(1) An attainment sub-scale on MALT of "multiplicative reasoning"
(2) An attainment sub-scale on MALT of "algebra"
Both of these are likely to be more sensitive to the intervention, and have been validated during the pilot stage.
(3) Student attitudes will be measured at pre- and post-test using a survey of dispositions towards mathematics. This is based on previously validated scales (see Pampaka & Wo, 2014), recalibrated during the pilot and with the final items shown in Appendix 2.

The primary and secondary attainment outcome measures will first be analysed using raw scores. However, owing to the small number of items in the secondary outcomes (e.g. MALT subscales) and the ordinal nature of items for the attitudinal measures for students these outcomes will also be calibrated using the Rasch modelling framework (Bond & Fox, 2001; Wolfe & Smith Jr., 2007a, 2007b) and analysed. Rasch modelling allows for objective measurement: the outcomes will thus be similar to standardised

[2] See, for example: http://www.george-spencer.com/images/itl_demo/doc/Maths%20Hub/Events/KS3%20Multiplicative%20Reasoning%20Project.pdf

scores. Outcomes from both analyses will be compared to understand if the raw scores have violated assumptions of linear regression modelling.

The student attitudinal instrument has also been delivered at the start of the academic year 2016-17 as a baseline pre-survey, and along with the post-test (as secondary outcome).

Additional measures

Additional measures of transmissionist/connectionist teaching have been developed and validated by the evaluator team during the pilot stage. They have been based on previously validated instruments designed for similar populations of students and teachers (Pampaka et al., 2013; Pampaka & Wo, 2014) (www.teleprism.com; www.transmaths.org). More details about the final instruments to be used are presented within the Analysis Plan.

A central element of IPE is to provide evidence of the conditions under which the intervention was implemented and explain the main impact evaluation hypothesis that there is a learning effect due to the very specific support that teachers will get to implement formative assessment (FA) practices from the materials and training they receive. The effect on students' cognitive and affective outcomes is therefore hypothesised to be positive, especially for outcomes that relate directly to these materials/practices (i.e. subscales of algebra and multiplicative reasoning). The transmissionist scale (Pampaka & Williams, 2016; Pampaka et al., 2012) is one measure of practices that can affect outcomes, and we might expect to see this measure showing real differences between the intervention and control groups, and partially explaining group differences in outcomes (at least of affective outcomes if not in attainment). It is therefore vital to capture this variable as it would be an indicator of what is denoted in the logic model (Figure 2) as "teachers improve feedback & pedagogy".

For these measures we have built on previous work (Pampaka et al., 2012) and have piloted an instrument that captures both (a) perception of transmissionist teaching and (b) perception of teaching in accordance with FA. Both measures are intended to be used as mediators of the effectiveness of the intervention not as outcomes measures in themselves: the former is more generic to take into account some of the variation in the 'business as usual' control schools. The latter is expected to be more relevant to the intervention schools. This information will be collected via teacher and student surveys (see Table 3).

It is expected that the teacher instruments will be provided both online and in hard copies. For the teacher survey during post-testing (June 2018) we will incorporate questions designed to capture elements of fidelity such as teachers' attendance at PD sessions (see Appendix 5 in SAP and fidelity section).

IMPLEMENTATION AND PROCESS EVALUATION METHODS

We propose to collect further evidence through a process evaluation with an aim to isolate the causal explanations of the intervention impact under usual conditions. Our Implementation and Process evaluation (IPE) will thus focus on both collecting evidence about how the intervention is delivered at its various levels (at PD, schools, and classrooms) as well as how this might affect and explain the primary and secondary outcomes and the relationships in the statistical models.

There may be reasons why effects do not arise or are not significantly different from the control schools. One of the features of the sample is that they consist of schools that expressed an interest in being involved in a maths FA development: they are not necessarily typical of all schools, and that applies to control schools as well. This willingness may not be entirely a 'good thing' for (i) the experiment itself (as one might expect the control schools to not be satisfied to carry on with 'business as usual') but also (ii) for the efficacy of the intervention (it may be that the schools selected in because of a perceived management problem with mathematics, say). There may also be a negative effect of teachers being 'drafted in' to a programme that they may not really believe in, or which assumes FA practices that are otherwise alien to their experience and disposition.

Our implementation and process evaluation focus around fidelity and integrity (RQ6), dosage and exposure (RQ6b), participant responsiveness (RQ8), possible adaptations (RQ7) and some evidence for the 'business as usual' practices in control schools (RQ9). The process evaluation will also provide opportunities to explore teachers' attitudes and practices (RQ10), as well as the effect of cascading (by comparing cascade vs core teachers). Finally, more intensive case studies including observations of key lessons will identify learning and teaching practices mediated by ICCAMS materials (and other contextual factors, e.g. institutional norms) that can explain targeted learning outcomes whose improvement is being measured. Table 3 summarises the various elements of the IPE.

Table 3: Overview of IPE

Methods (Groups)	**Data**	**Time**	**IPE Dimension**	**Research Questions**
(Longitudinal) Case study work				
Researchers Observations at PD sessions	Observation field notes (at least one session from every area)	November 2016 to June 2018	Fidelity Programme Differentiation Adaptations	RQ6
Researchers observation of PD Training Sessions	Observation field notes and material presented	June 2016 to June 2018	Fidelity	RQ6
Researcher Lesson Observations (Intervention)	Lesson Observations along with PDs (at least 1 in each area) – with Durham's Observation Schedule	April 2017 to June 2018	Fidelity	RQ6
Interviews with PD leads	Interview Transcripts (also to inform choice of schools for case study)	April 2017 to June 2018	Fidelity, Quality, Adaptations	RQ6
Longitudinal school case studies in a number of schools (3-5) in at least two areas (ensuring coverage of Low, High and Medium schools as per June 2017 fidelity	Classroom Observations (evaluators field notes and/or structured observation schedule to be progressively developed)	April-June 2017 Oct-Dec 2017	Quality, Fidelity, Programme Differentiation	RQ8 RQ7 RQ6 RQ9 RQ10
	Teacher Interviews (biographical interview at first time, 40 mins max, and short interviews at follow up visits)	 Jan-March 2018	Responsiveness, Fidelity, Quality Reach	RQ8 RQ7 RQ6

measurement and teacher surveys)	Student interviews Short interviews (10-15 mins) with students	May-June 2018	Responsiveness	RQ8
	Short student surveys during case study to explore engagement with ICCAMS material and teaching	Oct 2017 to June 2018	Responsiveness	RQ8
Surveys				
Teacher Survey (All)	Teachers' perception of transmisionist teaching Teachers perception of teaching in accordance with FA Participation on other PD	Sept-Oct 2016 and June 2018	Programme Differentiation Monitoring of control/comparison groups	RQ 10 and RQ7
Student Survey (All)	Students 'perception of transmissionist' teaching			
Teacher Survey (Intervention all)	Fidelity related questions (led by Durham)	June 2018	Fidelity, Dosage	RQ6
School Telephone Survey/interviews (Control Schools)	Key contact to discuss 'business as usual'	May 2017-June 2018	Monitoring of control/comparison groups	RQ9
Secondary Data (i.e. those to be shared by Durham)				
Lesson observation schedules by PDs	We suggest analysing the data (June 2017) from a measurement perspective and compare with Durham's suggested model of fidelity to ensure robustness	April 2017 to June 2018	Fidelity (School fidelity measurement)	RQ6
Teacher surveys		June 2017	Fidelity, Dosage, Reach	RQ6

Three main approaches will be followed to collect evidence in order to answer these questions, in addition to the evaluation team attending recruitment and training events.

SURVEYS

Teacher Surveys

Mathematics teachers in these schools will be a participating group of interest. The subgrouping here for the intervention group will consider their level of participation in PD: Direct or via school cascading. Teacher knowledge, beliefs and perceptions of practices to be collected through teacher questionnaires at the start (September/October 2016) and end of the project (May/June 2018) in all schools: it seems sensible and crucial for the evaluation of this intervention to have a measure of what is happening during the mathematics teaching in order to objectively 'monitor' practice. This is even more crucial since inevitably, the PD offered to some teachers in each school/department will spread to others in the department - a 'cascade' effect – but the extent of this cascade is likely to vary dramatically from school to school.

In order to **monitor the control conditions** we also intend to collect information from control schools/teachers through these surveys about their experience and any actual PD going on in their schools.

Students Survey

The student surveys (apart from the maths dispositions) also include an instrument measuring students' perceptions on the teaching they receive. This is to be used as a moderator/mediator in the models for primary and secondary outcomes (in a similar manner that the teacher survey is to be used – see next). We found in previous work that this measure, is a significant explanatory variable in models of students' dispositions to mathematics, and some times more important than teachers' perceptions of their practice (Pampaka & Williams, 2016). In addition capturing this information from students will also ensure less missing data, as usually teachers are less likely to complete such surveys.

CAPTURING FIDELITY

During the pilot phase, it has been identified through classroom/school case studies what are the practical forces limiting 'fidelity' and then working with Durham (and Nottingham) we have supported the design of instruments to 'measure' this in the main trial. These will take the form of observation schedules for the PD Leads to observe core and cascade teacher-taught ICCAMS lessons, and surveys of core and cascade teachers. The PD Lead observation measure was developed (Durham with support from Manchester) during 2016, with piloting ongoing between September and December 2016. The piloting aims to validate the PD Lead observation measure and survey, and its use and validity will also be triangulated by researchers from the evaluation team during the case studies and through light-touch invigilation in a small number of schools (about 10). Researchers from Durham double 'marked' around 10% of observations to gain a measure of inter-rater reliability. At the end of Year 1 of the intervention (August 2017), attendance logs, survey data and observation schedules will be collated to create a description of what a high, medium and low fidelity ICCAMS school is, based on these measures: Investigation of these data and discussions between the teams and EEF suggested the development of a simpler scoring system for overall school fidelity which is explained in SAP and consist of the 3 main elements of: attendance at PD sessions, cascade training and lessons taught. The more detailed records and observations will be used as part of the Process evaluation. This data will then be drawn again at the end of Year 2 of the intervention (August 2018) to create final indications of the fidelity 'level' of the school. Such a categorisation will also be used as part of analysis for secondary outcomes (see later). Logs of attendance at PD Sessions will also be shared (Durham will share with Manchester) in order to provide another indication of fidelity.

IN-DEPTH LONGITUDINAL CASE STUDIES

These will involve interviews with involved stakeholders (PD Leads, teachers, students) and lesson observations with both directly trained teachers, as well as those via the cascade model. In addition, we intend to collect survey data from students in these case studies in regards to their perceived engagement with the material. We also intend to observe 5 PD meetings and events in the first year and 2 in the second. For better coverage of the intervention, we propose to choose our case study schools by selecting at least 2 from each PD Lead (10 schools). The selection will also take into account the initial responses of teachers in the surveys (i.e. with an aim to observe teachers in the spectrum of a practice scale). Based on early visits to these schools we will progressively focus on a selected group of about 5 'telling' schools and classrooms that include a variety of practices likely to offer explanations of variation in

teaching and associated learning outcomes. These more intensive case studies will seek explanatory frameworks including the ways institutional and cultural norms, pedagogy, and ICCAMS materials and training mediate learning practices in the classroom. Despite the structured agenda for data to be collected from these case study sites, we aim to keep these case studies as open ended in nature as possible including the unexpected in schools that seem different/extreme or otherwise interesting. We anticipate that in order to achieve this we will need between at least 5 to 10 visits at each of these schools for the duration of the project, and in some cases involving a team of at least two researchers. The purpose of these case studies is to test the ICCAMS 'theory' and develop new hypotheses and explanations for phenomena that are unanticipated at this moment.

In addition we intend to choose a few 'control' schools including a diversity of telling and interesting responses to teacher surveys for close follow up interviews by telephone, exploring the way that 'business as usual' has developed in the perception of the key school contacts (at least 10 control schools).

The overall aim of this process evaluation is thus to gather more evidence about the mechanisms that support or inhibit the implementation of the ICCAMS approach, its effects in classroom practices, and students' outcomes, thus explaining the findings of the impact evaluation.

ANALYSIS PLAN

Analysis will need to account for the fact that schools were randomised into groups, while the outcome measures are collected from the students. Therefore multilevel models (with Stata and/or R statistical packages) will be employed to estimate a school-level and a student-level (and class-level for models which utilise the matched student-class/teacher level data) variance, in order to allow for schools to differ regarding their average outcome. The primary analysis model will include the outcome of interest as dependent variable (i.e. students' maths overall score, algebra, multiplicative reasoning, students' dispositions/attitudes, and teachers' perceptions of practice, etc.) and the following covariates will be included as independent variables: an indicator of group membership (ICCAMS Maths Intervention vs Control), student's KS2 maths score (or maths attitudes at start for attitude outcome) and the two variables related to randomisation (regional indicator and FSMever).

Analysis will be conducted using the principles of intention to treat, including all schools and students in the groups to which they were randomised irrespective of whether or not they actually received the intervention.

A standardised effect size will be calculated and reported using the proposed guidelines regarding multilevel models and Hedge's *g* (Cohen's *d* bias corrected), when needed (e.g. in FSM analysis). These effects will be accompanied by 95% confidence intervals as per EEF specifications, and along with other methods for handling missing data and further details are provided within a statistical analysis plan.

Primary Analysis: For the primary outcome (RQ1) we will conduct intention-to-treat analysis (Gupta, 2011), operationalized as two-level hierarchical linear models (student, school), with intervention group (e.g. ICCAMS vs. control), blocking stratifiers (e.g. % FSM) entered at the school level, and student's maths score at KS2.

Secondary/Explanatory Analyses:

Secondary Outcomes analysis
The effect of the intervention on attainment (both overall and subscales) will also be analysed by repeating the primary analysis in the sub-group of students who are eligible for FSM. Secondary outcomes (i.e. mathematics dispositions) will be analysed in a similar manner to the primary outcome.

Fidelity: treatment effects considering compliance indicator
We will also perform secondary analysis within the treatment group to explore the interaction between fidelity and attainment. As a compliance indicator we will use either a continuous or a categorical school-level variable constructed based on information in relation to PD attendance, ICCAMS lessons taught and cascade training. The details of the construction of these compliance indicators and the corresponding analysis are provided in the SAP (e.g. see Appendix 5).

Exploratory analysis
Additional models will be built following the models for primary and secondary outcomes presented above to include further relevant explanatory variables as covariates: gender, age,. In addition 3-level models (students-class/teacher – school) will be investigated to explore whether there is a significant effect of the teacher/class level in the primary and secondary outcomes.

Rasch modelling framework
Secondary outcomes (e.g. MALT subscales and attitudinal measures for students such as maths disposition in this case) will also be calibrated using the Rasch modelling framework (Bond & Fox, 2001; Wolfe & Smith Jr., 2007a, 2007b) and resulting interval scores will be further analysed with regression models. Rasch modelling allows for objective measurement: the outcomes will thus be similar to standardised scores. Outcomes from both analyses will be compared to understand if the raw scores have violated assumptions of linear regression modelling.

Mediating/Moderating factors
In order to explore the mediating and moderating effect of students and teachers perceptions of teaching practices on the primary and secondary outcomes, and their interaction with the intervention the following 3-level models will be explored building up from the models described under the 'Exploratory Analysis' section above:

- Add the measure of students perception of transmissionist teaching on the models
- Add an interaction term of the above measure and the intervention indicator
- Add teachers' perception of teaching practices (both for FA and transmissionist) into the model
- Add both the interaction at pupil level and the teacher's perceptions at class level,

In order to check for mediating and/or moderating effects these models need to be run and compared between them and the previous models without these variables.

COSTS

As part of the evaluation, we will collect data regarding the following costs for schools implementing their responsibilities in the intervention, as well as outside school costs of implementation. We note:

- Direct, marginal costs (i.e. costs directly attributable to the school's participation in the intervention): it is envisaged that this will include the financial costs for providing the training, for school visit (if necessary) and the cost of implementing the intervention and other necessary resources for the successful implementation. In particular, there will be costs related to salary costs (for teachers' time to take part in training), purchasing/printing resources and fees for services.
- In addition, it is expected that such intervention will entail 'Hub' costs of administration and implementation monitoring.
- Pre-requisites, especially in relation to the delivery of the intervention (and regarding the equipment needed or available at schools).

Data will be collected from the developer, as well as directly from schools as part of the process evaluation (e.g. interviewing via case studies, school-level surveys and/or use of pro-forma spreadsheets) to uncover the expected and any unexpected costs of this intervention.

ETHICS AND REGISTRATION

Each of the participating institutions has received ethics clearance within their institution. Ethical approval for the pilot stage of the independent evaluation was granted by the University of Manchester Research Ethics Committee 6 on 14/6/16 (Ref:16348) and ethical approval for the main trial was granted by the University of Manchester Research Ethics Committee 1 on 9/9/16 (Ref: 16405). Ethical approval for Phase 1 of the ICCAMS2 study was granted by the University of Nottingham's School of Education Ethics Committee on 8/10/15 (Ref: 2015/938/MO). The application for both Phase 1 and Phase 2 parts of the ICCAMS2 project was granted by Durham University's School of Education Ethics Sub-Committee on 11/12/15 (Ref: 2245).

Parental opt-out consent will be sought for collecting and using data for the trial. Opt-in consent will be sought from students and teachers for observations, interviews and surveys.

The Evaluation team will register the trial with ISRCTN (www.controlled-trials.com) once the protocol is agreed.

PERSONNEL

Roles and responsibilities have been updated and are detailed below:

Manchester University (Evaluator) – responsible for the independent evaluation, will look at the impact the programme on outcomes, as well as being responsible for randomisation, independent administration and marking of outcome measures, and writing the final report on the project.

Maria Pampaka, Principal Investigator of the Independent Evaluation
Julian Williams, Professor of Mathematics Education – Support and advice on the project evaluation
Lawrence Wo, Research Associate
Graeme Hutcheson, Statistician and Advisor
Abate Kenna, Researcher (Until August 2017)

David Swanson, Researcher (from October 2017)
Jack Quinn, Researcher (from October 2017)

Durham University Team– responsible for recruitment, delivery of the intervention and monitoring fidelity

Gemma Stone, Research Trials Officer (Maternity cover October 2016 – January 2018)
Vic Menzies, Research Trials Officer (Maternity leave – October 2016 – January 2018)
Stephanie Raine, Research Assistant (January 2016 to September 2016)
Jessica Hugill, Research Assistant (from May 2017)
Clare Collyer, Research Administrator (until October 2017)
Mary Nezzo-Thompson, Research Administrator (from March 2018)
Rob Coe, Professor of Education and Director of CEM – advice on intervention and trial conduct

UCL Institute of Education / Nottingham University (Developer) – responsible for developing and piloting the ICCAMS programme and the professional development training and overall responsibility for developer responsibilities in the project.

Jeremy Hodgen, Professor of Mathematics Education – Principal developer of the intervention (moved to UCL Institute of Education on 1st September 2017)

Dietmar Küchemann, Senior Research Fellow – Support and guidance to PI and developer of new lessons

Marc North, Senior Research Fellow – Responsible for developing Pilot PD and PD sessions (until 31st August 2016)

Colin Foster, Lecturer in Mathematics Education – Additional support and guidance on PD and lesson materials (from 1st September 2016. Moved to University of Leicester 1st January 2018)

Kanchana Minson, Project Administrator

RISKS

The main anticipated risks along with the mitigation considerations are presented in the following table.

Risks	**Assessment**		**Mitigation**
	Likelihood	**Impact**	
School and student recruitment	Low/Medium	High	Recruitment will be a collaborative approach between the implementation team and the evaluation team. All parties will work with networks of schools.
Possibility of attrition for those schools that agree to enter	Low/Medium	Medium	Control schools will be provided with a financial contribution of £1500 to acknowledge the time and resources required to take part in the study. Schools will sign up to MoU informing them of all aspects of the trial. Contact will be made with

			schools during the trials via social media and newsletters.
Refused Access to NPD	Low	Low	Data will be collected directly from schools.
Missing outcome data (MALT tests)	Medium	High	We can offer schools automated reports for students based on MALT test, subject to ethically approved data management protocols. Expertise in the evaluation team can alleviate partly missing data issues via imputation at the analysis stage if such a problem arises (Pampaka, Hutcheson, & Williams, 2014).
Other aspects of implementation relating to the PD, the PD leads and the hubs	Low/Medium	Medium	PD leads would be contracted to provide the training and would agree to different aspects. If a PD lead were not able to carry on a member of the Durham (or Nottingham) team could step in for an interim period until another PD lead could be recruited.
Researcher Loss (illness etc.)	Medium	Medium	Each institution has a large department with numerous researchers to take on. Senior staff can stand in if necessary
Administration of data	Low	High	All three institutions will agree to follow a data management plan registered online which details the acceptable processes for transferring and storing data as well as which data will be stored and used by each party. All processes specified will comply with the policies of the three institutions.
Management of the trial & the evaluation/test data			Clear protocols in place for communication between all three teams so that all teams are informed about any communication with schools. Regular and frequent communication between teams on milestones.
Maintaining and monitoring fidelity (intervention and control) [It is essential that as many schools as possible maintain a high level of implementation fidelity]	Medium	Medium	The evaluation team will provide support to the Implementation and Delivery teams, including a robust recording mechanism to allow for triangulation. Three forms of triangulation, supporting our observations and reports from a number of viewpoints will be utilised: (a) Comparing and contrasting evidence about the same actions and activities, from different stakeholders, (b) Scrutinising events from different perspectives by making use of a variety of methods for collecting information, and (c) Using 'outsiders' as observers.

TIMELINE

Date	Team*	Activity

1st August 2015	All	Project starts
Aug/15 to Jan/16	N, D	Intervention development work
Oct/15 to Aug/16	All	Development of new instruments and institutional ethic clearance 08/10/15 Phase 1 (N) 11/12/15 Phase 1 and 2 (D) ?/16 ? (E)
Jan/16 to Jul/16	N, (All)	Piloting of intervention, training and materials
June to Aug 16	E	Validating new instruments and sub-scales
Jan/16 to Jun/16	D, (E)	Recruitment of schools to trial
Oct/15 to May/16	D	Recruitment of PD Leads
May 2016	D	Training of PD Leads
July 2016	E	Randomisation of schools
September 2016	E	Pre-survey First year of intervention begins
September 2016 to July 2018	E	Process Evaluation
September 2017		Second year of intervention begins
June/July 2018	E	Final outcome assessment
December 2018	E	Draft report
March 2019	E	Final report
31st March 2019	All	Project end date

* N=Nottingham, D=Durham, E= Evaluator (Manchester)

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APPENDIX 1

SCHOOL PARTICIPATION AGREEMENT

Increasing Competence and Confidence in Algebra and Multiplicative Structures (ICCAMS 2) Research Project and Independent Evaluation

Durham University, University of Nottingham, and the University of Manchester (collectively "the Universities") are undertaking a research project entitled "Increasing Competence and Confidence in Algebra and Multiplicative Structures (ICCAMS 2)" (the "Project").

Through this document we wish to clarify the background of the Project along with the rights and obligations of the Universities and your School in the event you choose to participate.

Details of the Project including the expected involvement of a participating school can be found in Schedule 1 attached hereto.

ROLES AND OBLIGATIONS:

In the event your School chooses to participate in the Project, the following roles and obligations are hereby agreed by the Universities and your School:

Your School agrees to:

At sign up	
1.	Identify a lead contact in the school to liaise with Durham University and ensure that all responsibilities have been fulfilled and all necessary arrangements are in place.
2.	Provide Durham University with required information about the school.
3.	Identify and provide Durham University with the names of two nominated lead teachers for ICCAMS (to attend the training if school is allocated to receive the ICCAMS Maths intervention) one of whom should be senior in the Maths department.
September 2016	
4.	Send out opt-out consent letters to parents/caregivers of all Year 7 students and inform Durham University of the names of any students that wish to opt out.
5.	Securely provide Durham University with student information for all students in Year 7 except those who have opted out.
6.	Ask all Year 7 students to complete Attitudes to Maths questionnaires and return to University of Manchester.
7.	Ask all maths teachers who teach Key Stage 3 Maths to complete teacher surveys and return to University of Manchester.
July 2017, September 2017 and July 2018	
8.	Provide Durham University with updates to student information and information on which teachers are teaching which Year 7/8 classes (if any new students have joined the school or changed classes).

(continued overleaf)

June/July 2018	
9.	Ask all maths teachers who teach Key Stage 3 Maths to facilitate the completion of the MaLT maths assessment and Attitudes to Maths questionnaires and return to University of Manchester. Schools to arrange a suitable date with University of Manchester to complete the MaLT maths assessment and Attitudes to Maths questionnaires with all Year 8 students under exam conditions supported by a member of staff from University of Manchester.
Throughout the Project	
10.	Liaise with University of Manchester to allow researchers to visit the school to observe maths lesson practice and to talk with staff and pupils about maths teaching in the school if requested. This will include circulating information and consent forms for pupils and students provided by University of Manchester.

If allocated to the **ICCAMS Intervention Group**, **your school** also agrees to:

11.	Allow the two nominated lead teachers to attend 6 full days of ICCAMS PD spread across the 2016/17 school year and 3 full PD days across the 2017/18 school year (cover and travel costs not provided).
12.	Deliver 20 ICCAMS lessons to all Year 7 pupils during 2016/17 and 20 ICCAMS lessons to all Year 8 pupils during 2017/18 along with associated assessment tasks.
13.	Provide monthly, hour-long ICCAMS PD workshop sessions throughout each year for the KS3 Maths team led by the two Lead teachers using provided materials.
14.	Support visits from the local PD Lead (and occasionally other members of the research team) to the school to observe two ICCAMS lessons each year.

Durham University agrees to:

1.	Obtain consent from schools and parents for participation in the research, and for data matching so that National Pupil Database (NPD) data can be collated with project data to examine longer-term impacts of the programme.
2.	Store all data safely and securely.
3.	Inform schools of the results of the random allocation.
4.	Collate school and pupil level data provided by schools.
5.	Provide ICCAMS Intervention Group schools with teacher handbooks and resources to enable delivery of the ICCAMS Maths programme.
6.	Provide 9 sessions of PD to ICCAMS Intervention Group Lead Teachers and provide ongoing support to schools through local PD Leads in each area.
7.	Support and train PD Leads in each area.
8.	Securely share data provided by the school and necessary to complete the research, with University of Manchester and University of Nottingham.

University of Nottingham agrees to:

1.	Pay Comparison Group Schools £500 for completion of responsibilities detailed above up to end of September 2016 and pay Comparison Group Schools £1000 for completion of responsibilities detailed above to the end of the project.
2.	Store all data safely and securely.

University of Manchester agrees to:

1.	Store all data safely and securely.
2.	Conduct the random allocation of schools to ICCAMS Intervention Group or Comparison Group.
3.	Provide schools with MaLT Maths Assessments, student and staff questionnaires at appropriate points in the project.
4.	Work with the school lead contact to schedule the testing under exam conditions and support school with delivering this.
5.	Provide schools with the results from the MaLT Maths Assessment.
6.	Conduct the process evaluation including observation visits to schools, and interviews with staff and pupils and obtaining consent from participants for this aspect.
7.	Analyse data from the project in order to produce impact estimates.
8.	Produce an end of project evaluation report and share this with all participating schools.
9.	Share data provided by the school as necessary to complete the research with Durham University and University of Nottingham.
10.	Collate data collected as part of the project with data obtained from the National Pupil Database (NPD) and transfer school and pupil level data to the Education Endowment Foundation's (EEF) long term data archive for future research purposes.

DATA PROTECTION

a. For the purposes of this agreement Data, Personal Data and Process/Processing shall mean Data, Personal Data and Process/Processing as defined in Section 1 of the Data Protection Act 1998 ("the Act").

b. The Universities undertake to hold the all Personal Data shared by the School (the "Shared Data") securely and not to use such Data for any purpose other than in the course of the Project.

c. The Universities will hold the Shared Data in confidence and trust, and will not disclose any of the Shared Data, directly or indirectly, to any third party except as expressly permitted by this Agreement, without the express written consent of the School. The Universities may disclose the Shared Data within their organisation, but only to those having a need to know for the purpose of the Project.

d. The Universities shall ensure that all employees with access to the Shared Data have undergone training in data protection and in the care and handling of Personal Data.

e. The Universities shall be permitted to disclose Shared Data pursuant to a legal requirement or to the order of a court or administrative body of competent jurisdiction.

AGREEMENT TO PARTICIPATE AND WITHDRAWAL OF PARTICIPATION

Participation in the Project by your School is voluntary.

By completing, signing and returning the attached Consent Form you confirm your understanding of the Project and agree to all aspects of taking part in it. Please make sure to ask any questions you have about the Project before signing.

If your school or an individual from your school would like to withdraw from the Project they can do so at any point until the final data is collected (July 2018) by contacting the project administrator in the first instance (details below):

Project Administrator

Clare Collyer:

Email: ICCAMS@cem.dur.ac.uk

Tel: 0191 334 4682.

In the event your School chooses to participate in the Project, the Universities agree to perform the Project in keeping with their obligations as set out in this Participation Agreement.

This Participation Agreement may be executed in any number of counterparts, each of which shall be deemed to be an original, and all of which together shall constitute one and the same agreement. Each party acknowledges that an original signature or a copy thereof transmitted by facsimile or by PDF shall constitute an original signature for purposes of this Participation Agreement.

Accepted on behalf of Durham University	Accepted on behalf of University of Nottingham
Signature:	Signature:
Name/position:	Name/position:
Date:	Date:

Accepted on behalf of University of Manchester

Signature:

Name/position:

Date:

FORM OF CONSENT

Please complete and sign two copies of this Form of Consent, retaining one and returning the second copy to Clare Collyer at CEM, Rowan House, Mountjoy Research Centre, Durham University, Stockton Road, Durham DH1 3UZ.

- I confirm that I have read and understood the Participation Agreement for the ICCAMS 2 Project and have had the opportunity to ask questions about the Project and receive answers.

- I understand that by agreeing to take part in the Project the school will be randomly assigned in July 2016 to either the ICCAMS intervention group or the Comparison group:
    - Schools in the ICCAMS intervention group will begin the ICCAMS programme in 2016 and be expected to continue for two years.
    - Schools in the comparison group will receive £1500 (in two payments) for completing the required aspects of the project as set out in the Participation Agreement.

  I understand what is involved for schools in both groups and agree to the School taking part in the Project whichever group the school is assigned to.

- I agree to the responsibilities set out for the schools in this Participation Agreement and agree to deliver these.

- I consent to the school taking part in the above study.

Headteacher name: _____ Date: _____

Headteacher signature: _____

Email address: _____

School name and address: _____

_____

Schedule 1

THE PROJECT

Project Background

The ICCAMS 2 research project will work with schools over the next two years to support maths staff in developing Year 7 and Year 8 students' maths understanding, ability and confidence in order to investigate the impact of the ICCAMS Maths programme. The programme supports teachers in tackling students' common misconceptions around algebra and multiplicative reasoning and provides teachers with training, lesson plans and resources to help embed formative assessment in the Key Stage 3 maths classroom.
The programme is comprised of 40 evidence-informed lessons with additional assessment tasks and extensive teacher professional development (PD) to be delivered across two years. Lessons should be used with students at all levels and are designed to improve students' knowledge and use of algebra and multiplicative reasoning. Previous research using the ICCAMS programme with students in Year 8 suggested that ICCAMS doubled the rate of learning compared to a comparison group.

Research Aims

This project aims to study the impact that ICCAMS Maths has on students' maths attainment and attitudes towards maths. It will also investigate changes in teachers' practice and knowledge as a result of taking part in the programme. This will be done by comparing students and teachers in schools that use ICCAMS Maths over a two year period, with schools that do not use ICCAMS.

Research Design

Within each of our 5 areas participating schools will be randomly allocated to either:

1. **ICCAMS Intervention Group** – to receive the ICCAMS Maths programme between September 2016 and July 2018.
2. **Comparison Group** – to continue business as usual with KS3 Maths teaching and receive financial incentive of £1500 on completion of research aspects of the project.

Random allocation is essential to the evaluation as it is the best way of establishing what effect ICCAMS has on students' attainment. It is important that schools understand and agree to this process. Schools that are allocated to the comparison group still need to remain part of the project and complete relevant activities e.g. providing data, completing student assessment and teacher questionnaires.

What would the ICCAMS Maths Programme require of a Participating school?

Schools that are assigned to ICCAMS Intervention Group will use the programme with all Year 7 students starting in September 2016 and to continue to use the programme with the same students when they are in Year 8. This comprises of 20 lessons in Year 7 and 20 lessons in Year 8 with associated formative assessment tasks.

A full PD programme (full day sessions: 6 in first year and 3 in the second year) will be provided to two nominated Lead Teachers from each school in a location central to schools in your region. These PD sessions will be led by an external experienced PD Lead trained by the ICCAMS research team. These school's Lead Teachers will explore ICCAMS Maths in-depth during these sessions and will provide monthly shorter PD workshop sessions to other

KS3 maths teachers in their school to enable them to use the lessons with Year 7 (later Year 8) students. Resources will be provided for internal staff PD including a handbook containing the programme theory and lesson plans for all teachers as well as PD plans and resources. At least one of the Lead teachers should be senior in the maths department while the other can be any member of staff willing to attend and to disseminate the training back in school. Both teachers need to attend all 9 PD sessions.

The local PD Lead (and possibly other members of research staff) will visit each ICCAMS Intervention Group school to observe two ICCAMS Maths lessons per year. One lesson should be taught by an ICCAMS Lead teacher and one by another Year 7 maths teacher. These observations are done to provide support to the school and teachers involved and to provide research data on how ICCAMS lessons are delivered in practice.

All schools involved in the project (ICCAMS Intervention Group and Comparison Group)

All schools signed up to the project will need to provide the research teams with information about their school, students and teachers at different stages during the project. Schools will need to deliver maths assessments at the end of the project and also questionnaires at the start and end of the project.

Information required from schools

On signing up to the project schools will be asked to provide the following information about the school via email or post:

- School contact details and name of main contact for the project
- Name of Head Teacher and Head of Maths
- Expected size of year 7 intake 2016/17 and number of Year 7 Maths classes
- Number of maths teaching staff for year 7
- Names of two nominated lead teachers for ICCAMS (to attend full PD if school is allocated to receive the programme)
- Name of school main contact for project

In September 2016 schools will be asked to:

- Distribute opt-out consent forms to parents and caregivers of all Year 7 students. These letters will ask for consent for the child's data to be used by the three Universities and our funders for the research project. Should a parent wish for their child not to be involved they should inform the school or the research team directly. Schools will need to pass on names of any children who have opted-out in September and throughout the project as received. Opting out of the research does not affect whether a student is involved in the ICCAMS teaching in the school.
- Provide a list of all students in Year 7 (except those who have opted out of the research), including names, gender, date of birth, free school meals status, unique pupil number (UPN), Key Stage 2 results, Maths class.
- Provide a list of which teachers will be teaching which Maths classes.

At the end of Year 7 and the beginning and end of Year 8, schools will be asked to provide an update to student, class and teacher information.

Student assessment

Schools will be supported in facilitating the delivery of maths assessments to all students in Year 8 in June/July 2018 by the University of Manchester. The assessment will be the Maths Assessment for Learning and Teaching (MaLT), a standardised paper maths assessment which covers the full maths curriculum. This assessment will take around 45 minutes. Results from the assessment will also be returned to the school for their own use. The assessment will need to be delivered under exam conditions.

Student questionnaires

Students will be asked to complete questionnaires exploring attitudes towards maths in September 2016 and again in June/July 2018 (delivered at the same time as the assessment). These should take no more than 10 minutes.

Teacher questionnaires

Teachers involved in teaching Key Stage 3 Maths will be asked to complete questionnaires in September 2016 and again in June/July 2018. These questionnaires will explore teacher attitudes and practice particularly in regards to formative assessment and should take no longer than 10 minutes to complete.

Process evaluation

During the project, members of the evaluation team from the University of Manchester will visit ten schools to observe ICCAMS lessons (and other maths lessons within the comparison schools) and to talk to students and teachers about their experiences of maths and the ICCAMS Maths programme. Participation from students and staff in these visits will be voluntary. Consent for participation in the process evaluation will be sought from parents and staff by the University of Manchester.

How will the data collected from schools be used in this project?

Data collected as part of this project will be used only for research purposes and will be collected to evaluate the ICCAMS programme, its impact on staff and students and how the programme is implemented. No school, teacher or student would be identifiable from any report arising from the research.

Student data provided as part of this project will be linked with further information about students from the National Pupil Database (held by the Department for Education) and other official records, and shared with: the Department for Education, our funder (Education Endowment Foundation, EEF), and the EEF's data contractor FFT Education so they can investigate the longer term impact of different educational interventions. Data will also be transferred in a non-identifiable form to the UK Data Archive with restricted access for research purposes only.

About the teams

Durham University (Trial Lead – Vic Menzies) will be the main contact through the trial and they will work with and support schools who wish to sign up to the project. They will also work closely with the PD Leads and will be looking at how the programme is implemented in different schools.

University of Nottingham (Project Lead – Jeremy Hodgen) are developing the ICCAMS programme and the professional development training and have overall responsibility for the project.

University of Manchester (Evaluation Lead – Maria Pampaka) will be the independent evaluator looking at the impact the programme has on school outcomes, as well as being responsible for the random ballot, the assessment and other outcome measures and the process evaluation.

Appendix 2: The Items for Students' Disposition towards Mathematics

[Please circle the appropriate number in each line]		**Scale**
1.	Mathematics is important to me	Strongly Disagree (1), Disagree (2), Unsure (3), Agree (4), Strongly Agree (5)
2.	Learning maths is enjoyable for me	
3.	I am interested in learning new things in maths	
4.	I never want to take another mathematics course	
5.	I prefer my future studies to include a lot of maths	
6.	I look forward to studying more mathematics after school	
7.	I would like to be a mathematician	
8.	Maths is one of the most interesting school subjects	
9.	Maths is important for my future (after school)	